

**OPTIMIZING PRODUCTIVITY OF MAIZE UNDER
EMISSION BASED CLIMATE SCENARIOS BY MID
AND END OF 21st CENTURY IN PUNJAB**

Dissertation

**Submitted to the Punjab Agricultural University
in partial fulfillment of the requirements
for the degree of**

**DOCTOR OF PHILOSOPHY
in
AGRICULTURAL METEOROLOGY
(Minor Subject: Agronomy)**

By

**Shivani Kothiyal
(L-2017-A-10-D)**

**Department of Climate Change and Agricultural Meteorology
College of Agriculture**

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LUDHIANA-141 004**

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CERTIFICATE – I

This is to certify that the dissertation entitled, **“Optimizing productivity of maize under emission based climate scenarios by mid and end of 21st century in Punjab”** submitted for the degree of **Ph.D.**, in the subject of **Agricultural Meteorology** (Minor subject: **Agroonomy**) of the Punjab Agricultural University, Ludhiana, is a bonafide research work carried out by **Shivani Kothiyal (Admission No. L-2017-A-10-D)** under my supervision and that no part of this dissertation has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

(Dr Prabhjyot Kaur Sidhu)
Major Advisor
Principal Scientist-cum-Head
Department of Climate Change
and Agricultural Meteorology
Punjab Agricultural University
Ludhiana – 141 004

CERTIFICATE II

This is to certify that the dissertation entitled, **“Optimizing productivity of maize under emission based climate scenarios by mid and end of 21st century in Punjab”** submitted by **Shivani Kothiyal (Admission No. L-2017-A-10-D)** to the Punjab Agricultural University, Ludhiana, in partial fulfillment of the requirements for the degree of **Ph.D.**, in the subject of **Agricultural Meteorology** (Minor subject: **Agronomy**) has been approved by the Student’s Advisory Committee after an oral examination on the same in collaboration with External Examiner.

(Dr Prabhjyot Kaur Sidhu)
Major Advisor

(Dr G.S. Mahi)
External Examiner
Associate Professor (Retd.)
Department of Agricultural Meteorology
Punjab Agricultural University
Ludhiana

(Dr Prabhjyot Kaur Sidhu)
Head of the Department

(Dr Jaskarn Singh Mahal)
Dean, Postgraduate Studies

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Place:

Dated:

(Shivani Kothiyal)

Title of Dissertation : Optimizing productivity of maize under emission based climate scenarios by mid and end of 21st century in Punjab

Name of Student and Admission No. : Shivani Kothiyal
L-2017-A-10-D

Major Subject : Agricultural Meteorology

Minor Subject : Agronomy

Name and Designation of Major Advisor : Dr Prabhjyot Kaur Sidhu
Principal Scientist-cum-Head

Degree to be Awarded : Ph.D (Agricultural Meteorology)

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Punjab, India

ABSTRACT

The study was conducted to analyse the maize yield and phenology under the future scenarios at different zones in Punjab. The CERES-Maize model was used to analyse the yield trend and observe the deviation of yield and phenological stages of two cultivars PMH1 and PMH2 during the mid-century (2021-50) and end-century (2066-95) from the baseline period (2010-2020). The CERES-Maize model was calibrated for the crop data collected under the mandatory trial of the “All India Co-ordinated Research Project on Agrometeorology” during 2018 and validated for the same trial during 2019. The calibration and validation results showed the simulated model results to be close to the observed with a low NRMSE (%) for both the cultivars PMH1 (1, 0.8, 3, 11.7) and PMH2 (0.9, 0.7, 2, 9) for anthesis, maturity, grain yield and LAI, respectively. The yield and LAI showed a polynomial relationship with the sowing window (20th May to 30th June) in Punjab with high grain yield peaks/ LAI during 20 May to 7 June as 5200-6000 kg ha⁻¹/ 2.9-3.2 and 4200-5400 kg ha⁻¹/ 2.8-3.0 respectively for varieties PMH1 and PMH2, respectively. The calibrated and validated model was used to study the future maize yield trend, deviation of yield and phenology from the baseline and optimization practices to avoid the negative effects. The maize yield and phenology of both the cultivars was analysed under the four scenarios RCP2.6, RCP4.5, RCP6.0 and RCP8.5 using the weather data of four GCMs (CSIRO-Mk-3-6-0, FIO-ESM, IPSL-CM5A-MR and Ensemble). The simulated maize yield trend for the current sowing dates showed a strong deviation at agroclimatic zone II (upto 94% and 77%), III (95% and 90%), IV (92% and 88%) and V (92% and 90%) for PMH1 and PMH2, respectively while the maturity for all the zones shortened by 25 days during the end-century under RCP8.5. The optimized sowing window (10th May to 14th July) was evaluated and the results showed the late dates of sowing to perform well at agroclimatic zone II and III while early sowing dates at V (Faridkot). The optimization of nitrogen doses (lower: 65kg ha⁻¹; higher: 185 kg ha⁻¹) showed slight yield increment at higher doses for agroclimatic zone II, III and V (Faridkot). Amongst the four GCMs, the FIO-ESM model overestimated the yield while the CSIRO-Mk-3-6-0 under estimated the yield. The optimization practices if used efficiently can help avoid climate change impact on maize crop in Punjab but only during mid-century under all the scenarios while under RCP8.5 during end-century no yield increment was observed.

Keywords: Maize, RCP scenarios, GCMs, phenology, yield, Punjab

Signature of Major Advisor

Signature of the student

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ਸਾਰ ਅੰਸ਼

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ਮੁੱਖ ਸ਼ਬਦ: ਮੱਕੀ, RCP ਸੀਨੇਰੀਓ, GCMs, ਵਿਨੋਲੋਜੀ, ਝਾੜ, ਪੰਜਾਬ

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CHAPTER I

INTRODUCTION

Maize (*Zea mays* L), one of the most versatile emerging crop has wide adaptability under varied agro-climatic conditions. Globally, maize due to its highest genetic yield potential is known as “Queen of Cereals”. Maize accounts for 9% of total food grain production in the country and is the third most important cereal crop in India after rice and wheat (Panda *et al* 2004). Currently over 170 countries covering an area of 193.7 million ha produce nearly 1147.7 million MT of maize with an average productivity of 5.75 t/ha (FAOSTAT 2020). India ranks 4th in area and 7th in production amongst the maize growing countries which represents almost 4% of world maize area and 2% of total production. During 2018-19 the maize area has reached to 9.2 million ha (DAC 2020) in India. Maize acts as a staple food for humans and as a good quality feed for the animals. It acts as a basic raw material in various industrial products like protein, alcoholic beverages, gum, package, textile, food sweeteners, etc. In India maize is found to be useful as industrial purpose (12%), poultry feed (51%), beverages, human consumption (23%) and seed purpose (1%).

Maize covers an area of 109.2 thousand hectares with a production of 395.9 thousand tonnes in Punjab (Anonymous 2020). Maize is a crop suitable for various soils ranging from loamy sand to clay loam. Organic matter containing soil along with neutral pH is considered good for maize productivity. It is a sensitive crop to moisture stress particularly excess soil moisture and salinity stresses therefore, fields with proper drainage should be opted for maize cultivation. Maize can be sown during different seasons i.e. *kharif*, *rabi*, spring and post monsoon. To achieve higher yield assured irrigation facilities are required at farmer's field during *rabi* and spring seasons. The sowing operation for maize should be completed within 12-15 days during pre-monsoon period while it is vice-versa for rainfed areas where it should coincide with monsoon. Last week of June till first fortnight of July is considered optimum sowing time for maize (*kharif*), for *rabi* 15th November is considered optimum and spring maize can be grown in 1st week of February. Optimum plant stand is the key factor in determining higher productivity and resource-use efficiencies. The seed rate in maize varies depending on the seed size, sowing methods, season, plant type, purpose etc.

Significant yield gaps are evident across various maize growing areas in the country. Within the simulated attainable and actual yield there is wide ‘management yield gaps’ (36 to 77%) in South Asia. These gaps are ascribed mainly to three major factors, namely low yielding genotypes, inappropriate nutrient application and poor crop establishment. Today, increasing maize productivity, production and resource utilization are not the matter of choice but a necessity due to higher population pressure (Waongo *et al* 2015).

Climate change has become a major concern of today's world and it is sufficiently contributing in reshaping or altering the earth's ecosystem. The climate change has always been a constant process but with the increasing variant earth and human activities this process has sped up manifolds. Intergovernmental Panel on Climate Change (IPCC) defines the global warming on the basis of 30-year period average and determines the human activities to cause approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C-1.2°C (IPCC 2018). The current rate of increased global warming determines it to reach 1.5°C between 2030 and 2052. If climate change continues to occur without any strategy adapted then it projects to a strong impact on crop productivity. The annual report of Weather, Climate and Catastrophe Insight determines economic losses of USD 225 billion across the world in 2018 due to natural disasters alone and since 2016 these losses are crossing USD 200 billion per year (Arora 2019). The climate change and agriculture hold an inseparable bond which is being affected due to the ached variations in climate, threatening food security globally. An editorial by Arora (2019) mentions the World Food Programme in 2018 reported that the rate of increasing population is much higher as compared to the increasing crop yield per hectare leading to food shortage. According to the data published by Food and Agriculture Organization (FAO) 2016, the continuation of present condition of GHG emissions and climate change will lead to decline in production of major cereal crops (20–45% in maize yields, 5–50% in wheat and 20–30% in rice) by 2100. If similar trend remains then agriculture will be greatly affected in future with high crop losses followed by decreased food availability to feed the increasing population. In late 20th century temperature increase by 2°C or above it would have a negative impact on some of the major crops like wheat, rice and maize in temperate as well as tropical regions while in individual locations it shows medium confidence (IPCC 2014). In rainfed areas a single increase in degree-day over 30°C will decrease the yield by 1% while 1.7% decrease will be seen in Africa where drought persist (Lobell *et al* 2011). According to IPCC (2014) Southern Africa and Sub Saharan Africa would have an average crop yield decrease of 18% and 22% respectively under climate change till mid 21st century. Climate and agriculture are strongly co-related, the international policies regarding them are need of the hour and their implementation has to be done at ground level for efficient outcomes. Climate change is occurring at a very fast pace with negative impacts on our ecosystems and their productivity thus it is high time that we prepare ourselves for the further challenges and apply measure to combat the climate change impact along with ensuring food security to all the living beings on earth.

Global Circulation Model (GCM) is used to simulate general circulation of planetary atmosphere or oceans as the term general circulation indicates large-scale atmospheric or oceanic motions with its persistent and transient features on various scales. The GCM

employs a combination of mathematical calculation governing the physics of circulation processes and empirical calculations which are used to replicate processes based on data. Atmospheric and oceanic circulation involves complex processes which are difficult to model thus many assumptions are taken into account while representing these processes in the model. GCMs model planetary atmospheric processes, oceanic and land surface processes known as atmospheric, oceanic and land surface GCMs respectively. Processes of atmosphere, oceans and several other components like biosphere, hydrosphere and cryosphere interact to drive the climate on Earth. Modelling a climate system requires coupling of various GCMs so that components that model sea ice and other key planetary processes can also be included. Coupled GCMs are known as Global Climate Models (GCMs).

Plausible descriptions of future evolution with respect to socio-economic change, technological change, energy and land use, emission of greenhouse gases and air pollutants is possible with socio-economic and emission scenarios that are being taken up for climate research. These scenarios when used as climate model inputs, help in assessment of possible climate impacts, their mitigation options and associated costs. Easier communication of the results and better comparisons is possible with the use of common set of scenarios across the scientific community. Previously, such role has been performed by several set of scenarios which includes the IS92 scenarios (Leggett *et al* 1992), the Special Report on Emission Scenarios (SRES) (Nakicenovic and Swart 2000) and currently the Representative Concentration Pathways (RCPs) (vanVuuren *et al* 2011). Scientists use these four emission scenarios to describe how greenhouse gas emissions could evolve between 2000 and 2100, depending on various hypothesis. The results of the various climate models can be indispensably compared using these scenarios. As per projection for 2021-2050 13.3%-21.5% increase in the average precipitation annually in respect of baseline that is 1961-1990 is indicated while precipitation during winter season is projected to decrease. Till 2021-2050, the mean for maximum temperature on annual basis will have an increase of 1.0-1.8⁰C while mean for minimum temperature annually will have an increase of 1.9-2.1⁰C for Punjab as per Punjab State Action Plan on Climate Change (2012). A1B greenhouse gas scenario as per IPCC indicate the rapid increase in growth due to the efficient technologies introduced globally which would also consider the solutions for sustainability on local basis (Kang *et al* 2009). There is a current need of new scenarios for the research community as determined by Moss *et al* (2010). As per vanVuuren *et al* (2011) primarily the current climate models require more detailed information for better performance than provided by the previous scenarios. Secondly, scenarios that explore the impact of different climate policies are required in addition to the previous one SRES (no-climate-policy scenarios). An innovative

collaboration between integrated assessment modelers, climate modelers, terrestrial ecosystem modelers and emission inventory experts provide the RCPs, a comprehensive dataset with high spatial and sectoral resolutions for the period extending to 2100. The development process of the RCPs includes the calculation of future policies and emissions that would lead to specified radiative forcing. RCPs differ from the previous scenarios (SRES) as their beginning is with the atmospheric concentrations of the GHGs rather than the socio-economic processes. This is important because every modelling step from a socio-economic scenario to climate change impacts adds uncertainty but as RCPs start with concentrations the uncertainty is reduced due to lesser steps to impact. The four RCP scenarios are RCP2.6 (low-emission scenario), RCP4.5 and RCP6.0 (stabilization scenario) and RCP8.5 (high-emission scenario). These RCPs include policies, adaptation and mitigation strategies to reduce climate change. The RCPs generally show decreasing emission trends for air pollutants that are determined by changes in use of fossil fuels and fertilizer and assumed air pollution control and climate policy. vanVuuren *et al* (2011) describe the RCP8.5 as a no-climate policy and high population where the CH₄ and N₂O emissions show an increasing trend, for RCP2.6 the emissions are projected to reduce by 40% and RCP4.5 and RCP6.0 are considered to stabilize the emissions during the century.

DSSAT (Decision Support System for Agrotechnology Transfer) was developed by a group of scientists in the International Benchmark Sites Network for Agrotechnology Transfer project (IBSNAT 1993; Tsuji 1998; Uehara 1989; Jones *et al* 1998). This package of models has been developed to contribute a systematic approach to agronomic researchers where various crop models can be used to simulate growth and development of crops as a function of soil, weather and management conditions. The framework is such that first through research the system and its functions is understood which is further integrated in model to predict the results, once the model is able to simulate the real world precisely, hundreds and thousands of computer experiments can be performed to obtain the best management system. Jones and Kiniry (1986) gave a crop simulation model named CERES-Maize which can simulate the yield and analyse the growth process along with the phenology of crop keeping the various environmental factors (soil factors, weather factors and management operations) in view. The processes that can be modelled consider the growth duration during different stages, vegetative and reproductive development, leaf and stem growth, production, partitioning of biomass to different plant parts, leaf senescence and dynamics of root. Simulation of soil, crop water and nitrogen balance, which is capable of simulating effects of deficient nitrogen and soil water on photosynthesis and carbohydrate distribution in crops, can be done using subroutines included in model.

The CERES-Maize model takes weather data, soil data and management data as input. The weather data in models consist of solar radiation, maximum and minimum temperature and rainfall, soil data consist of the drainage, runoff, evaporation and radiation reflection function, water holding capacity of soil, initial soil water and rooting preference coefficients and management data will consist of date of sowing, population of plants in the field, fertilizer and irrigation amount to be applied, etc.

Temperature is one of the weather variables which has a major effect on the rate of development in CERES-Maize model. In this the response of various genotypes can be characterized by coefficients which modify the thermal time period for each phase. Since the climate change scenarios consider the rise in temperature as an inevitable change so the model can provide an insight to the direction in which the phenological development, growth and yield of maize plant would alter. Thus, these models can be considered for analysis on regional basis and for simulating the changes that might occur in various regions under changing temperature and precipitation.

Therefore, the present study was planned to scrutinize the changes in maize crop growth, phenological development and yield under four scenarios of climate change during the 21st century in Punjab state with the following objectives:

- To generate downscaled future climatic scenarios upto end 21st century in Punjab.
- To predict the changes in growth duration and yield of maize by the mid and end 21st century in Punjab.
- To evaluate the management practices in maize under changing climatic scenarios in Punjab.

CHAPTER II

REVIEW OF LITERATURE

The review of literature pertaining to the problem is given below under the relevant headings:

2.1 Climate change

2.1.1 Historical climate change

2.1.2 Current scenarios of climate change

2.1.3 General Circulation Models (GCMs)

2.2 Crop simulation models (CSMs)

2.2.1 Decision Support System for Agrotechnology Transfer (DSSAT)

2.2.2 DSSAT CERES-Maize model

2.2.3 Calibration and Validation

2.3 Projected Changes in growth duration and yield of maize

2.4 Optimization of management practices in maize under climate change

2.1 Climate change

Climate change poses greatest threat to human beings in social, environmental as well as economic terms. The climatic variables have a direct influence on agriculture as all the physiological processes of the plants are linked to climate inputs. The alterations in temperature and precipitation pattern have an influence on the crop water cycle as it changes the growth period, photosynthesis ability and respiration pattern which ultimately leads to stress on crops and food security (Tao *et al* 2003a, b). Studies represent a substantial reduction in yield of crops under a temperature change upto 2°C during the dry seasons (Lobells *et al* 2008; O'Neill 2007). Mall *et al* (2004) depicted through a study on soybean productivity that under the future climate change, the agricultural production is predicted to be influenced by the changes in growth and transpiration pattern of crops. The rate of development and crop efficiency will also be influenced leading to shorter crop cycle. The physiological processes of crops such as respiration, photosynthesis and photoassimilate partitioning will suffer due to the increasing temperatures (Chartzoulakis and Psarras, 2005; Yang and Zhang, 2006).

2.1.1 Historical climate change

Climate change has been a major issue since a long time and still remains a challenge for the countries, government and citizens. The socio-economic status of the people is influenced by the increasing population, depleting resources and changing lifestyle resulting in a global challenge to reduce climate change but maintain the social and economic status of the

country. The changes in the rainfall and temperature pattern of the world are affecting the agricultural production and water resource availability.

Narain *et al* (2009) researched to find that after years of protracted negotiations the countries of the world agreed to Kyoto Protocol during late 1990s under which the industrialized world decided to cut down emissions by 5.2% of 1990s by 2008-12. UNFCCC (2007) under a review found the industrialized countries whose economy was in transition to have a decline in CO₂ emission by 1.3% during 1990-2006 while those without economic transition saw emission increase by 14.5%. It is very difficult for the developed countries to control their emission which has resulted in the major power USA to walk out of this global agreement and similar circumstances are being faced by the European countries. The only countries found to decrease CO₂ emissions include Sweden, UK and Germany (Narain *et al* 2009). India faces the challenge of improving its per capita energy use, thus improving the human development level. Large part of the Indian population still rely on traditional cook stoves and millions have no access to electricity thus making it difficult for this fast economy to combat emissions and improving energy availability.

Several studies by the scientists across the globe regarding variations in temperature and rainfall have been done to understand the severity of climate change and its impact. (IPCC, 2013) determined an increase of 0.89°C (0.69-1.08°C) in combined land and ocean temperature globally during the period 1901-2010. Various researchers worldwide have contributed in climate change study based on long term analysis of climate change.

Longobardi and Villani (2010) did a statistical analysis of the database for annual and seasonal rainfall trend over the Mediterranean region using parametric t-test and the non-parametric Mann-Kendall test and determined it to be negative for both the annual and seasonal scale except for the summer period where it was positive. They also detected the trends to appear extremely severe during the last 30 years. Scientists in various parts of the world reported a rising trend in maximum temperatures. However to know and understand the impact of regional scenarios local study of rainfall and temperature regimes is required.

Opiyo *et al* (2014) studied rainfall and temperature variability trend over Turkana, Kenya and found significant rise in both maximum and minimum temperature from 1979-2012 which were according to the predictions made by IPCC.

Kothawale *et al* (2010) studied recent trends in pre-monsoon daily temperature extremes over India and found the pre-monsoon season (March–May) to be the hottest part of the year over almost the entire South Asian region, in which hot weather extremes including heat waves are recurring natural hazards having serious societal impacts, particularly on human health. The time series analysis over a network of 121 stations for the period 1970-2005 depicted significant increase in hot days and hot nights for East Coast (EC), West Coast (WC)

and Interior Peninsula (IP) whereas significant decrease in cold days and cold nights for Western Himalayas (WH) and West Coast (WC). For India as whole, the frequency of hot days and nights showed increasing trend while cold days and nights showed decreasing trends.

Mondal *et al* (2012) used Mann-Kendall (MK) Test and Modified Mann-Kendall Test along with Sen's Slope Estimator to determine the trend and slope magnitude of monthly variability of rainfall for daily rainfall data of 40 years from 1971 to 2010 of a river basin in Orissa (agricultural and cultivation zone of the area). Overall insignificant changes were suggested by the researcher with rising rates of precipitation in some months and decreasing in other.

Dash *et al* (2013) studied changes in rainfall and temperature patterns at four cities and corresponding meteorological subdivisions over coastal regions of India. The analysis was done based on observed gridded datasets from the India Meteorological Department (IMD) and climate projections from nine IPCC models. The gridded datasets determined the rise in annual mean temperature at 1% significant level during 1969-2005 in Kochi and its subdivision indicating strong warming while at Madurai this warming is weak. At Howrah and Vishakhapatnam no strong warming was indicated. The projected data depicted the mean temperature to rise strongly in the coming 30 years at Vishakhapatnam, Madurai and Kochi at 1% significance whereas weakly at Howrah. Paul *et al* (2015) studied trends for four agroclimatic zones of India and determined an increase in mean temperature on annual basis as well as during winter for a period 1901-2004 for all four zones.

Kumar *et al* (2015) did a study over mid Himalayan regions during 1985-2012 and determined a positive trend at Salooni ($1.1^{\circ}\text{C}/\text{decade}$) of mean annual maximum temperature while a negative trend at Ranichauri ($0.4^{\circ}\text{C}/\text{decade}$) of mean annual minimum temperature and an increasing trend at Shimla (22mm/year) of rainfall.

Hundal and Prabhjyot-Kaur (2002) conducted a study for different locations in Punjab (Ballowal Saunkhri, Amritsar, Ludhiana, Patiala and Bathinda) for a period of 1970-1998 and found the rainfall to show an overall increase for all the locations.

Prabhjyot-Kaur *et al* (2006) observed a slight decreasing and increasing trend in annual *kharif* and *rabi* season, respectively during 1970-2004 while the minimum temperature saw a significant increase of $0.07^{\circ}\text{C}/\text{year}$. A large variation in rainfall was indicated by high standard deviation and coefficient of variation by the annual as well as seasonal rainfall.

Prabhjyot- Kaur and Hundal (2008) noticed no significant trend in increase/decrease of rainfall at all the locations during the period from 1999 to 2005. During this period however, Ballowal Saunkhri saw a significant decreasing trend in rainfall.

Prabhjyot-Kaur *et al* (2013) studied variations in maximum, minimum temperature and rainfall for the past four decades at different agroclimatic regions of Punjab. The rate of change in mean annual maximum temperature observed at Ballawal Saunkhari, Ludhiana, Patiala and Bathinda was 0.05, -0.03, 0.01 and -0.02 °C per year while for annual minimum temperature at Jalandhar Patiala and Bathinda was 0.05, 0.02, 0.02 °C per year, respectively. Amritsar district showed no significant increasing/decreasing trend in minimum and maximum temperature.

Paul *et al* (2014) analysed the trends of meteorological parameters over Punjab (Amritsar, Patiala and Ludhiana) and Haryana (Ambala, Hisar and Chandigarh) for the period 1980-2010. They indicated the maximum temperature to increase higher over Punjab than Haryana and the diurnal range of temperature and annual rainfall indicated a decreasing pattern at all locations except Ambala and Chandigarh respectively.

Prabhjyot-Kaur *et al* (2016) analysed the temperature trends over four decades in different agroclimatic zones of Punjab. They observed the maximum temperature to show an increasing trend at Ballawal Saunkhari, Ludhiana and Patiala and a decreasing trend in Amritsar and Bathinda while the minimum temperature indicated an increasing trend for all locations. On annual basis the 9 diurnal range of temperature significantly decreased at Ludhiana and Bhatinda and on seasonal basis at all locations except Ballawal Saunkhari.

2.1.2 Current scenarios of climate change

Characterization of uncertainty in complex human and environmental interactive systems has been done using scenarios which are considered to be a key component in global change research for four decades. They help in exploring the evolution of future under alternative conditions and how desirable outcomes could be achieved and undesirable avoided. Scenarios provide good opportunity in global climate change research. They provide a small set of common climate change and societal features that can be used by various research communities (O’Niell *et al* 2020).

The greenhouse gas concentrations, aerosols and other pollutants present in the atmosphere are described by the emission scenarios which may be released by natural or artificial source. They also provide information regarding the land use and cover. The SRES (Special Report on Emission scenarios) have been mentioned as the baseline or reference scenarios without considering any current or future techniques. Various approaches have been used to generate scenarios regarding climate research over the disparate times which vary from schematic representations used for indicating increase in average greenhouse gas emissions to representation of particles affecting climate which have been derived keeping socio-economic and technical assumptions in mind. These scenarios were generated approximately 15 years ago.

IPCC during their fifth assessment report in 2014 adopted Representative Concentration Pathway (RCP) which is not their emission pathways but they represent actual greenhouse gas concentrations. They used these four pathways in earth-system modelling which was used for determining projections and studying climate change. These pathways have been driven in accordance with the estimated volume of greenhouse gases to get emitted in the future years and they describe different climates in future. The four RCPs being used for the studies are RCP 2.6, RCP 4.5, RCP 6.0, and RCP 8.5 which are considered to cause radiative forcing of 2.6, 4.5, 6.0 and 8.5 W/m², respectively during the year 2100.

Deb *et al* (2015a) researched on the future climate change at Gangtok site in Sikkim, India in which they evaluated six GCMs (ECHAM5, CCSM, HadCM3, CSIRO-MK3.0, CGCM3.1 and MIROC3.2), out of which the best GCM (HadCM3) was selected based on the statistical results and was further considered for impact assessment. The downscaled climate variables were analysed and they represented an increase in average annual maximum temperature by 1.91⁰C and 1.59⁰C for A2 and B2 scenarios, respectively for the 2085s period relative to 1995s (baseline). The minimum temperature represents a higher increase for the scenarios considered by 1.98⁰C and 1.74⁰C respectively and precipitation is predicted to reduce by 1.7-22.6% for the considered scenarios and time periods relative to the baseline (1995s).

Deb *et al* (2015b) continued to investigate the future climate change and its impact on the productivity of rainfed maize at three locations (Geyzing, Gangtok, and Mangan) of Sikkim state in India using the same GCMs as above. The future weather data obtained was bias-corrected using the power law transform technique for refining the data spatially at station scale. Bias-corrected data was used to study the impact and it indicated an increase up to 1.98 and 1.85 °C for maximum temperature and 2.31 and 1.96 °C for minimum temperature during 2085 under A2 and B2 scenarios, respectively. The average annual rainfall for Geyzing and Gangtok showed a significant reduction with maximum decline during 2085 of 22.6 and 19.5% for A2 and B2 scenarios, respectively. Under the corresponding scenarios and time period the Mangan station determined an increase of 11.4 and 12.4% in precipitation.

Kaur (2016) studied the minimization of biasness in PRECIS modelled data of maximum and minimum temperature and rainfall for Ludhiana. Corrective functions for three corrective methods were developed and validation was done for bias minimization. The bias corrected projections revealed an increase in the maximum and minimum temperature under A1B, A2 and B2 scenarios by mid and end of 21st century. Higher rainfall in comparison to baseline was projected for the mid and end 21st century.

Prabhjyot-Kaur *et al* (2017) conducted a study to show a rise in the maximum and minimum temperature under different scenarios of climate change and at different agro-climatic zones of Punjab. An increase in maximum and minimum temperature and rainfall was seen

between 2.0 to 2.2°C, 3.3 to 5.4°C and 33 to 66%, respectively in zone II (Ballawal Saunkhri); in zone III (Ludhiana, Amritsar, Patiala and Jalandhar) by 0.4 to 5.8°C, 2.5 to 7.4°C and 3 to 62%, respectively and zone V (Bhathinda) by 0.5 to 4.0°C, 4.7 to 7.7°C and 58 to 69% respectively.

The IPCC felt a need of development of new scenarios and asked the scientific community to update and expand the existing published scenarios (SRES) in the Special Report on Emission Scenarios (Nakicenovic and Swart, 2000). This led to development of new pathways which were more detailed and they provide an important input for decadal and long term projections of climate change in climate model experiments. These pathways are known as Representative Concentration Pathways (RCPs). These RCPs are designed to include a range of radiative forcing levels which on examination contain relevant information regarding climate model runs (van Vuuren *et al* 2011).

The fifth Assessment Report of IPCC (2013) represented an increase by 0.85°C in land and ocean temperature over the 1800-2012 period and an increase of $0.74 \pm 0.18^\circ\text{C}$ has occurred during the last hundred years (1800-2012). The GCMs predict an increase in temperature in various countries where South Africa under current climatic conditions would have a temperature increase of 0.6 to 1.4°C by 2030 while Zambia is already experiencing a temperature increase of 1.3°C since 1960. The rainfall has depreciated across Zambia by 2.3% per decade from a period 1960-1990. A warming between 2.4-4.3°C will be experienced relative to 1961-1990.

The IPCC (2013) reported an increase in the total radiative forcing by 43% in IPCC Assessment Report5 (AR5) over AR4. According to IPCC AR5, a temperature increase of around 0.74°C has been seen during the last century (1906-2005) according to IPCC AR5 (IPCC 2013). Mahmood and Babel (2013) confirmed the well reporting of likely increase in global warming trends during the 21st century through Representative Concentration Pathways (RCPs). Relative to 1980-2005, the projected values of increase as per IPCC (2013) is 0.3-1.7°C (RCP 2.6), 1.1-2.6°C (RCP 4.5), 1.4-3.1°C (RCP 6.0) and 2.6-4.8°C (RCP 8.5) for 2081-2100. In recent years the changes occurring from 2003-2012 with respect to 1850-1900 show an alarming increase of 0.78°C (0.72-0.85).

Houghton *et al* (2001) explained that the four “families” of emission scenarios developed by IPCC are required because the future greenhouse gas concentration depend on the future social, political and technological decisions. Cayan *et al* (2008) investigated the diverse set of possible climates in California during 21st century to provide context and drivers for evaluation of impact on a variety of sectors. The main aim was to study the surface climate variables that are temperature and precipitation and immediate implications for snowpacks and runoff in the state. The projections as simulated by GCMs were analysed and among these as

well as among all other IPCC projections, the 21st century saw a significant rise in temperatures. The extent of projected warming differs from model to model and after the middle of 21st century these projections vary from emission scenario to emission scenario. The rise in temperature of California as per study between 2000 and 2100 was by 1.7-3.0°C in the lower range, 3.1-4.3°C in the middle range and 4.4-5.8°C in the higher range of projected warming.

Wada *et al* (2013) studied the global climate change impact on irrigation water demand (IWD) in currently irrigated areas by the end of this century using a set of seven global hydrological models (GHMs). He also assessed the uncertainties that would occur due to these GHMs and climate projections. Although the ensemble predictions depict an increase in future IWD but this increasing trend variation depends on the degree of global warming and regional precipitation changes. The highest greenhouse emission scenario (RCP 8.5) shows an increasing IWD (>20% by 2100) during the summer in Northern Hemisphere. GCMs as well as GHMs give rise to large uncertainties and the uncertainties in case of GCMs increase from the mid century thus influencing the choice of GCMs and associated emission scenarios.

Tesfaye *et al* (2017) found the major climate risks pertaining to the crops of Bihar to be heat stress during rabi (winter) due to an increase in the minimum temperatures, high minimum and maximum temperatures during spring season and intense rainfall along with longer dry spells in the *kharif* (monsoon) season. Though the extended crop periods along with increased annual and seasonal rainfall provide good opportunities during *kharif* season but increasing temperatures across the state have negative consequences on the staple crops affecting their phenology, physiology and plant-water relations.

Shafiq *et al* (2019) analysed the projections for the Kashmir Himalayas under different RCPs to reveal an increasing trend at all stations for both mean maximum and minimum temperatures. The mean maximum and minimum temperatures showed the highest increase under RCP8.5, under RCP2.6 an increase of 0.3-0.9°C was seen and an increase of 0.2-0.8°C was seen under other scenarios. For maximum and minimum temperatures an increase of 0.7-2.3°C and 0.2-1.9°C, respectively is seen under RCP8.5. The study was conducted to have an insight of the future climate scenario and it determined a temperature and precipitation increase from 2030s to 2090s in comparison to baseline from 1980-2010.

Dar *et al* (2019) averaged the data for rainfall, maximum and minimum temperature of Ludhiana district in central Punjab for the last 46 years which were 759.7mm, 29.7°C and 16.6°C, respectively. The climate predictions as per their study revealed an increase of 1.56°C and 3.11°C in mean annual temperature and decrease in rainfall of 97.5mm (12.8%) and 89mm (11.8%) under RCP 4.5 for mid and end century, respectively. Under RCP 8.5, an increase of

2.75⁰C and 5.46⁰C in mean annual temperature and by 153 mm (20%) and 251mm (33%) in rainfall was seen during mid and end century, respectively.

Kaur (2020) performed the study on the predicted data by various GCMs for 7 locations of Punjab. On the basis of the statistical properties determined for maximum and minimum temperature, rainfall and solar radiation, amongst the 17 GCMs three GCMs that are CSIRO-Mk3-6-0, FIO-ESM, IPSL-CM5A-MR and one ensemble model was selected for analysing the climate change conditions in Punjab. The corrected data was further analysed to depict an increase in hotter days and warm nights at the end of 21st century on annual/seasonal/monthly and weekly basis in Punjab. The projections reveal the maximum temperature to rise from 29.8-31.3⁰C (baseline) to 30.5-31.6⁰C, 31.8- 32.8⁰C, 31.6-32.6⁰C and 33.6-34.7⁰C for RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively while the minimum temperature is projected to rise from 15.5-20.3⁰C (baseline) to 17.8-19.1⁰C, 19.0- 20.2⁰C, 19.2-20.5⁰C and 21.1-22.4⁰C for RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively during the end century. The northern and central part of the state is predicted to see a decrease in rainfall while the extreme weather events will increase under the four RCPs.

2.1.3 General Circulation Models (GCMs)

The United Nations National Program on Climate Change in 2001 published the Third Assessment Report for which the scientists created a series of economic development scenarios and used four major GCMs for estimation of anthropogenesis-forced climate change. These were the Special Report Emission Scenarios (SRES) and the GCMs are used to produce worldwide grids of predicted monthly temperature, cloud and deviations in precipitation for the period 1961-90.

Wilby *et al* (2004) recommends the technique of spatial and temporal downscaling in combination for obtaining GCMs projections for temperature and precipitation for local climate studies. In order to avoid missing the local meteorological, topographical and circulatory phenomena which is present at the meso- or microscale, the synoptic data produced by the GCMs need downscaling. This is a quantitative method where regressing of modelled and observed weather data is done for the 20th century and correlations are determined which are then applied to modelled 21st century synoptic scale data. The GCM output is widely obtained from The Intergovernmental Panel on Climate Change (IPCC).

Several simplified categories of downscaling methods are present which can be divided on the basis of usage of mathematical or technological methods in them. (Zhang *et al* 2004;Woznicki *et al* 2011; Joh *et al* 2011) discussed Delta-change or change factor methods which involve linear scaling of 21st century outputs for GCMs on the basis of the absolute difference between the historical micro-scale observations and the modelled synoptic scale observations for the 21st century for each variable independently. (Zhang 2005; Sheshukov *et al*

2011) studied the Transfer function methods which operate similarly to change-factor methods, but this method uses non-linear relationships to scale historical data relative to synoptic-scale GCM output. (Kendon *et al* 2010) High quality downscaled data can be obtained through mesoscale Regional Circulatory Model coupling or artificial neural networks but such cutting-edge computer modelling requires computational, financial as well as skilled human resource which is prohibitive to most of the institutions.

Various scientists consider that the comprehensive impact assessment of climate change is possible with the use of multiple GCMs under multiple greenhouse gas forcings because the chaotic nature of the atmosphere is unpredictable by a single model and its results are unreliable. Wilby *et al* (2004) mentions the acknowledgement of IPCC for the impact studies that were traditionally restricted to single locations and climate scenarios to advanced statistical measures and computer software. The methods involved in downscaling of data requires time for their learning as well as their applications and their absence from literature makes it challenging for those with limited knowledge of statistical or programming skills. Statistical downscaling methods indicate balance between spatial resolution and resource requirements but the steep learning curves require time for producing data for a particular location. Downscaling of GCM output is possible with updated GCMs and emission scenarios released by IPCC, every few years with new iteration of the IPCC assessment report (Mearns *et al* 2003; Wilby *et al* 2004; Chiew *et al* 2009, 2010).

2.2 Crop simulation models (CSMs)

Crop production and resource management involves crop models widely for operational or strategic research and decision support tools. Crop models are currently being implied for studying the impact of climate change on crop production as a result of rising greenhouse gases (Rosenzweig and Liverman, 1992; White *et al* 2011). Crop models have played an important role in optimization of resource management as a study in Zimbabwe by Mupangwa *et al* (2011) on Agricultural Productivity Simulator (APSIM) model focused on understanding the long-term effects of conservation agriculture on the productivity of smallholder systems. The experiment suggested the optimum time and amount of fertilizer application under the semi-arid conditions of Zimbabwe and also it focussed on the importance of seasonal weather forecasts which would help farmers in acquiring the adequate amount of inorganic fertilizer for wetter seasons. The models are an efficient tool used to simulate the growth, development and yield of crop based on the weather, soil, genotype and management data. These help in improving our understanding of the crop-environment relationships (Crout *et al* 2014). Different crops require different models so various models developed for the crop modelling studies include DSSAT (Jones *et al* 2003), APSIM (Keating *et al* 2003), AquaCrop

(Vanuytrecht *et al* 2014) and STICS (Brisson *et al* 2003). These models work as an efficient tool in different fields which involve management of irrigation and fertilizer (nitrogen)

Asseng *et al* (2002) simulated grain protein content using validated APSIM-N wheat model for soil water, soil nitrogen, crop phenology, biomass production and yield. Under very high or very low nitrogen input conditions along with the terminal drought, the grain protein simulations have been very poor as proved by the previous studies. The scientists change the grain protein routine and tested it across field data sets under a number of growing conditions and confirmed its good performance with Root mean squared deviation (RMSD) which is consistent across different environments and soil types. To study grain protein interaction this improved model was found to be reliable and robust enough to be used in specific simulation experiments in different regions.

de Wit and van Diepen (2007) researched on improvement of regional crop yield forecasts using Ensemble Kalman filter (EnKF) by assimilating the crop model data. The study area consisted of Germany, France, Spain and Italy and the problem was with the uncertain spatial and temporal rainfall distribution in crop yield simulations which caused major error in simulated results. Crop model simulations were done for the study for the period 1992-2000 and evaluation of results was done using regression with crop yield statistics at national and regional level. The results clearly indicated an improved relationship between soil moisture estimates (SWI) and crop yield statistics for winter wheat for majority of regions (66%) where relationship was established while for grain maize this improvement was less evident as improved relationship was found for 56% of the regions. This may be due to the non-inclusion of irrigation in the model thus the author suggests an addition of sources of error in the simulations and observations.

Araya *et al* (2010) used FAO AquaCrop model version 3.0 to validate and simulate the barley biomass and grain yield under various water inputs and planting dates because improvement in water use is vital in arid and semi-arid regions of Ethiopia. Independent data sets for the cropping seasons of 2006, 2008 and 2009 were used and evaluation of optimal planting date was done for the crop. Out of the tested dates of planting July 4 (early sowing) was found to maximize the biomass, grain and water use efficiency for barley. The experimenter used the model to evaluate irrigation strategies and found the crop to perform slightly lower under mild stress condition.

Asseng *et al* (2012) studied the optimization of nitrogen fertilizer based on the seasonal forecast using APSIM model which helped in taking management decisions for the farmers according to the rainfall season types in Australia.

He *et al* (2012a) used DSSAT-CERES maize model to study the best management practices for nitrogen and irrigation application in sweet corn under sandy soil condition of

Florida. He used carefully calibrated and evaluated Ceres- maize model (He *et al* 2009; He *et al* 2010; He *et al* 2011) to determine the strong influence of irrigation frequency and amount on yield of corn. More Nitrogen application led to more leaching that is why on application of nitrogen even after 168 kg ha⁻¹, simulated dry matter yield remained approximately 3.4 Mg ha⁻¹ with no increase in yield with increasing nitrogen application. The trend of increasing N leaching with more frequent and small irrigation depth occurred because less rainfall could be stored when soil moisture content was high. More N applied resulted in more being leached. The scientists observed an increase in nitrogen leaching from 82 to 266 kg N ha⁻¹ when the application was increased from 196 to 561 kg N ha⁻¹. The results confirmed that small application rates (e.g. 5 or 10 kg N ha⁻¹) would increase the fertigation events which were impractical for sweet corn so the application rates of 30-50 kg N ha⁻¹ were fixed. Small application rates decreased the leaching. Though in sweet corn grown in sandy soils, the loss of nitrogen is inevitable with periodic heavy rainfall but CERES-Maize does provide an economical and convenient way to solve the problem. The model provides useful interactions between the crop, soil, weather and field management strategies but the results obtained depend on many model assumptions so application of results sometimes become difficult.

Thorp *et al* (2012) estimated the crop biophysical properties using remotely sensed data by inverting linked radiative transfer and ecophysiological models. Past studies determine that crop yield and LAI estimates can be improved by taking remote sensing observations as the basis for model inversion. The study shows usefulness of model inversion through linking of radiative transfer and ecophysiological models like PROSAIL and DSSAT-CSM. This inversion of linked models provide good estimates of LAI, canopy weight, plant nitrogen content and crop yield in comparison to model alone.

Angulo *et al* (2013) worked on calibration strategies of model to assess the regional impacts of Climate Change in Europe. This study focusses on the importance of crop model calibration for enhanced assessment of climate change impact on crop yield on regional scale. Calibration on regional level does affect the model simulations for climate change impacts on yield thus calibration with region-specific data improves the regional projections of crop models. Proper calibration requires crop growth and development data for the entire region which is not sufficiently available. The study confirms the earlier results of considering not only the changes in weather variables but also the rising levels of atmospheric CO₂ and technology development for the future yield predictions. The climate change studies require an extension for a large range of crops because different crops respond differently and also ensemble climate change scenarios result in a range of yield responses which are more pronounced under the considered technology development.

Fan and Shibata (2014) did a study on spatial and temporal analysis of hydrological provision ecosystem services for watershed conservation planning of water resources. Spatial planning requires precise information on the local potential for providing water yield in a watershed. The results found that sustainable management planning of water resources and their hydrological ecosystem could be achieved by using a combination of hydrologic and cost zonation models.

Jeuffroy *et al* (2014) conducted a study on usage of agronomic model in predicting the cultivar performance in various environments and cropping systems. A diversity of crop management systems with various cultivars and specific characteristics are preferred due to the diversity of growing conditions and the development taking place for the new outlets in agriculture. Genotype performance is usually assessed through multi-environment trials comparing a variable number of genotypes grown in a wide range of soils, climatic conditions and cropping systems. Agronomic models are good simulation tool for evaluating and predicting the dynamic response of crops to their environment and thus techniques which modify it. The paper reviews to confirm that to take well account of farmer's practices, one requires a diversity of model which can vary from being based on physiology to agroecology based cropping systems or landscape models.

Martinez-Ruiz *et al* (2021) performed an experiment on global sensitivity analysis and calibration by differential evolution algorithm of HORTSYST crop model for fertigation management in University of Chapingo, Mexico and determined the global sensitivity analysis based on Sobol's method as the best for deciding the most influential parameters in the HORTSYST model. This procedure helped in reducing the parameters from sixteen to nine and these had temporal variation in their sensitivity which could be explained by each development stage of the crop. The parameter estimation for each crop period was required because the climatic conditions varied in the crop cycles. The deviation between simulated and observed values was minimal thus determining the accuracy of the model predictions. The HORTSYST model consists of a simple mathematical structure and because it has reduced number of influencing parameters (sensitivity analysis), good accuracy in prediction during calibration and validation, its application for irrigation and nutrient management in intensive crops is feasible.

2.2.1 Decision Support System for Agrotechnology Transfer (DSSAT)

Model, in general is a representation of the real world system; it is an imitation of the real system which improves our understanding of the system, its behaviour, functioning and how it would react to the changing conditions. With time these models have evolved and they act as practical tools for scientists, engineers, planners, managers, and growers, who are responsible for improving management and control of such systems(Hoogenboom *et al* 1992).

Crop growth models are tools that integrate the soils, weather, management, genetics and pest effect on daily growth of the crop and help in gaining insight into their spatial yield variability. The most widely used crop growth models are the DSSAT models which have been designed to simulate the growth, development and yield of the crops along with the changes in soil water, carbon and nitrogen that takes place over the time under a particular cropping system (Jones *et al* 2003). DSSAT has been fulfilling a large range of purposes of the scientists since the past 15 years which include crop management (Fetcher *et al* 1991), climate change impact studies (Alexandrov and Hoogenboom, 2001), sustainability research (Quemada and Cabrera, 1995), and precision agriculture (Paz *et al* 2001, 2003) and is well validated for a number of regions and crops.

DSSAT family includes modules for simulation of different crops, including maize, soybeans, wheat, rice and others. Regardless of the selected plant growth module, DSSAT uses common modules of soil dynamics and soil-plant-atmosphere interactions. The requirements of the model include weather inputs (daily maximum and minimum temperature, rainfall and solar radiation), soils classification, and crop management practices (variety, row spacing, plant population, fertilizer and irrigation application dates and amounts). Opportunities for critical analysis are wide while using the DSSAT family of crop growth models but because it is built for single homogenous field unit, it is difficult for decision support and precision agriculture studies. DSSAT usage for precision agriculture decision support requires automated procedures and related tools to apply crop growth simulations spatially across field-level management zones.

Thorp *et al* (2006) have developed methods that use DSSAT family of crop growth models to understand the causes of spatial yield variability, conduct yield gap analysis for understanding the factors limiting yield and estimating the economic consequences of moving from uniform to spatially variable management. Methodologies on automating the preparation of necessary input files for DSSAT for simulating spatially variable crop development has been achieved and successfully used in wide studies (Thorp *et al* 2006; De Jonge *et al* 2007; Miao *et al* 2006) but still they lack explanation. Mechanistic way of crop models helps in well estimation of the interactions of spatial differences existing in the soil properties and the pest populations along with the temporal stresses on the yield variance within the field. The models once calibrated to simulate the historical yield variability within the field can be further used to develop risk management strategies that can help in balancing the economic losses suffered by the producers with the environmental risks impacting society.

Jones *et al* (2003) explains the importance of the crop models which have become a helpful tool for the conventional researchers who conducted traditional agronomic experiments at particular points in time and space, making the results site and season specific, time

consuming and expensive. This is currently a modern technique that can contribute in improving the agricultural production. The particular crop in the rotation consists of separate module which simulates its phenology, daily growth and development and partition of biomass to different plant parts based on the requirement and supply of soil water, carbon, nitrogen and phosphorous nutrients in response to weather and management conditions. Different versions of DSSAT have evolved in better ways to improve its sensitivity and accuracy of simulation results. (Tsuji *et al* 1994; Jones *et al* 2003) The DSSAT also facilitates simulation of long term rotation experiment with its well developed process-oriented Cropping System model.

2.2.2 DSSAT CERES-Maize model

First version of DSSAT was released in 1989 and it consisted of four crop models that are CERES-Maize (Jones and Kiniry, 1986), CERES-Wheat (Ritchie and Otter 1985), SOYGRO (Wilkerson *et al* 1983) and PNUTGRO (Boote *et al* 1987). Among all these models CERES-Maize continues to dominate, it is in high demand globally and remains the mother-seed of other maize models like APSIM (Keating *et al* 2003) and the CSM-IXIM (Lizaso *et al* 2011). (Jones and Kiniry, 1986) described the CERES-Maize model as a simulation tool to explain the daily phenological growth and development under the influence of environmental factors (soil, weather and crop management). The processes modelled by the tool are the phenological development taking in the crops which include duration of growth stages, growth of vegetative and reproductive plant parts, growth of leaves and stems, leaf senescence, biomass production and its distribution and dynamics of its root system. It also includes subroutines which simulate the soil and crop water balance and nitrogen balance thus simulating the effect of nitrogen and water deficiency on crop growth processes like photosynthesis and carbohydrate distribution. The phasic development is primarily influenced by the temperature variable and the thermal time required for the particular phase which is modified by the coefficients. These coefficients are used as a characterization parameter for different genotype responses.

CERES-Maize module present in DSSAT v4.5 (Hoogenboom *et al* 2010) uses minimum data sets (MDS) (Hunt and Boote 1998) for computation of vegetative and reproductive growth daily as a function of photosynthesis, stage of growth, water and nitrogen stresses.

Basso *et al* (2016) reviewed the CERES-Wheat, Maize and Rice models' performances and determined that the total number of field studies done testing these models were 215, out of which 111 tested the CERES-Maize model, 104 tested the CERES-Wheat model and 26 tested the CERES-Rice model. Validation of the CERES models has been done in 43 countries across all continents, except Antarctica. The intention behind the development of CERES models is its global application under any weather and soil conditions for any cultivar whose genetic

coefficient information is known and does not require calibration in space and time. Often some critical input information is unknown in the models and then it needs to be approximated by various procedures.

Testing of model simulations has been done under varied climatic conditions by a number of scientists like under monsoonal (Liu *et al* 2013), semi-arid tropical (Carberry *et al* 1989), subhumid, subtropical (Behera and Panda, 2009), Mediterranean (Hasegawa *et al* 2000), cold winter, dry summer (Thaler *et al* 2012) and humid temperate (Otegui *et al* 1996). Extensive validation studies of these models have been conducted in the United States (64 studies), China (27 studies) and India (18 studies) under treatments such as varied irrigation and fertilizer amounts, timing and method of application, sowing dates and other altered management practices.

2.2.3 Calibration and Validation

Documentation of various approaches for estimation of cultivar coefficients have been provided however key information is required for a particular cultivar which include planting dates, anthesis, maturity dates and grain yield. Calibration of the time for crop phenological stages is possible by altering the coefficients, characterizing the juvenile phase duration (P1), sensitivity of the photoperiod (P2) and reproductive phase duration (P5).

Anothai *et al* (2008) used a sub module available in DSSAT (v4.5) which is a genetic coefficient calculator (GENECALC) to determine the crop cultivar coefficients of new peanut lines in Thailand. Bannayan and Hoogenboom (2009) used similarity measures based pattern recognition technique for estimation of crop cultivar coefficients in maize.

Hoogenboom *et al* (2010) informed about the generalized likelihood uncertainty estimation (GLUE) module in DSSAT v4.5 for crop cultivar coefficient estimation. He *et al* (2010) estimated the maize cultivar coefficients using generalized likelihood uncertainty estimation (GLUE). The above mentioned approaches require some necessary information regarding the particular cultivar for estimation of crop cultivar coefficients but in case of situations where paucity of data from standard trials occur then repeated field experiments are required. Research and well decision making is possible with accurate estimation of crop cultivar coefficients as it acts as an entry point in dynamic crop model.

Optimization of crop management (MacCarthy *et al* 2012), evaluation of climate change impact (Jones and Thornton 2003), development of options to optimize resource use or development of new crop genotypes (Craufurd *et al* 2013) is possible with a good calibrated crop model.

Jiang *et al* (2011) researched that local applications of crop growth models require prior parameter calibration for accurate results thus the common method of trial-and-error helps

in selecting the combination of parameters through continuous attempts until the model ceases to find the solution. Hsiao *et al* (2009) researched and found this method to be simple but non-effective in case large numbers of parameters are included.

Model parameter estimation has been attempted using various systematic algorithms like simplex method (Inoue *et al* 1998), simulated annealing method (Soldevilla-Martinez *et al* 2014), genetic algorithm (He *et al* 2012a,b), Bayesian methods (Ceglar *et al* 2011), and the particle swarm optimization method (Li *et al* 2015).

This GLUE method has been integrated into the DSSAT software as a tool of crop cultivar coefficient determination for different crops and it considers the cultivar parameters related to crop growth stages and grain characteristics. These are important for crop growth and development and they also guide in field management strategies (Hoogenboom *et al* 2010, He *et al* 2010).

Fraisse *et al* (2001) made historical use of crop simulation models has been for prediction of average crop development and yield under altered weather and management scenarios. The research aimed to test the latest version of CERES-Maize which has been modified to simulate site-specific crop development and yield in seven monitoring sites in Central Missouri. The results depicted that modifications done to simulate root growth and development were important for soils with high-clay restrictive layer such as the claypan soils. The yield variability was well simulated by the model but the simulated leaf area indices were below the measured values at five monitoring sites which suggest a model improvement. Accurate simulation for the area was possible if the effect of other processes such as run-on or subsurface flow was taken into consideration.

Liu *et al* (2011) evaluated the model performance by comparing the simulated and measured values of maize grain yield for the 50 year period, nitrogen distribution in soil profile for 2008 and loss of nitrate in tile drainage water for 1998-2000. Quantification of the comparisons was done using “EasyGrapher” program (Yang and Huffman, 2004).

DSSAT performance has been assessed in the past extensively through deviation and test statistics and its merits have been reviewed by other scientists (Kobayashi and Salam, 2000; Loague and Green, 1991; Willmott, 1982). An overall model evaluation is not possible with a single statistic because each deviation/ test statistic addresses only a specific aspect of a model’s performance (Rinaldi *et al* 2007; Timsina and Humphreys, 2006).

Cultivar coefficients are specific to the crop cultivar as well as the local climate and it is through these that the growth stages are defined so these coefficients need to be individually calibrated.

The CERES-Maize model has 6 cultivar coefficients which are used for crop simulation studies. Out of these three coefficients (P1, P2 and P5) represent early growth, two coefficients (G2, G3) represent grain filling and one (PHINT) represents the phyllochron interval between successive leaf tip appearances (Hoogenboom *et al* 2003). Calibration of cultivar coefficients is a must so that the observed and simulated grain yield or biomass yield match under no stress of water, heat or nutrition during growing conditions (Boote, 1999).

Liu *et al* (2011) evaluated the CERES-Maize using long term (1959-2008) continuous maize experiment on clay loam soil in Southern Ontario and found that the model could not simulate the annual maize yield precisely but the results were as good as the other researchers had obtained. For long-term simulations more than one soil profile should be used in DSSAT or modifications are required for the model to update the soil profile characteristics during these long-term simulations. Also, the model should be able to consider the other short term but large impacting factors like soil erosion, high winds, floods, hailstorm and insect-weed infestation so that evaluation is based on the immediate as well as the cumulative effect of short-term extreme events.

The reliability of the simulation results are guaranteed through rigorous calibration and validation. Model calibration is a process of adjusting the set of genetic coefficients until the simulated crop parameters adjust with the observed ones (Timsina and Humphreys, 2006) while validation is an assessment process whereby the ability of the calibrated model to simulate the characteristics of the selected cultivar is done through comparison of simulated and observed values (Uryasev *et al* 2004).

Arije *et al* (2018) conducted an experiment to evaluate the CERES-Maize model and studied the response of different fertilizer application in rainfed agro-ecological zone of Nigeria. The observed thermal time (P1) for two maize varieties Suwan-SR-Y and ART/98/SW6 was 140°C day and that for ART/98/SW1 was 120°C day. All the varieties were photo-insensitive thus it was fixed at 0.5. The yield determining factors (P5, G2 and G3) were higher for the former two varieties thus determining the two varieties Suwan-SR-Y and ART/98/SW6 to have higher yield and longer maturity period than the ART/98/SW1. The PHINT ranged from 40°C day (ART/98/SW6 and ART/98/SW1) to 44°C (Suwan-1-Sr-Y) day for the three varieties. The simulated values were found to be close to the observed for all the parameters with low statistical error.

Malik *et al* (2019) determined the accuracy of CERES-Maize model for yield and biomass estimation for the Mediterranean region with a RMSE of 708 and 2018 kg ha⁻¹ respectively and high Willmott Agreement Index (d-statistic) that was >0.9.

Ramawat *et al* (2012) calibrated and validated CERES-Maize model for four varieties that are KH9451, KH5991, Early Composite and local in Northwest Himalayas in India.

Model's performance was satisfactory as it closely simulated the grains per cob ($R^2=0.545$) and number of grains m^{-2} ($R^2=0.485$) but poorly the single grain weight ($R^2=0.002$). The simulated grain yield was higher than the observed while the predicted stover yield was fairly well simulated. Validation of the accuracy of the model was fair supported by high value of goodness of fit (low RMSE=559 kg ha⁻¹, CV=12.08%) between the observed and simulated value hence is applicable for further utilization as a decision support system for yield prediction.

Rani *et al* (2016) describes that extensive test for CERES-Maize has been done under tropical conditions of Hawaii, Indonesia, Phillippines, USA and Europe, Kenya and India. An experiment conducted by Rani *et al* (2016) calibrated and validated CERES-Maize model (DSSAT v4.5) for maize hybrid (cv Dekalb Super 900M) using field experiment at Agricultural Research Institute, Hyderabad, India. The evaluation revealed the satisfactory estimates with RMSE of 0.87 days, 363 and 412 kg ha⁻¹ for the phenology, grain yield and total biomass, respectively. The results confirmed the suitability of CERES-Maize model for taking strategic decisions and improving maize production in different agro climatic zones of Telangana.

Abedonipur and Sarangi (2018) calibrated and validated the CERES-Maize model for three irrigation and nitrogen treatment at Water Technology Centre, IARI, New Delhi and used it to estimate the yield and biomass for the same with reasonable accuracy. The accuracy of the model was greater under full and 75% of field capacity irrigation. The results helped the experimenter confirm the applicability of model in maize yield estimation with good accuracy under dynamic water and nitrogen regimes in semi-arid environment.

Kaur (2016) conducted a field experiment at Punjab Agricultural University, Ludhiana, Punjab and determined the model ability to simulate the phenological events i.e. anthesis date (RMSE = 3.5 day, d-stat = 0.752), maturity date (RMSE = 1.4 day, d-stat = 0.908); yield parameters i.e. grain yield (RMSE = 956 kg/ha day, d-stat = 0.592) and biomass yield (RMSE = 1880 kg/ha, d-stat = 0.628) for maize cultivars under different sowing dates during the two crop years.

Kaur and Arora (2018) did a study at Punjab Agricultural University, Ludhiana, Punjab and determined the reasonability of the model with normalized root mean square of deviations (RMSD) between simulated and measured values less than 20% for harvest-time biomass, grain yield and water use; and slightly greater variance (30%) for grain N uptake.

2.3 Projected Changes in growth duration and yield of maize

Byjesh *et al* (2010) simulated maize yields at high atmospheric temperature and found a decline in yield which occurred due to reduced crop duration i.e. days to 50% flowering and grain filling duration (GFD), reduced leaf area index and leaf area duration. A considerable

reduction in crop phenology could be seen with the increase in temperature of 16% (days to 50% flowering) and 14% (GFD) at 5°C rise in temperature. Yield components like grain weight, test weight and number of grains were also impacted by high temperature. The number of grains per hectare reduced from 6% to 32% at 1°C and 5°C temperature rise, respectively. The results of the study depict a decrease in the projected maize yield under reduction or no increase in rainfall at fixed temperature simulations. The HadCM3 model scenario indicated a rise in rainfall as projected for various locations in India leading to a slight less impact of climate change on maize yield.

Thornton *et al* (2010) studied the effect of climate change in East Africa and found that maize yield would decrease by more than 5% under warm climate change scenario. Also a review and meta-analysis by Knox *et al* (2012) show that projected change in maize yield is expected to be -5% across Africa.

Wang *et al* (2011) reported the maize yield in different regions of China and projected its decline in central plain and western regions of Jilin by 10 to 30% while an increase in the marginal areas of eastern countries under climate change during the years 2050-70. This yield reduction in the major areas of maize is due to the changes in temperature and precipitation together and the crop growth season is also predicted to shorten by 15-20 days till 2070. The marginal areas of eastern regions may show a yield increase but as it is not a major maize crop region so the whole yield decrease would be substantial for China in the coming decades.

Bannayan *et al* (2016) worked on the vulnerability of maize yield under climate change scenario and found that the simulated yield depicted a decline in the maize yield from the baseline during future century at all locations in north-east Iran. The compared results showed that the yield would reduce from -2.6% to -82%. Similar trend of decline was observed for the phenological stages as well as the leaf area index. The increase in temperature caused an increase in the development rate and reduction in the growth period of the crop which ultimately leads to yield reduction. The A2 scenario reported higher negative impact on the maize yield and growth in comparison to B1 which showed more optimal conditions for the yield which is due to more annual warming under A2 scenario as per the predictions.

Lin *et al* (2017) simulated the climate change impact on maize in northeast China and the results represented shortened maize growth duration and reduced maize yield under increased temperature in future climate scenarios. If the effects of CO₂ fertilization and adaptation measures to prevent the CO₂ effect are not considered then the projections for maize yield indicate a decrease on an average by 2.1 to 22.7% and 6.3 to 47.5% from 2020s to 2080s under RCP4.5 and RCP8.5, respectively. The trend of continuous decline in the maize yield was seen for both RCPs and that under RCP8.5 was predicted to be greater than the RCP4.5.

Deb *et al* (2015a) conducted a study to investigate the climate change impact on rainfed maize productivity Gangtok site in Sikkim and the outputs of the crop simulation model represented a significant decline in the productivity of maize ranging from 10.7% to 18.2% and 6.4% to 12.4% for A2 and B2 scenarios, respectively in comparison to the baseline yield of 3.96 t ha⁻¹ (1995s). The maize yield was also simulated for a number of CO₂ concentration levels and incremental temperature and the study indicates higher CO₂ to be beneficial for maize productivity while higher temperature at constant CO₂ level represented reduced yield.

Deb *et al* (2015b) extended his study to three locations (Geyzing, Gangtok, and Mangan) in Sikkim, India and used two crop simulation models, AquaCrop and CERES–Maize to analyse the climate change impact on the productivity of maize. The calibrated and validated crop models were utilized to analyse the impact for three future periods: 2021–2030 (2025 s), 2051–2060 (2055 s), and 2081–2090 (2085 s) in comparison to the baseline period (1991–2000) for the three locations. The simulated yield by Aquacrop indicated an average decline in yield ranging from -4.7 ± 1.4 to -12.8 ± 4.85 % and -2.5 ± 0.9 to -10.9 ± 3.9 % while for CERES-Maize the yield reduction ranged from -10.9 ± 4.1 to -20.4 ± 7.2 % and -7.4 ± 2.9 to -15.8 ± 5.7 % for A2 and B2 scenarios, respectively, for the time period 2085 s. The study revealed an increase in yield for high altitude station (Geyzing) by -1.1 ± 0.25 to 4.2 ± 1.52 % for the future sowing time window.

Haris and Chhabra (2015) used the HADCM3 model projected climate data and reported increased simulated yield for winter maize that from the baseline yield. During the time periods 2020, 2050 and 2080 the simulated yield of winter maize increased by 10.7, 18.7 and 37.4% respectively for Samastipur, by 18.2, 25.4 and 76.7%, respectively for Bhagalpur, by 8.8 to 23.6%, respectively for Madhepura and by 8.4, 14.1 and 28.5% respectively for Patna district.

Srivastava *et al* (2021) used evaluated CERES-Maize model to determine the climate change impact on maize yield and yield attributes under different climate scenarios in eastern India. The projected results of maize yield for the time periods 2021–2050 and 2051–2080 were compared with the baseline scenario of 1982–2012 for different representative concentration pathways (RCPs). For the time slice 2021–2050 and 2051–2080 the recorded change in yield was -10.58% , -14.80% , -21.02% , and -23.39% and -15.20% , -18.54% , -24.75% , and -26.83% , respectively for irrigated condition. The recorded change in yield for rainfed condition was higher for both the time slice 2021–50 and 2051–80 by 10.55%, 9.20%, 8.13%, and 7.47% and 10.63%, 6.65%, 7.47%, and 4.31%, respectively. The time period 2051–2080 observes major loss in grain yield against the baseline yield in case of irrigated condition while under rainfed condition an increase in grain yield was observed for both the periods which clearly depict the reduction in the negative impact of temperature on the crop yield with the

increase in rainfall. Under both rainfed and irrigated conditions for different CO₂ levels an increase in maximum temperature impacts the maize grain yield more than the increase in minimum temperature.

Prabhjyot-Kaur and Hundal (2008) studied temperature rise impact on maize crop in Ludhiana using CERES-Maize and showed the advancement in maturity days by 1,3,3,1,2, and 2 days and grain yield decrease of 4.26, 0.02, 12.15, 10.99, 15.92 and 16.85% for a temperature increase from normal by 0.5, 1.0, 1.5, 2.5 and 3.0°C respectively.

Kaur (2016) used the PRECIS model projected data for different locations in Punjab and revealed that the CERES-Maize model under A1B, A2 and B2 scenario predicted significant decrease in crop duration by 19 to 25, 12 to 21 and 7 to 16 days respectively till end century. Significant decrease in grain yield was also predicted as 80 to 89%, 52 to 81% and 46 to 60% for A1B, A2 and B2 scenario respectively. The decreased crop duration might be the effect of high temperatures that are predicted at the end of the century and this reduced duration result in yield decrease under different scenarios. The reduce in maturity period (≤ 70 days) is more under A1B and A2 which are considered high emission scenarios than B2 which is low emission scenario and this is due to high temperatures. Under the A1B and A2 scenarios the years with a yield decrease $< 500\text{kg/ha}$ are more than that for B2 scenario. Such results indicate dire need to introduce management strategies to stabilize the maize yield in Punjab state.

2.4 Optimization of management practices in maize under climate change

The predictions for climate change determine its impact on the productivity of various crops thus there is an expectation in improvement of agricultural systems with time so that efficient management of the crops is possible. Thus, various researchers have done studies at various locations to help the farmers plan their management strategies accordingly.

Kaboré and Reij (2004) and Sawadogo (2011) studied the improved soil conservation and water management practices that are helping in renewing degraded lands in Burkino faso. They found that farmers had adopted low-cost crop management strategies like building stone-bunds and following water harvesting techniques like Zaï at micro-level and Demi-Lune.

Antwi-Agyei *et al* (2013) explains the farmer's ability to cope up and adapt to the conditions is little difficult in Sub-Saharan Africa thus it is necessary for the researchers to select the crop management strategies that can help farmers to efficiently adapt to climate change. Also, the technologies and approaches that can help farmers in soil conservation and water management will definitely help in building a difference in food security and agricultural development in this region.

Waongo *et al* (2015) performed an experiment in Burkina Faso, West Africa on optimizing the maize planting dates based on crop model and fuzzy rule based approach. The

current climate change predictions require a joint attempt by the farmers where they can adapt several farming practices as a response to the lingering climate risks. A combination approach by the farmers can be taken up of optimized planting dates (OPD) as per the climate forecasts for the current season. The researchers evaluated the impact on future maize production for two time periods (2011-2030 and 2031-2050) and in different domains (North, western and south). The evaluation results indicated a decrease in the average maize yield under RCP8.5 for major locations across Burkino Faso during 2031-2050. The climate change adaptation could be strengthened with a combined approach of planting dates based on OPD in association with other management strategies. The farmers could follow the prediction of OPDs with a lead-time of few weeks which would also help them in making choices of crops and planning labour for the on-time field preparation.

Bannayan *et al* (2016) worked on the possible adaptation strategies that can be taken up in north-east of Iran for maize against the vulnerability that maize yield holds under the climate change scenario. Under the climate change scenarios the vulnerability index indicated the effectiveness of adaptation strategies in all the study locations of Iran. The study depicted that the use of delayed sowing dates at all the locations would be advantageous for higher maize yield as it would help in avoiding the thermal stress that would occur at the growth period of the crop.

Lin *et al* (2017) simulated the impact of climate change and adaptation on maize yield in Northeast China. The results for the adaptation measures interpreted that the three adaptation measures of optimizing planting dates, growing a late-maturing cultivar with long growth period and breeding of cultivars with high thermal requirements could help the farmers improve their maize yield. Out of these shifting to a better cultivar was an effective measure to cope up with the adversities of future climate change.

Haris and Chhabra (2015) researched on the impact and adaptation for *kharif* maize in Bihar under different climate change scenarios and found the yield to decline under the predicted scenarios with the current management practices and inputs being used. Aversion of effect of increase in temperature and CO₂ is possible with agricultural practices like advanced sowing, one irrigation in rainfed crop and increased dose of fertilizer. The study shows that an advancement of 7 days showed a decline in yield from baseline yield at Pusa during 2020 and 2050, for Madhepur during 2020, 2050 and 2080 and for Patna only during 2080. Advanced sowing combined with a single irrigation will help Pusa and Madhepura during all of the future time periods while Patna will show reduction in decline of yield only with different combination of adaptation strategies. Best sowing time worked out were last week of April for the hybrids, first week of May for early composite variety and first week of May for local

variety. Best N application schedule for all varieties was found to be 60+30 kg N ha⁻¹, 60 kg N ha⁻¹ at sowing and 30 kg N ha⁻¹ at knee high stage.

Deb *et al* (2015a) at Gangtok site in Sikkim investigated the impact of climate change on maize productivity and what adaptation measures could be taken up. The study revealed early shifting of sowing dates to 1st February, 25th and 18th January for the years 2025s, 2055s and 2085s, respectively under both A2 and B2 scenarios enhanced the maize yield. Reduced application rate of FYM to 80% for 2025s, to 60% for 2055s and 2085s under A2 scenario and 80%, 70% and 60% for 2025s, 2055s and 2085s respectively helped in enhancing the yield. Also, application of four irrigation 20,30 and 40mm under A2 scenario and four irrigation applications of 30mm for 2025s, 2055s and 2085s, respectively relative to rainfed under future climatic conditions helped in increased yield. Shifting in varieties also helped in an increase in yield under future climatic scenario.

Deb *et al* (2015b) at the three locations in Sikkim evaluated management strategies to counterattack climate change and the study represented the forward shift in sowing time of seeds led to an increase in yield ranging from 5±1.5 to 22.5±4.2 % and 10.9±2.3 to 12.9 ± 1.6 % for A2 and B2 scenarios, respectively. A reduction in farm yard manure application can also help in enhancement of yield from 6.2±2.0 to 7.5±2.2 % and 2.6±0.85 % to 7.7±2.6 % for A2 and B2 scenarios, respectively. The study also determined the cultivation of heat tolerant varieties like NAC6004 and Sethi Makai 2 which had minimum influence of climate change.

McDermid *et al* (2016) analysed the climate change impact on the rainfed maize production of Tamil Nadu using a multi-model approach and found that both the models APSIM and DSSAT CERES-Maize indicated a median increase of 20% and above in the farm, yield. Minimal effect of additional fertilizer was observed on the simulated yields and their variation across farms while supplemental irrigation indicated an increase in yield across most of the farms. Earlier date of sowing and supplemental irrigation was found to be beneficial for the crop under current climatic conditions.

Patidar *et al* (2020) researched the potential impact of climate change on rainfed maize yield in central India. The grain yield saw a reduction by 8% at 1^oC rise in temperature for 30th June as the sowing date while advancement of sowing date beyond 30th June i.e. for 7th and 14th July saw a reduction in yield in the range from 7.5% to 7% from the normal. Adaptation of shift in sowing date from 7th to 14th July will help in reducing the temperature change impact on maize yield. Similar trend of maize yield reduction was found on increase in temperature by 2, 3 and 4^oC. The adverse effect of climate change on yield can be offset by delaying the sowing dates and shifting the water requirement in tune with the peak of seasonal rainfall as this would reduce the chances of exposure to drought during the silking-tasseling stage of the crop.

CHAPTER III

MATERIAL AND METHODS

The current study entitled, “**Optimizing productivity of maize under emission based climate scenarios by mid and end of 21st century in Punjab**” was carried out in the Department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana. The details of the material used and the methods followed are presented in this chapter.

3.1 Location and climate

The state Punjab is located in the north-western region of India and is subdivided into three parts namely Malwa, Majha and Doaba. The state extends from 29°33' N to 32°34' N latitude and 73°53' E to 76°56' E longitude which covers 1.54% of country's total geographical area. The climate of the state is sub-tropical, semi-arid and monsoon type. The annual average minimum and maximum temperature for Punjab ranges between 29 to 32°C and 15 to 20°C, respectively. During the summer months of May and June the maximum temperature can rise to 44°C while during the winter months of December and January the minimum temperature can be as low as 1°C. The variation of maximum and minimum temperature occurs during the two crop seasons that are *kharif* and *rabi* season during which the mean maximum temperature is 38°C and 25°C respectively and mean minimum temperature is 23°C and 8°C, respectively. Within the state the rainfall has high variability in space as well as time and the mean annual rainfall ranges from 400 to 1300mm. The state receives its maximum rainfall i.e. more than 75 to 80% during monsoon season (June to September) while the rest 20 to 25% is received during the remaining eight months under the westerly influence. As the onset, duration and withdrawal of monsoon varies year to year, these variations invite dry spells during the critical crop growth stages. The climate of the state consists of three seasons that are summer season (mid-April to end of June), rainy season (early July to end of September) and winter season (early December to end of February). The post monsoon and post winter seasons are the transitional seasons in Punjab. The post monsoon transitional season remains quite fair and dry while the post winter transitional season there is occurrence of brief showers and hailstorms which damage the crops.

3.2 Experimental location, climate and soil

Ludhiana district lies in the central region of Punjab and is considered under the Trans-gangetic agroclimatic zone of India. It is situated at an altitude of 247m with a latitudinal and longitudinal extent of 30°54' N and 75°48' E respectively. The climate of the place can be classified as tropical steppe, hot and semi-arid which is mostly dry with very hot summer and cold winter except during monsoon season when the moist air of the ocean enters into the district. Ludhiana experiences four seasons that are hot weather season starting from mid March to last week of June followed by the south west monsoon which lasts upto September while the transition period from September to November is the post monsoon season. The

winter season starts late in November and lasts upto first week of March. The region experiences a mean annual rainfall of 680mm out of which 75% is received during monsoon season (June-September) by the south-west monsoonal winds. July and August are the wettest months and the rest 22% of rainfall is received during non-monsoon period due to western disturbances and thunderstorms. During summer season the temperature exceeds 38⁰C and reaches upto 51⁰C with dry summer spell while the winter months that are December, January experience frost and here the temperature goes upto 0.5⁰C with a dominance of northeast winds. Indo-gangetic alluvium soil occupies the district and it has been developed under semi-arid conditions with texture being sandy loam to clayey and pH=7.8-8.5.

3.3 Weather conditions during the crop season

The meteorological data for the maize crop season 2018 and 2019 was obtained on standard meteorological week (SMW) from meteorological observatory situated at Punjab Agricultural University, Ludhiana. Fig. 3.1 and Fig. 3.2 represent the same.

The mean weekly maximum air temperature during the crop season ranged between 29.9 to 40.9⁰C and 31.5 to 43.0⁰C during 2018 and 2019, respectively. Mean weekly minimum temperature ranged between 13.6 to 28.1 ⁰C and 23.9 to 28.9 ⁰C during 2018 and 2019, respectively. The highest maximum and minimum weekly temperatures of 40.9 ⁰C and 28.1 ⁰C were recorded during 22nd (28-05-18 to 03-06-18) and 28th (09-07-18 to 15-07-18) SMW of 2018, respectively, which were 1.2⁰C and 1.7⁰C higher than the normal weekly maximum and minimum temperature. Maximum and minimum temperature of 43.0 ⁰C and 23.9 ⁰C were recorded during 22nd (28-05-18 to 03-06-18) and 28th (09-07-18 to 15-07-18) SMW of 2019, respectively, which were 3.3⁰C and 2.5⁰C higher than the normal weekly maximum and minimum temperature. The mean weekly relative humidity ranged from 35.0 to 80.0 per cent and 33.0 to 80.0 per cent in 2018 and 2019, respectively. The maximum value of 80.0 per cent was recorded during 29th SMW (16-07-18 to 22-07-18) for 2018 which was lower than the normal value (84.1 per cent) and 83.0 per cent during 39th(24-09-19 to 30-09-19) SMW for 2019 which was again lower than the normal value (87.1 per cent). The minimum value of 35.0 and 33.0 per cent was recorded during 22nd SMW (28-05-18 to 03-06-18) for 2018 and 2019, respectively which were higher than the normal value (27.3 per cent). The maximum value of mean weekly rainfall was 167.8 and 208.0 as recorded during 29th SMW (16-07-18 to 22-07-18) and 33rd SMW (13-08-19 to 19-08-19), respectively. The total rainfall recorded during the crop season (May-October) and (May-September) was 959.0 (2018) and 844.5 (2019), respectively. The evaporation ranged from 21.6 to 74.0 and 21.0 to 77.4 mm, respectively during *kharif* 2018 and 2019. The weekly sunshine hours (SSHr) ranged from 4.0 to 9.6 hr and 3.5 to 11.5 hr respectively, during *kharif* 2018 and 2019.

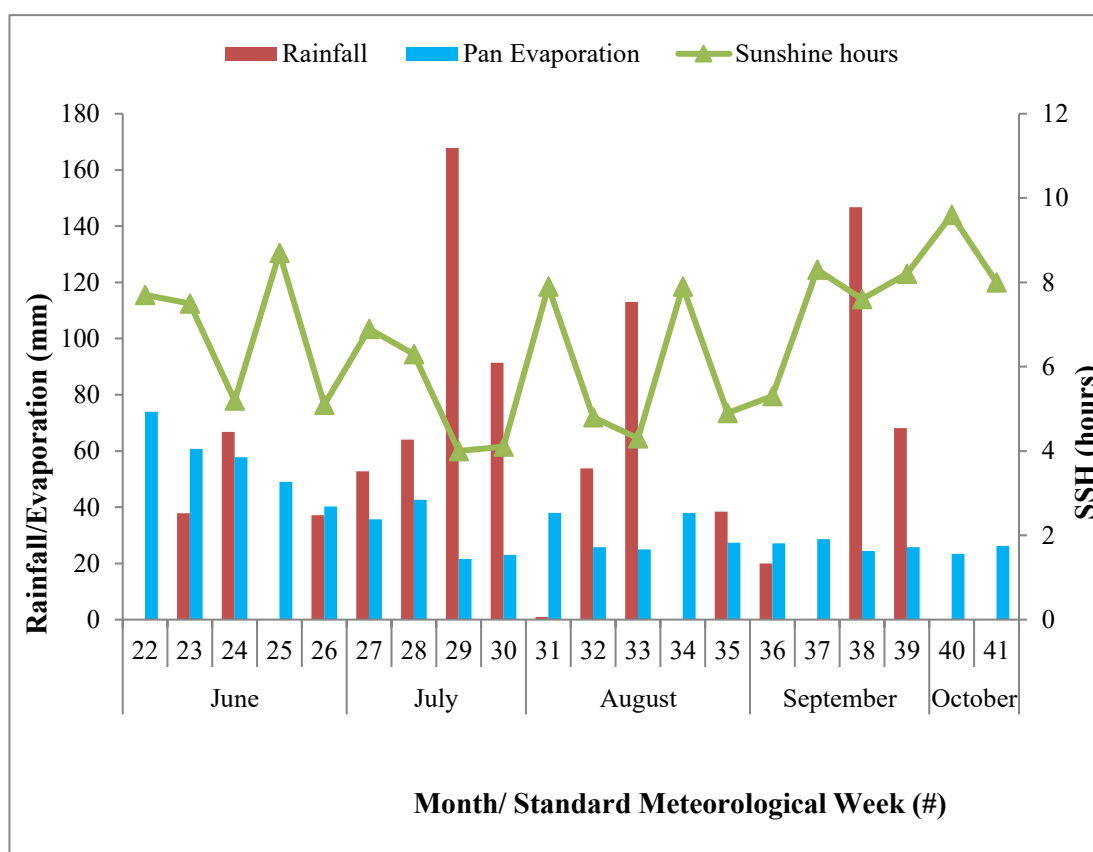
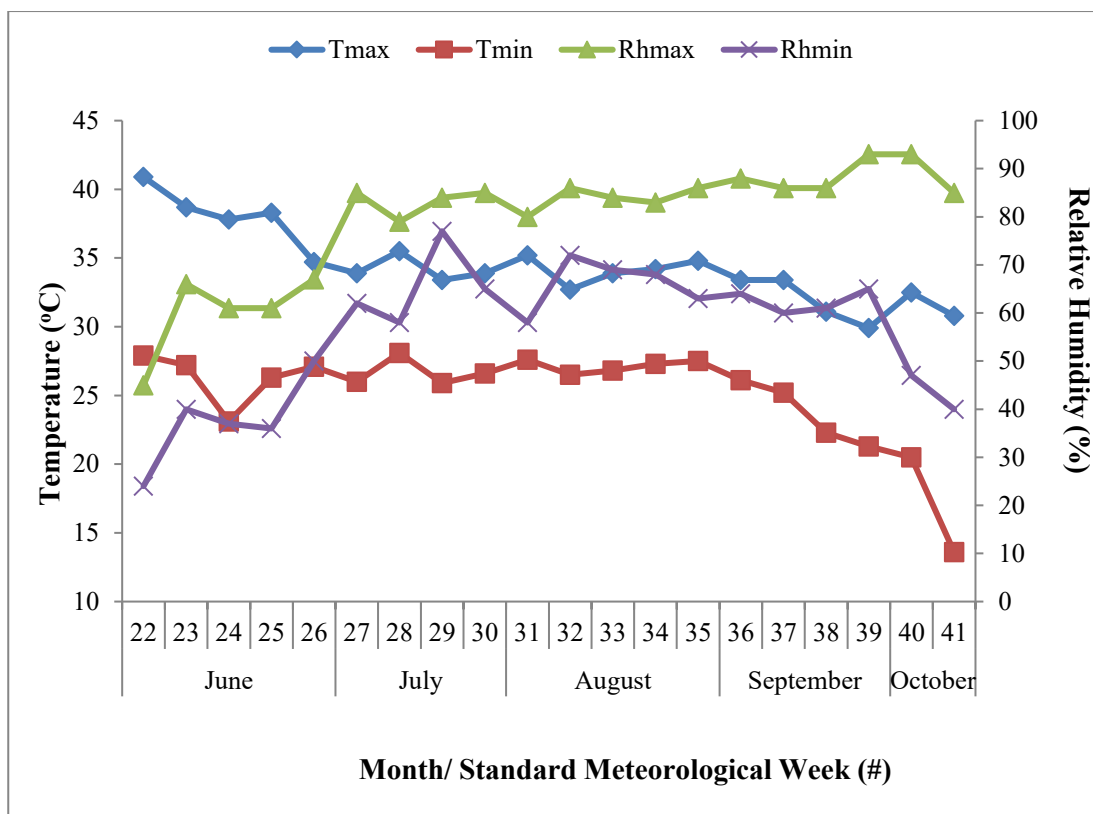


Fig. 3.1 Weekly meteorological data during maize crop season, *kharif* 2018

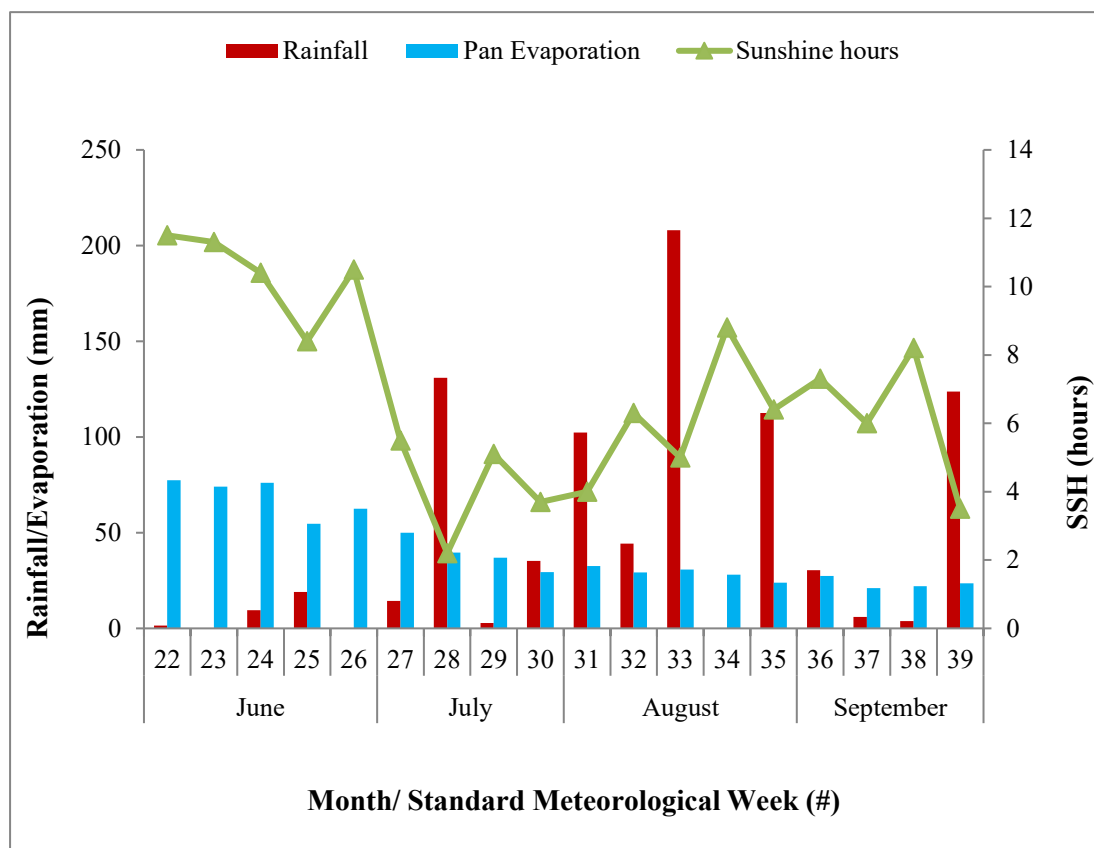
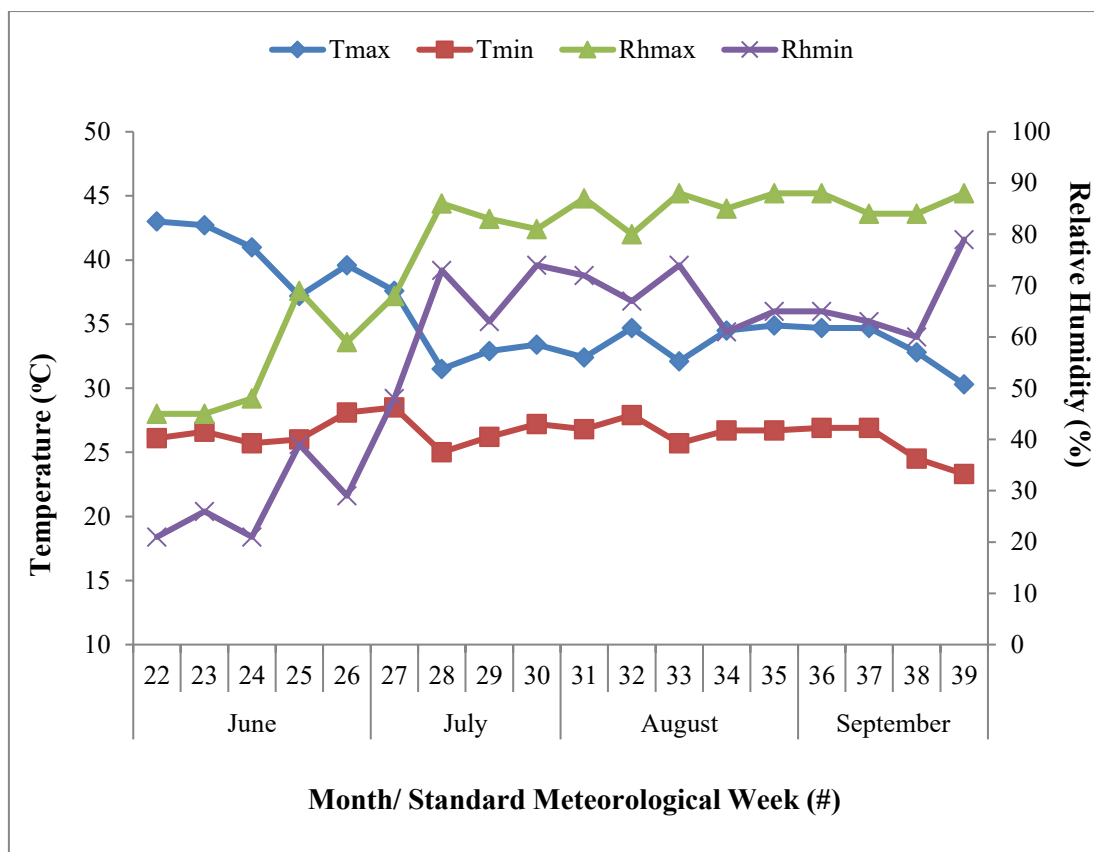


Fig. 3.2 Weekly meteorological data during maize crop season, *kharif* 2019

3.4 Crop data

The data on maize cultivars (cv PMH1 and PMH2) was collected under the mandatory trial of the “All India Co-ordinated Research Project on Agrometeorology” operational in the Department of Climate Change and Agricultural Meteorology. The data was further used for the calibration and validation of the DSSAT CERES-Maize (v4.7.5) model. The actual crop, soil and weather data were extracted for 2 years *i.e.* 2018 and 2019 from the above reports (Anonymous 2018 and 2019).

i) Actual crop data

- Crop variety
- Date of sowing
- Row to row and plant to plant spacing
- Fertilizer application (Date and rate of application)
- Irrigation application (Date and rate of application)

ii) Weather file

- Daily maximum temperature (°C)
- Daily minimum temperature (°C)
- Daily precipitation (mm)
- Daily solar radiation ($\text{MJ m}^{-2} \text{ day}^{-1}$)

iii) Site information

- Latitude
- Longitude
- Altitude

iv) Soil management file

The soil data includes the various parameters such as classification, albedo, slope of the surface, soil colour, permeability and drainage. These comprise of:

- Upper and lower horizon depths (cm)
- Percentage sand, silt, and clay content
- Bulk density (g cm^{-3})
- Organic carbon (%)
- pH in water

The soil properties of the experimental field is given in Table 3.1

Table 3.1: Soil properties of experimental field

Characters	Soil depth (cm)		Method used
	0-15	15-30	
Sand (%)	83.02	81.29	International Pipette Method (Piper 1966)
Silt (%)	10.74	11.12	
Clay (%)	6.24	7.59	
Textural class	Loamy sand	Loamy sand	
Bulk density (Mg m^{-3})	1.57	1.60	Core Sampler Method (Bodman 1942)
Chemical			
pH	7.2	7.6	1:2 soil:water suspension (Jackson 1967)
EC (dSm^{-1}) at 25°C	0.32	0.59	1:2 soil:water supernatant Solubridge conductivity meter (Jackson 1967)
Organic carbon (%)	0.54	0.32	Walkley and Black's rapid titration method (Piper 1966)
Available Nutrient (kg ha^{-1})			
N	174.6	158.83	Modified alkaline potassium permanganate method (Subbiah and Asija 1956)
P	14.0	13.3	0.5N Sodium bicarbonate extractable P by Olsen's method (Olsen <i>et al</i> 1954)
K	147.6	140.8	Ammonium acetate extractable K (Jackson 1967)

iv) Experimental file

1. Phenological observation

- Emergence stage
- Anthesis stage
- Phenological maturity stage
- Maximum leaf area index

2. Harvest parameters

- Grain yield (kg ha^{-1})
- 1000 grain weight
- Harvest index

Treatment details:

The calibration and validation of the crop model was done using the following environment

1. Crop year: Two

- 2018
- 2019

2. (i) Date of sowing: Three (2018)

- D₁ 1 June
- D₂ 15 June
- D₃ 30 June

(ii) Date of sowing: Four (2019)

- D₁ 28 May
- D₂ 6 June
- D₃ 15 June
- D₄ 24 June

3. Cultivar :Two

- V₁ PMH1
- V₂ PMH2

3.5 Description of model

Crop simulation model (CSM) is an efficient tool for analysing the growth and yield of crops (Hoogenboom *et al* 2017). CSMs are computer programs that simulate crop growth and describe the dynamics of crop in relation to the environment (Matthews and Stephens, 2002). These models mimic the growth using soil, weather and crop information as on field for a region. In agricultural production system, study of plant and climate relationship is very important and similar studies have been extensively and effectively performed by various scientists (Matthews and Stephens, 2002; Jones *et al* 2003; Easterling *et al* 2007).

3.5.1 Decision Support System for Agrotechnology Transfer (DSSAT)

The DSSAT (Decision Support System for Agrotechnology Transfer) is a software package developed by collaborated efforts of scientists and researchers of various institutes such as the University of Florida, the University of Georgia, University of Hawaii, University of Guelph, the International Centre for Soil fertility and Agricultural Development, Iowa State University and the International Consortium for Agricultural Systems Application (Tsuji *et al* 1994; Jones *et al* 2003).

3.5.2 CERES-Maize model

DSSAT consists of different crop models including CERES-Maize that was developed by Jones and Kiniry (1986). The model is capable of simulating daily crop growth, development and yield under different climate and soil conditions using different agronomic management practices thus the model was selected to study the yield of maize in Punjab under projected climatic scenarios and what optimization practices can be followed for higher yield in future.

3.5.3 Sensitivity analysis

The sensitivity of the model is determined using sensitivity analysis in which observation is made regarding sensitivity of the model output towards the changes that are done in the input parameters. This helps in understanding the behaviour of the model. The sensitivity of a parameter towards an output is determined by making small changes in the input parameter and if this small change causes a relatively large change in the output then the output is sensitive to that parameter. This implies that this parameter requires accurate determination as it will affect the output. The CERES-Maize model consists of a genotype file which stores information on phenological and growth parameters of the crop in form of genetic coefficients which are cultivar specific and altering these help in sensitivity analysis. The CERES-Maize model was sensitized for the genetic coefficients using Sensitivity Index (Eq. 1) which was calculated as:

$$SI = ((O_2 - O_1)/O_{avg})/((I_2 - I_1)/I_{avg}) \quad (1)$$

Where I_2 , I_1 and I_{avg} are minimum, maximum and average input values of CSPs while O_2 , O_1 and O_{avg} are corresponding output values of crop parameters. Sensitivity index is a mathematical approach given by Lamsal *et al* (2012) of determining the sensitive parameter impacting the yield, growth and duration of the crops. Graphical approach was also used to determine the same.

3.5.4 Model calibration

Calibration of model is the process of adjusting the model parameters according to the local conditions of the region. This is necessary in determining the genetic coefficients for new cultivars being used in the study. The calibration process was done for the crop parameters (anthesis, physiological maturity, grain yield and LAI) collected for the first date of sowing (28th May), for both the varieties (PMH1 and PMH2) using GENCALC. The genetic coefficients were further adjusted through trial and error method for better simulation results. Though the model DSSAT CERES-Maize v4.5 was calibrated for the same varieties

(Kaur 2016), still to obtain better results the calibration for the DSSAT CERES-Maize (v4.7.5) was done for the year 2018. The cultivar coefficients dealing with vegetative growth and phenology of the crop (P1, P2, P5 and PHINT) and those with the grain number per cob and grain filling (G1 and G2) are determined using several iterations till they give close simulations to that observed on field. The reliability of the simulation results are guaranteed through rigorous calibration and validation. The description of these cultivar specific parameters is as given in Table 3.2

Table 3.2: Description of the cultivar specific parameters used in DSSAT CERES-Maize model

Genetic Coefficient	Definition
P1	Thermal time from seedling emergence to the end of juvenile phase
P2	Extent to which development (expressed in days) is delayed for each hour increase in photoperiod above the longest photoperiod at which development proceeds at maximum rate (which is considered to be 12.5 hrs)
P5	Thermal time from silking to physiological maturity
G2	Maximum possible number of kernels per plant
G3	Kernel filling rate (mg/day)
PHINT	Phylochron interval, the interval in thermal time (degree days) between successive leaf tip appearance

3.5.5 Model validation

After the calibration, the validation process was done for the year 2019. The validation of the model was evaluated using various statistical measures that include coefficient of determination (R^2), Root Mean Square Error (RMSE), Normalized Root Mean Square Error (NRMSE), index of agreement (d-stat) and Nash-Sutcliffe model efficiency (EF). The R^2 (Eq. 2) is the coefficient of determination which if near to 1 represents a good fit while RMSE (Eq. 3) represents the amount of error in the model which should have a low value. The d-stat (Eq. 5) gives the single index of model performance which covers the biasness and variability in the model and indicates the 1:1 prediction better than R^2 (Willmott 1982). Further, a low value of NRMSE (Eq. 4) represents a good fit. NRMSE value <10% indicates excellent fit, >10% to <20% good fit, >20% to <30% fair fit and >30% a poor fit (Jamieson *et al* 1991). The d-stat value varies between 0 and 1 with 1 indicating the best fit while EF (Eq. 6) has no dimension with a value 1 representing a perfect match of observed and simulated values (Nash and Sutcliffe, 1970).

The following evaluation parameters have been shown in equations given below:

$$R^2 = 1 - \frac{\sum_{i=1}^n (m_i - s_i)^2}{\sum_{i=1}^n (m_i - \bar{m})^2} \quad (2)$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^n (m_i - s_i)^2}{n}} \quad (3)$$

$$NRMSE = \frac{RMSE * 100}{\bar{m}} \quad (4)$$

$$d\text{-stat} = 1 - \frac{\sum_{i=1}^n (m_i - s_i)^2}{\sum_{i=1}^n (|s_i| + |m_i|)^2} \quad (5)$$

$$EF = \frac{\sum_{i=1}^n (m_i - \bar{m})^2 - \sum_{i=1}^n (s_i - m_i)^2}{\sum_{i=1}^n (m_i - \bar{m})^2} \quad (6)$$

Where,

m_i = measured value of the parameter

s_i = simulated value of the parameter

n = no. of observations

$\bar{m}$ = mean of the observed parameter

3.6 Optimizing the sowing window for Maize

The calibrated and validated DSSAT CERES-Maize model was run for the sowing window applicable for Maize in Punjab that is from 20th May to 30th June. This helped in deciding the optimum dates of sowing for maize as well as how late sowing would affect the yield.

3.7 Downscaling and bias correction of the futuristic meteorological data

The futuristic meteorological data downscaled and bias corrected for the seventeen GCMs and an ensemble was performed by Kaur (2020) using Difference method, Leander and Buishand method and Modified difference method for the different locations (Ludhiana, Amritsar, Ballawal Saunkhri, Patiala, Bathinda, Faridkot and Abohar) of Punjab from 2010 to 2095 under the four emission based scenarios (RCP2.6, RCP4.5 RCP6.0 and RCP8.5) as per IPCC. After the bias correction amongst the seventeen GCMs, three GCMs i.e. CSIRO-Mk3-6-0, FIO-ESM, IPSL-CM5A-MR and one Ensemble model were selected on the basis of statistical analysis (mean, standard deviation and coefficient of variability, NRMSE and RSME) of maximum and minimum temperature, rainfall and solar radiation.

The description of the RCPs and the three GCMs is given in Table 3.3 and 3.4

Table 3.3: Description of Representative Concentration Pathways (RCPs) of scenarios

RCP	Description	Developed by
RCP 2.6	The radiative forcing first raises upto around 3.1 W/m ² during mid-century and then returns to 2.6 W/m ² by 2100. The GHGs and emission of air pollutants will diminish over the time under this scenario.	IMAGE modelling team of the Netherlands Environmental Assessment Agency
RCP 4.5	Stabilization scenario where the radiative forcing under employment of technologies and strategies to reduce GHGs will stabilize before 2100.	Mini CAM modelling team at the Pacific Northwest National Laborator's Joint Global Change Research Institute
RCP 6.0	Stabilization scenario where employment of technologies and strategies to reduce GHGs will stabilize the radiative forcing after 2100.	AIM modelling team at the National Institute for Environmental Studies), Japan
RCP 8.5	Under this scenario the GHG emissions will increase over the time representing the scenarios with high GHG concentrations.	MESSAGE modelling team and the IIASA Integrated Assessment Framework at the International Institute for Applied Systems Analysis (IIASA), Austria

Table 3.4: Details for the four GCMs used in the study

Sr. No.	Model name	Institutions	Resolution (degree)
1.	CSIRO-Mk 3.6.0	Commonwealth Scientific and Industrial Research Organization and the Queensland Climate Change Centre for Excellence	1.875×1.875
2.	FIO-ESM	The First Institute of Oceanography, SOA, China	2.812×2.812
3.	IPSL-CM5A-MR	Institute Pierre-Simon Laplace	1.2587×2.5
4.	Ensemble	Ensemble of seventeen GCMs	

3.8 Simulation of maize yield trend

The downscaled and bias corrected weather data of the four GCMs was used as input weather file for different locations of Punjab in DSSAT-CERES Maize (v4.7.5). The maize grain yield, anthesis, maturity and LAI parameters were simulated under the future climatic conditions as predicted under RCP2.6, RCP4.5, RCP6.0 and RCP8.5. The simulations were made for the current experimental dates of sowing that were 28 May, 6 June, 15 June and 24 June. The simulated parameters for the 85 years as provided by the GCM were divided into two time periods of mid-century (2021-2051) and end-century (2066-2095). The maize yield for both the varieties was analysed for the 85 year period under the four RCPs. A linear

regression model was used to determine the trend of the yield. The coefficient of determination (R^2 , Eq. 2) was evaluated for each scenario with each date of sowing for different locations.

The changes in the simulated yield, phenology and LAI were observed from the baseline (2010-2020). The deviation% (Eq. 6) for the yield while deviation (Eq. 7) for the anthesis and maturity from the baseline was calculated

$$\text{Deviation\%} = ((P_{(i)} - O_{(i)}) / O_{(i)}) \times 100 \quad (6)$$

$$\text{Deviation} = P_{(i)} - O_{(i)} \quad (7)$$

Where,

$P_{(i)}$ -Predicted value of the parameter

$O_{(i)}$ -Observed value of the parameter

3.9 Evaluation of the management practices in maize

Two important management practices were adjusted for different locations of Punjab and under the four RCPs to determine the suitable ones for mid-century and end-century

- (i) Date of sowing for maize: The yield, anthesis, maturity and LAI were simulated for the 85 years period for the sowing window from early May to late June.
- (ii) Nitrogen fertilizer dose for maize: The yield was simulated for the 85 years period and for nitrogen doses from lower amount i.e. 25kg/ha to higher amount i.e. 185 kg/ha.

The above two management practices were evaluated and determined on the basis of the deviation% (Eq. 6) for yield and deviation (Eq. 7) for anthesis and maturity from 4th June (baseline).

CHAPTER IV

RESULTS AND DISCUSSION

The findings through the study under the topic entitled “**Optimizing productivity of maize under emission based climate scenarios by mid and end of 21st century in Punjab**” has been done in this chapter in a systematic manner. The findings have been explained through tables and graphs as per requirement and the earlier findings are also taken in consideration while discussing the results. The findings of the present investigation have been described under the following heads and subheads:

4.1 Modelling the phenology, yield and LAI of maize using CERES-Maize model (v4.7.5)

4.1.1 Sensitivity analysis of CERES-Maize model

4.1.2 Calibration

4.1.3 Validation

4.2 Optimization of sowing window for maize

4.3 Futuristic maize yield trend under different emission scenarios for different agroclimatic zones of Punjab

4.4 Predicted deviations in yield, phenology and LAI for different agroclimatic zones of Punjab

4.5 Optimization of sowing dates in maize cultivars under future projections

4.6 Optimization of nitrogen application in maize cultivars under future projections

4.1 Modelling the phenology, yield and LAI of maize using CERES-Maize model (v4.7.5)

4.1.1 Sensitivity analysis of CERES-Maize model

The mathematical approach (Table 4.1) was used to determine the sensitivity of the genetic parameters towards anthesis, maturity and yield of PMH1 and PMH2. For PMH1 the P1 followed by PHINT and P2 were found to be sensitive to anthesis while P5, G2 and G3 were insensitive for the same. Conversely P5 was determined to be more sensitive to maturity, followed by P1, PHINT and P2. P5 and G2 were found to be most sensitive to the grain yield, followed by PHINT, G3, P1 and P2. The P1 followed by P2 and PHINT were found sensitive to anthesis while P5 followed by P1 and P2 were sensitive toward the maturity. For yield P5 was the most sensitive parameter followed by G2, G3, P1 and PHINT. This concludes that the yield was sensitized by P5, G2 and G3 for both PMH1 and PMH2 while G2 and G3 were non-sensitive to anthesis and maturity. Lin *et al* (2017) and Mereu *et al* (2019) through their simulation results prove that an increase in P5 coefficient will increase

the grain yield in maize that implies an increase in thermal resource requirements of maize cultivars during their vegetative growing periods would be beneficial to the yield.

The graphical approach was also used to represent the sensitivity results for PMH1 (Fig.4.1) and PMH2 (Fig. 4.2). It clearly explains the most linear relationship of anthesis and maturity with P1 and P5 respectively while yield is found most linearly related to P5 and G2 for both PMH1 and PMH2. The sensitization of the model to CSPs helps in further calibration and validation of the model.

Table 4.1: Range and sensitivity index (SI) for Anthesis (ANT), Maturity (MAT), Grain yield (GY) and Range considered of the cultivar specific parameters (CSPs) for maize hybrids (PMH 1 and PMH 2)

CSPs	PMH 1				PMH 2			
	ANT	MAT	GY	Range	ANT	MAT	GY	Range
P1 (°C d)	0.46	0.28	0.28	104.4-504.4	0.46	0.27	0.30	100-500
P2 (d)	0.17	0.11	0.25	0.167-4.167	0.25	0.15	0.26	0.944-4.944
P5 (°C d)	0	0.33	0.83	541.4-941.4	0	0.39	1.01	581.4-981.4
G2	0	0	0.82	707.0-1007.0	0	0	0.83	873-1273
G3 (mg d⁻¹)	0	0	0.67	10.0-30.0	0	0	0.75	10.5-20.5
PHINT (°C d)	0.27	0.17	0.68	46.0-66.0	0.18	0.08	0.29	30-50

4.1.2 Calibration

After sensitizing the model to the genetic coefficients used in CERES-Maize, the model was calibrated for the cultivar specific parameters determining close agreement between simulated and observed crop growth parameters for the crop year 2018. The genetic coefficients (Table 4.2) were obtained where the P2, P5 and G2 was found to be on higher side in PMH2. Kaur (2016) and Ramawat *et al* (2012) also indicated the G2 coefficient to be higher for both the varieties in Punjab and north western Himalayas, respectively. Further evaluation was done using the above mentioned statistical parameters for anthesis and maturity in days after sowing (DAS) while yield in kg ha⁻¹ and LAI of both the varieties.

Table 4.2: Cultivar specific parameters used in calibration for both varieties (PMH 1 and PMH 2)

Varieties	Cultivar specific coefficients					
	P1 (°C d)	P2 (d)	P5 (°C d)	G2	G3(mg d ⁻¹)	PHINT(°C d)
PMH 1	304.40	1.167	841.4	887.0	18.0	56.0
PMH 2	260.00	1.944	881.4	1073.0	14.50	40.0

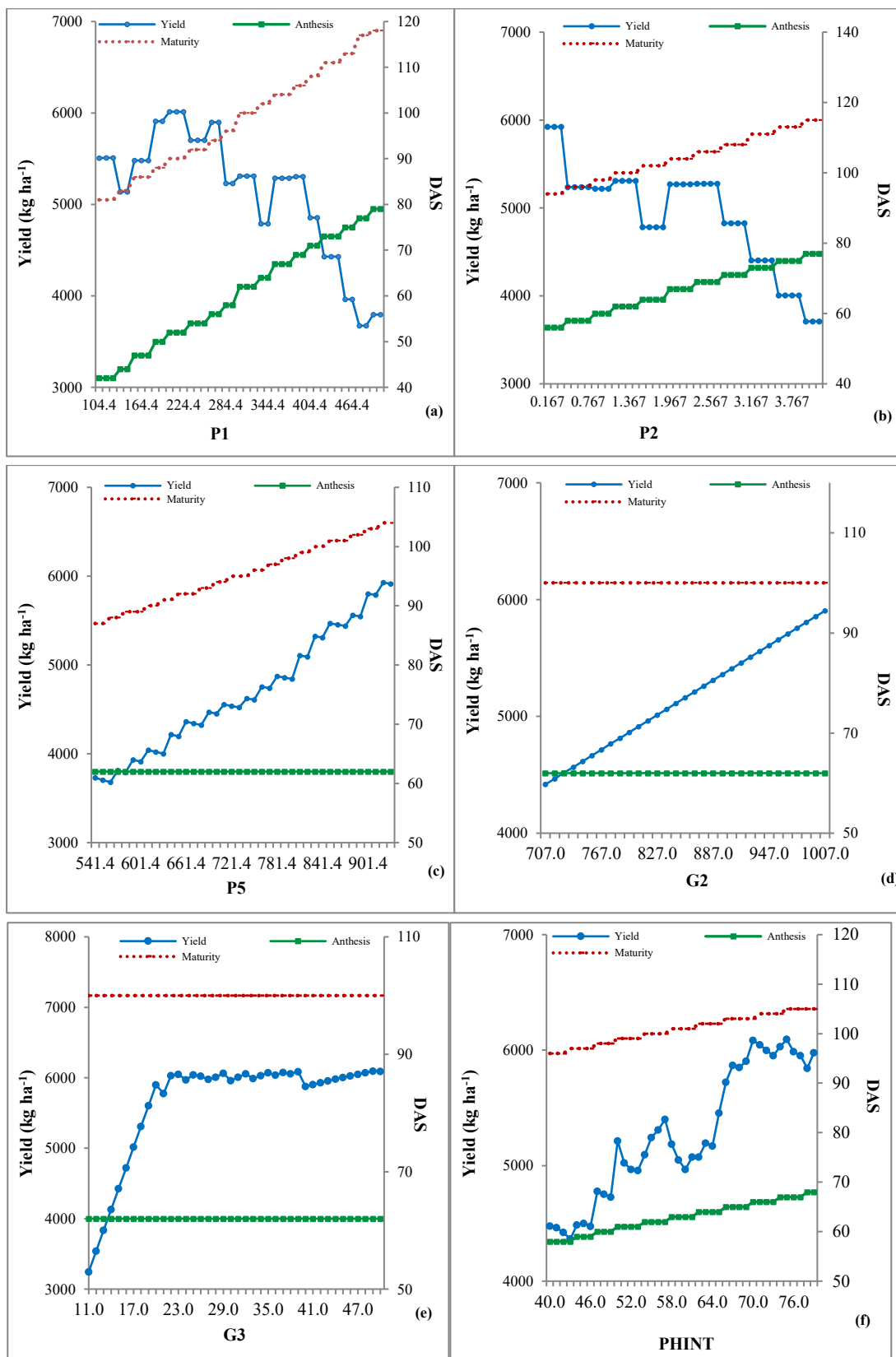


Fig. 4.1: Variations in grain yield (kg ha⁻¹), anthesis and maturity (DAS) of PMH 1 to changes in genetic parameters (a)P1 (b)P2 (c)P5 (d)G2 (e)G3 and (f)PHINT

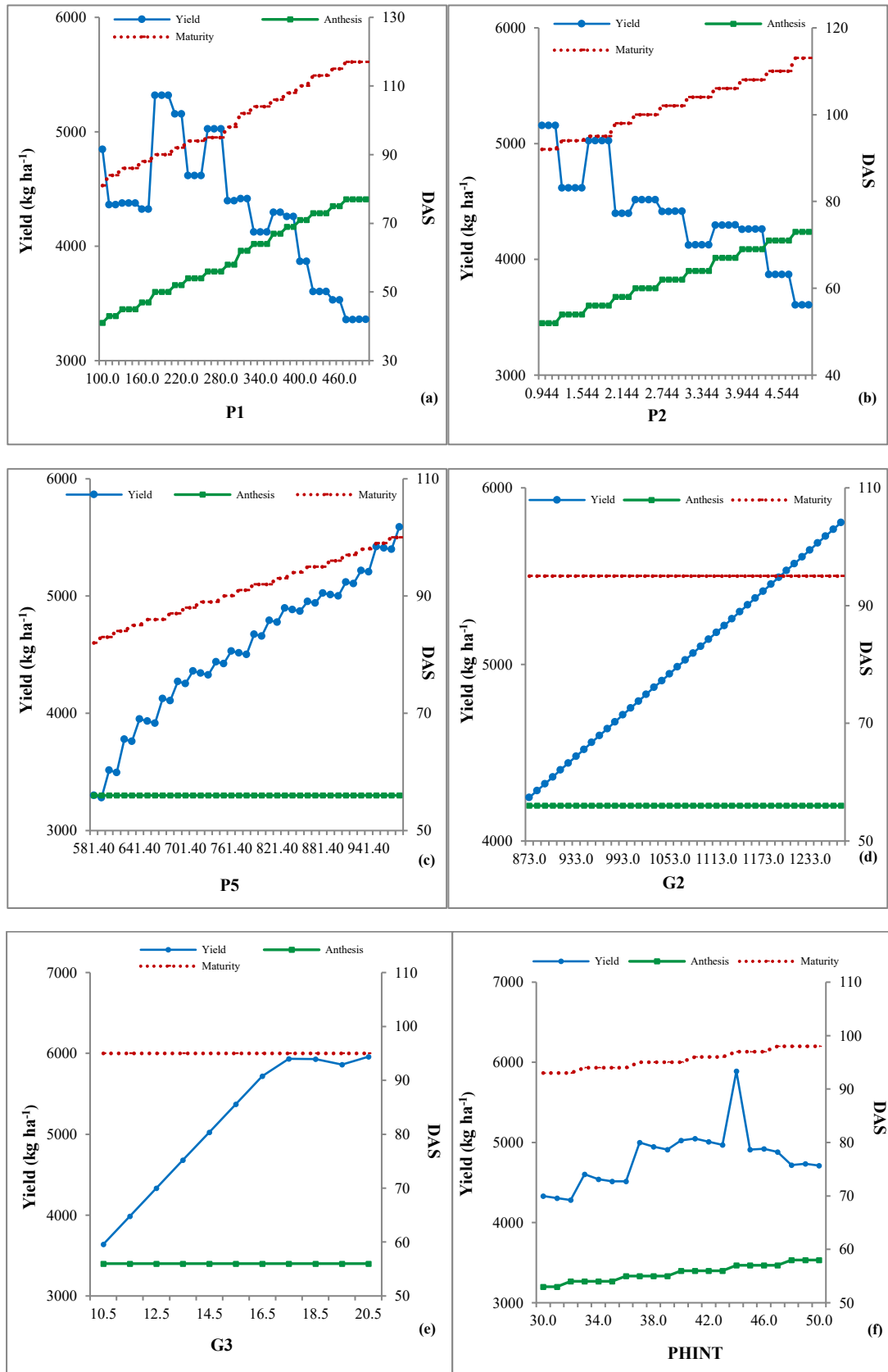


Fig. 4.2: Variations in grain yield (kg ha⁻¹), anthesis and maturity (DAS) of PMH 2 to changes in genetic parameters (a)P1 (b)P2 (c)P5 (d)G2 (e)G3 and (f)PHINT

4.1.3 Validation

The calibrated CERES-Maize model was validated for the year 2019 and statistical measures were evaluated to determine the accuracy of the model. The observed and simulated mean for both varieties was found to be same for anthesis as well as maturity (Table 4.3) with the ratio 1. The model closely simulated the anthesis days to that observed and gave good results with good R^2 value of 0.82 and 0.80 for PMH1 and PMH2, respectively under all the sowing dates for two years. The model was also in close agreement for maturity days with R^2 values of 0.67 and 0.94 for PMH1 and PMH2, respectively. For anthesis stage in PMH1 and PMH2 the RMSE value was low as 0.65 day and 0.53 day, respectively with high d-stat of 0.90 and 0.94, respectively while the error was low for maturity for both the varieties PMH1 (RMSE=0.84 day) and PMH2 (RMSE=0.65 day). Value of NRMSE for anthesis was found to be excellent (1.07%) for PMH1 as well as PMH2 (0.94%). The model simulated well for maturity with high d-stat (0.90 for PMH1 and 0.96 for PMH2) and excellent NRMSE (0.84% for PMH1 and 0.67% for PMH2). The modelling efficiency in case of anthesis was fair (0.56) for PMH1 and good (0.94) for PMH2 and similarly for maturity was fair (0.61) for PMH1 and good (0.84) for PMH2.

The simulated grain yield (Table 4.3) for both the years and varieties was closely related with the ratio 1 and high R^2 (0.95). The RMSE was low with 179.4 kg ha⁻¹ for PMH1 and 128.3 kg ha⁻¹ for PMH2 while d-stat was high (0.98) for both varieties. The NRMSE <10% i.e. 3.02 and 2.41 for PMH1 and PMH2 respectively proved the model to be an excellent fit. The modelling efficiency was good for both (0.93) the varieties. The simulated and observed mean for LAI (Table 3) for both PMH1 and PMH2 do not hold much difference with ratio of 0.89 and 0.93 for respective varieties. The R^2 value is good for PMH1 (0.85) and PMH2 (0.82). The RMSE was low with high d-stat respectively for PMH1 (0.40, 0.76) and PMH2 (0.26, 0.84). The NRMSE was good with value 11.66 for PMH1 and 9.21 for PMH2. The modelling efficiency was not found to be good. Abedonipur and Sarangi (2018) calibrated the CERES-Maize model under different irrigation and nitrogen levels and validated it for the simulated grain yield and biomass yield. The evaluation results provided $0.86 < EF < 0.88$, $0.36 < RMSE < 0.86$ t ha⁻¹ and $6 < NRMSE < 8\%$ under all the treatment levels for grain and biomass yield, respectively determining the reasonable accuracy of model application at regional level in New Delhi. Rani *et al* (2016) validated the CERES-Maize model under four dates of sowing and five nitrogen levels during the year 2009 and 2010, respectively in Hyderabad. Their results for anthesis and maturity indicated a low RMSE (1.17, 0.7 days) and NRMSE (1.97, 0.6%) value, respectively. The grain yield was closely simulated with NRMSE (14.6%) and RMSE (902.8 kg ha⁻¹). It was reported that the reduction in yield with delayed sowing was not well reflected by the model as detected on field. The model was found to be satisfactory for further application for climate change studies.

The comparison of simulated and observed anthesis (DAS), maturity (DAS), yield (kg ha⁻¹) and LAI for the two maize cultivars under different environments for the year 2018-19 was done using 1:1 line graph (Fig.4.3).

Table 4.3: Statistical measures for evaluation of CERES-Maize v4.7.5 simulation performance

Parameters	PMH 1		PMH 2	
	Observed	Simulated	Observed	Simulated
Anthesis				
Mean (DAS)	61	61	57	57
Ratio	1.007		1.00	
SD (DAS)	0.99	1.161	1.069	1.195
R ²	0.821		0.80	
RMSE (DAS)	0.655		0.535	
d-stat	0.908		0.94	
NRMSE (%)	1.07		0.94	
Model efficiency	0.56		0.94	
Maturity				
Mean (DAS)	100	100	97	97
Ratio	0.99		1.004	
SD (DAS)	1.35	1.41	1.641	1.906
R ²	0.672		0.94	
RMSE (DAS)	0.845		0.65	
d-stat	0.90		0.96	
NRMSE (%)	0.845		0.67	
Model efficiency	0.61		0.84	
Grain yield				
Mean (kg ha ⁻¹)	5942	5901	5309	5377
Ratio	0.99		1.013	
SD (kg ha ⁻¹)	616.66	491.64	474.388	471.222
R ²	0.951		0.95	
RMSE (kg ha ⁻¹)	179.371		128.266	
d-stat	0.97		0.98	
NRMSE (%)	3.02		2.41	
Model efficiency	0.92		0.93	
Leaf area index (LAI)				
Mean	3.44	3.06	2.8	2.615377
Ratio	0.89		0.93	
SD	0.33	0.34	0.257	0.374
R ²	0.85		0.82	
RMSE	0.401		0.26	
d-stat	0.76		0.84	
NRMSE	11.66		9.21	
Model efficiency	-0.47		-0.01	

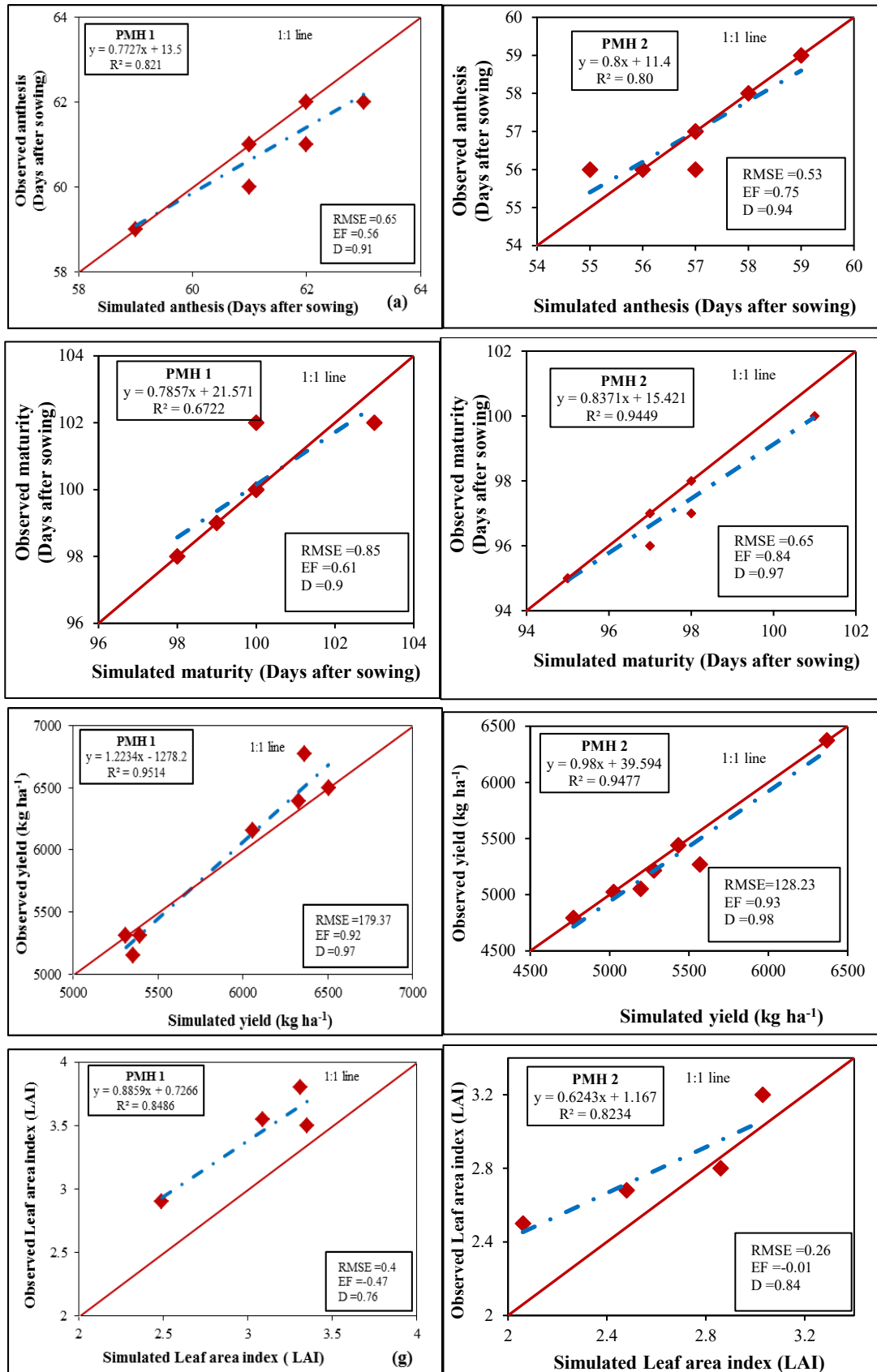


Fig. 4.3: Evaluation results for anthesis (a & b), maturity (c & d), grain yield (e & f) and LAI (g & h) of maize cultivars

4.2 Optimization of sowing window for maize

The sensitivity analysis, calibration and validation of the model confirmed the good agreement of simulated and observed parameters for anthesis, maturity, grain yield and LAI. The calibrated model was used to optimize the date of sowing for the two varieties of maize. The sowing window evaluated was the optimum sowing window considered in Punjab region i.e. from 20th May to 30th June. The yield and LAI for PMH1 and PMH2 have been depicted in Fig. 4.4.

The yield and LAI showed a polynomial relationship with the date of sowing with high grain yield peaks/ LAI during 20 May to 7 June as 5200-6000 kg ha⁻¹/ 2.9-3.2 and 4200-5400 kg ha⁻¹/ 2.8-3.0 respectively for varieties PMH1 and PMH2. The coefficient of determination (R^2) of grain yield/LAI was found to be 0.51/0.87 for PMH1 and 0.56/0.83 for PMH2. The graph clearly indicated reduced yield/ high LAI from 9 June to 18 June which varied between 5000-5400 kg ha⁻¹/ 3.1-3.4 for PMH1 and 4000-5000 kg ha⁻¹/ 2.7-3.2 for PMH2. The LAI increases upto June 18 for PMH1 and upto June 24 for PMH2. Later both the LAI and grain yield showed a decrease. The polynomial regression model represents 50% variation in grain yield with date of sowing and 80% in LAI. The CERES-Maize model simulated 20 May to 7 June as the optimum sowing window for maize in Punjab while a delay in sowing between 8 to 18 June saw a decrease in yield at the expense of profuse vegetative growth as indicated by high LAI during this period. Ramawat *et al* (2012) worked out the best time for maize hybrids (KH 9451, KH 5991) cultivation as last week of April, for early composite as first week of May and for local variety the second fortnight of April in north western Himalayan region. The harvest index of the maize plant gets reduced as the LAI and biomass increases. Late sown crops will suffer due to weather conditions prevailing during that month causing a reduction in yield.

The graphical representation (Fig. 4.5) of the deviation of grain yield and HI from mean clearly depicted the depreciation in HI with that of the grain yield. The deviation for the yield and HI varied between +14.36% to -18.28% and +20.40% to -15.05% respectively for PMH1. The depreciation (Fig.4.5a) of grain yield and HI, respectively for PMH1 occurred after 9th June (-0.31%, -2.31%) and continued to depreciate till 30th June (-14.47%, -13.44%). The variety PMH2 showed a deviation of +19.75% to -21.66% and +14.71% to -11.20% for grain yield and HI respectively. A continuous decrease in grain yield and HI, respectively was observed after 12th June (-6.49%, -0.13%) till 30th June (-15.48%, -10.93%) while a sharp increase was detected after 20th May (-21.66%, -10.39%) for PMH2 (Fig.4.5b). The days between 20th May and 7th June came out to be the best period for efficient utilization of resources for high yield as delay in sowing after 7th June caused a significant depreciation in yield.

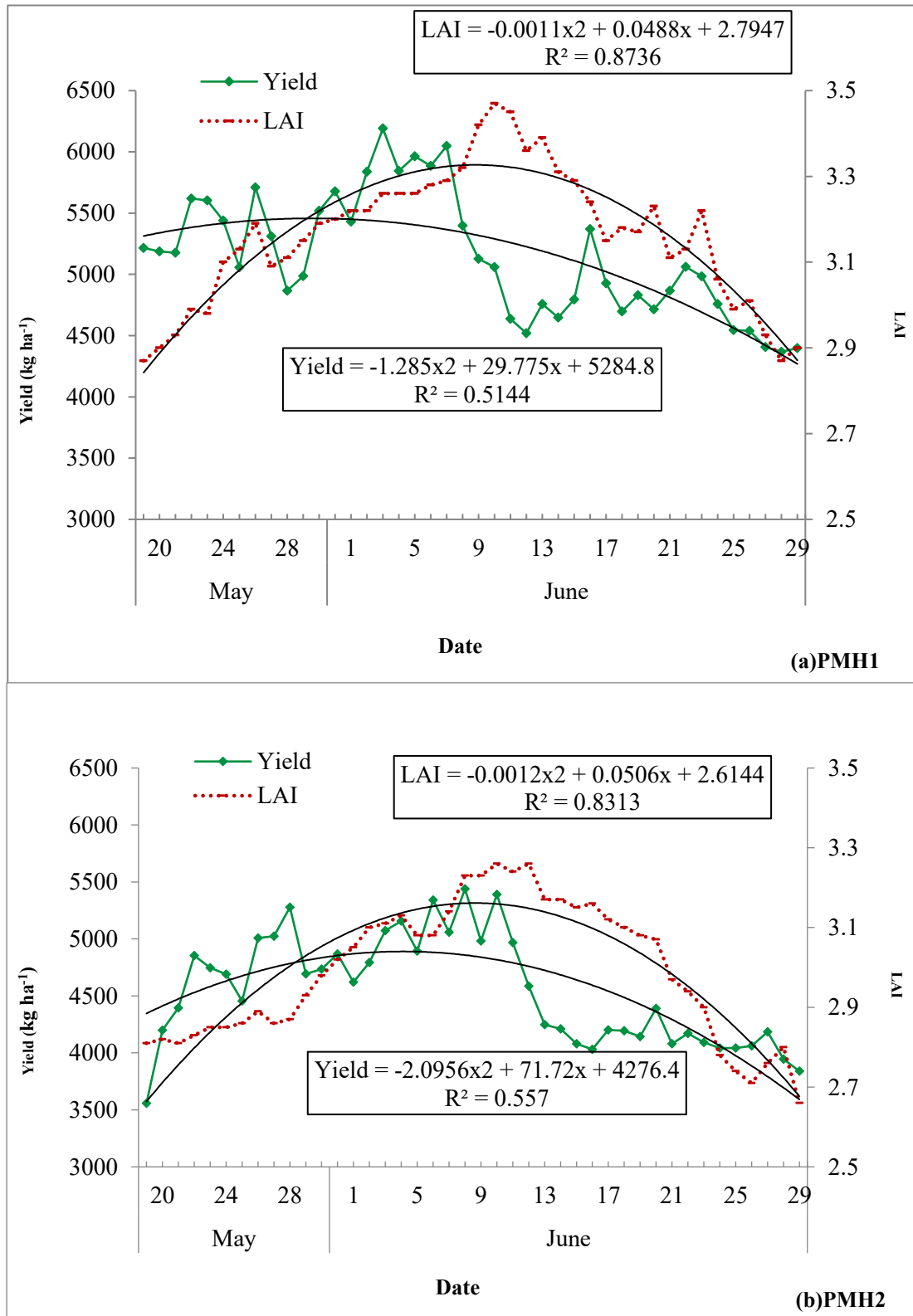


Fig. 4.4: Yield and Leaf area index (LAI) relation with the sowing window for (a) PMH 1 and (b) PMH 2

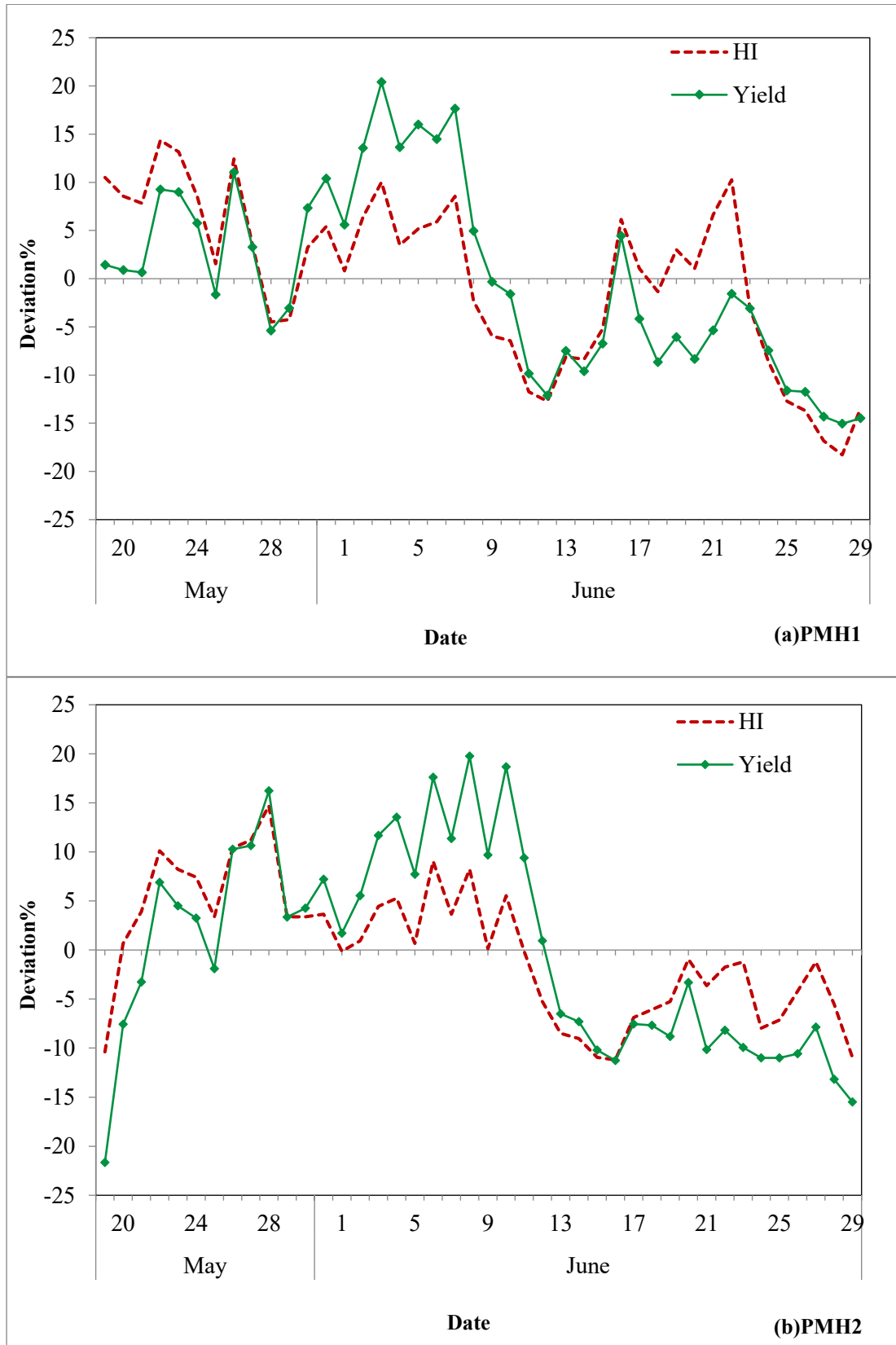


Fig. 4.5: Yield and harvest index (HI) relation with the sowing window for (a) PMH1 and (b) PMH2

4.3 Futuristic maize yield trend under different emission scenarios for different agroclimatic zones of Punjab

The selected GCM models (Kaur, 2020) were used to predict the maize yield for a period of 85 years and it was further analyzed to determine the yield changes from the baseline (2010-2020)

Agroclimatic zone II (Ballowal Saunkhri)

CSIRO Mk-36-0 model

The model projected a significant decline in yield for the region under the four scenarios for all the four sowing dates and maize cultivars PMH1 and PMH2 (Table 4.4). Maximum decrement (kg ha^{-1}) in yield was observed on 15th June (-15.70 and -95.26) under RCP2.6 and RCP8.5, respectively and on 6th June (-75.93 and -66.63) under RCP 4.5 and 6.0, respectively for PMH1. The minimum decrease in yield (kg ha^{-1}) was observed on 24th June (-6.01, -33.92, -28.20 and -61.76) under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively with high R^2 values. The yield decline for the cultivar ranged between -6.01 kg ha^{-1} to $-95.26 \text{ kg ha}^{-1}$. A strong linear relationship was observed for all the scenarios between date of sowing and yield with high coefficient of determination. The maximum decrease rate (kg ha^{-1}) of yield for PMH2 (Table 4.4) was obtained on 15th June (-16.30, -54.76, -45.83 and -59.20), respectively for RCP2.6, RCP4.5, RCP6.0 and RCP8.5. The yield decline ranged between -4.68 kg ha^{-1} to $-59.20 \text{ kg ha}^{-1}$. The four scenarios depicted high R^2 values under all the four dates of sowing except RCP2.6 which depicted fairly weak R^2 values.

FIO-ESM model

The model simulated an increase in yield (kg ha^{-1}) for PMH1 (Table 4.4) and PMH2 (Table 4.4) in Ballowal Saunkhri under RCP2.6 for all the four dates of sowing; 28, 6, 15 and 24 June with fairly weak coefficient of determination. The yield decrease for PMH1 ranged between -2.03 kg ha^{-1} to $-84.61 \text{ kg ha}^{-1}$. Under RCP4.5 a low increase in yield (kg ha^{-1}) was simulated for 15th June (+0.60) for PMH1. The cultivar depicted a maximum decrease (kg ha^{-1}) in maize yield on 24th June (-10.24 and -35.55) for RCP2.6 and RCP4.5, respectively and on 6th June under RCP8.5. The coefficient of determination was found to be high for all RCPs and four dates of sowing. The decrease (kg ha^{-1}) in the maize yield for PMH2 ranged between -2.47 to -75.55. The variety depicted high R^2 values which determine strong linear relationship between yield and dates of sowing. Simulated yield under RCP 8.5 depicted maximum decrement for both the maize cultivars.

IPSL-CM5A-MR model

The model simulated an increase (kg ha^{-1}) in yield under RCP2.6 on 6th June (+5.50) while for the other three scenarios the reduction ranged between -1.60 kg ha^{-1} to $-70.40 \text{ kg ha}^{-1}$ for PMH1 (Table 4.4).

Table 4.4: Impact of projected temperature and rainfall by four GCMs on the rate of change in yield (kg ha⁻¹) of maize cultivars under four dates of sowing and four RCP scenarios during 2010-2095 at Ballawal Saunkhri, Punjab

Date of sowing	PMH1				PMH2			
	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
CSIRO-Mk3-6-0 model								
28-May	(-) 10.38* (R ² =0.50)	(-) 43.98 (R ² =0.89)	(-) 43.52 (R ² =0.85)	(-) 62.49 (R ² =0.92)	(-) 12.12 (R ² =0.60)	(-) 35.04 (R ² =0.87)	(-) 33.42 (R ² =0.75)	(-) 36.79 (R ² =0.76)
6-June	(-) 8.13 (R ² =0.27)	(-) 75.93 (R ² =0.82)	(-) 66.63 (R ² =0.72)	(-) 80.38 (R ² =0.80)	(-) 4.68 (R ² =0.29)	(-) 45.69 (R ² =0.77)	(-) 38.17 (R ² =0.62)	(-) 49.05 (R ² =0.71)
15-June	(-) 15.70 (R ² =0.27)	(-) 64.46 (R ² =0.85)	(-) 47.85 (R ² =0.52)	(-) 95.26 (R ² =0.88)	(-) 16.30 (R ² =0.26)	(-) 54.76 (R ² =0.84)	(-) 45.83 (R ² =0.72)	(-) 59.20 (R ² =0.74)
24-June	(-) 6.01 (R ² =0.27)	(-) 33.92 (R ² =0.90)	(-) 28.20 (R ² =0.53)	(-) 61.76 (R ² =0.90)	(-) 5.10 (R ² =0.09)	(-) 35.53 (R ² =0.85)	(-) 26.65 (R ² =0.35)	(-) 47.25 (R ² =0.66)
FIO-ESM model								
28-May	(+) 9.54 (R ² =0.08)	(-) 2.03 (R ² =0.02)	(-) 16.48 (R ² =0.59)	(-) 63.75 (R ² =0.74)	(+) 3.91 (R ² =0.14)	(-) 5.07 (R ² =0.23)	(-) 16.62 (R ² =0.78)	(-) 58.11 (R ² =0.79)
6-June	(+) 7.61 (R ² =0.07)	(-) 5.53 (R ² =0.08)	(-) 18.50 (R ² =0.37)	(-) 84.61 (R ² =0.68)	(+) 8.07 (R ² =0.06)	(-) 6.61 (R ² =0.05)	(-) 16.85 (R ² =0.22)	(-) 57.45 (R ² =0.69)
15-June	(+) 5.12 (R ² =0.02)	(+) 0.60 (R ² =0.00)	(-) 25.62 (R ² =0.62)	(-) 66.93 (R ² =0.70)	(+) 4.41 (R ² =0.11)	(-) 10.28 (R ² =0.19)	(-) 23.01 (R ² =0.54)	(-) 75.55 (R ² =0.83)
24-June	(+) 4.27 (R ² =0.02)	(-) 10.24 (R ² =0.16)	(-) 35.55 (R ² =0.80)	(-) 48.09 (R ² =0.79)	(+) 2.81 (R ² =0.02)	(-) 2.47 (R ² =0.03)	(-) 23.47 (R ² =0.70)	(-) 51.33 (R ² =0.77)
IPSL-CM5A-MR model								
28-May	(-) 8.90 (R ² =0.27)	(-) 1.60 (R ² =0.02)	(-) 24.70 (R ² =0.78)	(-) 46.42 (R ² =0.81)	(-) 8.63 (R ² =0.37)	(-) 7.81 (R ² =0.49)	(-) 25.13 (R ² =0.84)	(-) 42.09 (R ² =0.88)
6-June	(+) 5.50 (R ² =0.03)	(-) 17.43 (R ² =0.29)	(-) 30.14 (R ² =0.54)	(-) 70.40 (R ² =0.68)	(-) 8.44 (R ² =0.09)	(+) 0.13 (R ² =0.00)	(-) 21.74 (R ² =0.73)	(-) 43.92 (R ² =0.68)
15-June	(-) 4.77 (R ² =0.03)	(-) 21.93 (R ² =0.34)	(-) 40.80 (R ² =0.69)	(-) 61.36 (R ² =0.67)	(-) 18.49 (R ² =0.49)	(-) 29.30 (R ² =0.75)	(-) 42.18 (R ² =0.74)	(-) 54.59 (R ² =0.80)
24-June	(-) 6.86 (R ² =0.06)	(-) 17.75 (R ² =0.26)	(-) 26.58 (R ² =0.57)	(-) 44.30 (R ² =0.60)	(+) 1.27 (R ² =0.00)	(-) 22.58 (R ² =0.47)	(-) 28.01 (R ² =0.60)	(-) 54.86 (R ² =0.70)
Ensemble model								
28-May	(-) 4.10 (R ² =0.11)	(-) 11.68 (R ² =0.51)	(-) 17.77 (R ² =0.60)	(-) 53.39 (R ² =0.86)	(-) 1.72 (R ² =0.05)	(-) 12.07 (R ² =0.64)	(-) 41.40 (R ² =0.90)	(-) 40.40 (R ² =0.84)
6-June	(+) 0.72 (R ² =0.02)	(-) 24.15 (R ² =0.85)	(-) 20.75 (R ² =0.42)	(-) 24.15 (R ² =0.85)	(-) 10.98 (R ² =0.14)	(-) 12.35 (R ² =0.72)	(-) 46.37 (R ² =0.78)	(-) 48.79 (R ² =0.77)
15-June	(+) 3.00 (R ² =0.02)	(-) 4.42 (R ² =0.14)	(-) 12.65 (R ² =0.16)	(-) 61.92 (R ² =0.74)	(-) 7.74 (R ² =0.21)	(+) 12.36 (R ² =0.28)	(-) 55.25 (R ² =0.83)	(-) 61.99 (R ² =0.69)
24-June	(-) 8.45 (R ² =0.09)	(-) 2.32 (R ² =0.02)	(-) 8.45 (R ² =0.09)	(-) 30.97 (R ² =0.66)	(+) 1.25 (R ² =0.00)	(-) 4.91 (R ² =0.24)	(-) 35.66 (R ² =0.62)	(-) 52.97 (R ² =0.76)

* Slope of curve = Kg ha⁻¹ per year

The coefficient of determination was strong for RCP6.0 and RCP8.5 depicting a large and linear decrement in yield while the values were weak for the other two scenarios RCP2.6 and RCP4.5. The model projected a slight increase in yield for PMH2 (Table 4.4) on 24th June (+1.27 kg ha⁻¹) and on 6th June (+0.13 kg ha⁻¹) with poor coefficient of determination. The yield decline for the cultivar ranged between -7.81 kg ha⁻¹ to -54.86 kg ha⁻¹. 15th June (-18.49, -29.30, -42.18 and -54.59) was observed to depict the maximum decrease with fairly good coefficient of determination (0.49, 0.75, 0.74 and 0.80) for RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively. Maximum reduction of yield had occurred under RCP8.5.

Ensemble model

The projected yield trend (kg ha⁻¹) for PMH1 (Table 4.4) under RCP 2.6 indicated a slight increase on 6th June (+0.72) and 15th June (+3.00) under RCP2.6 but with poor coefficient of determination. The range for the yield decline was obtained between -2.32 kg ha⁻¹ to -61.92 kg ha⁻¹. The maximum decrease under RCP4.5 and RCP6.0 was obtained on 6th June as -24.15 kg ha⁻¹ and -20.75 kg ha⁻¹, respectively with strong coefficient of determination while on 15th June (-61.92 kg ha⁻¹) under RCP8.5. The least decrease was depicted on 24th June. The coefficient of determination was strong for all the scenarios except RCP2.6 where weak R² values were obtained. PMH2 (Table 4.4) observed a yield decrease between -1.72 kg ha⁻¹ to -61.99 kg ha⁻¹. Maximum reduction was observed on 15th June (-55.25 kg ha⁻¹ and -61.99 kg ha⁻¹), respectively for RCP6.0 and RCP8.5 with high R² value (0.83 and 0.69). A strong linear relationship with high R² values under the four scenarios with maximum values under RCP8.5.

Prabhjyot-Kaur *et al* (2020) The end-century observed rise in maximum as well as minimum temperature under RCP2.6 (1.0⁰C and 4.0⁰C), RCP4.5 (1.8⁰C and 5.2⁰C), RCP6.0 (1.9⁰C and 5.3⁰C), RCP8.5 (3.2⁰C and 7.1⁰C), respectively while the rainfall was also projected to decrease during the *kharif* season depicting the high temperature and decreasing rainfall to impact the maize yield under future scenarios.

Agroclimatic zone III (Ludhiana, Amritsar and Patiala)

CSIRO Mk-36-0 model

The model projected a significant decline in yield for all the four scenarios under all the four sowing dates for both the maize cultivars PMH1 and PMH2 (Table 4.5) in Ludhiana. Under the four RCPs 2.6, 4.5, 6.0 and 8.5 maximum decrease rate (kg ha⁻¹) was observed on 15 June (-35.05, -65.89, -58.77, -50.56) with minimum (kg ha⁻¹) on 24 June (-9.17, -30.68, -37.38, -21.41), respectively for PMH1. The decline rate of yield ranged between -9.17 kg ha⁻¹ to 50.56 kg ha⁻¹. The coefficient of determination (R²) for all the dates of sowing showed a strong linear decrease in yield for all the years from 2010-2095. The cultivar PMH2 under RCP2.6 (Table 4.5) observed a maximum decrease on 6 June (-24.96 kg ha⁻¹) and minimum decrease on 15 June (-11.85 kg ha⁻¹). The yield decrement for the cultivar ranged between -11.85 kg ha⁻¹ to -50.63 kg ha⁻¹. Under the other three scenarios RCPs 4.5, 6.0 and

8.5 maximum yield decrease (kg ha^{-1}) was projected for the third sowing date (-47.13, -50.63 and -37.65), respectively and minimum (kg ha^{-1}) for second sowing date (-28.24, -37.32 and -24.84), respectively. The R^2 value for all the scenarios showed a strong linear relationship of sowing dates with the simulated yield.

Table 4.5: Impact of projected temperature and rainfall by four GCMs on the rate of change in yield (kg ha^{-1}) of maize cultivars under four dates of sowing and four RCP scenarios during 2010-2095 at Ludhiana, Punjab

Date of sowing	PMH1				PMH2			
	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
CSIRO-Mk3-6-0 model								
28-May	(-) 22.16* ($R^2=0.65$)	(-) 42.86 ($R^2=0.89$)	(-) 41.64 ($R^2=0.94$)	(-) 32.19 ($R^2=0.72$)	(-) 17.59 ($R^2=0.82$)	(-) 38.60 ($R^2=0.94$)	(-) 38.96 ($R^2=0.96$)	(-) 37.99 ($R^2=0.80$)
6-June	(-) 24.34 ($R^2=0.19$)	(-) 46.86 ($R^2=0.56$)	(-) 57.42 ($R^2=0.71$)	(-) 41.00 ($R^2=0.48$)	(-) 24.96 ($R^2=0.51$)	(-) 28.24 ($R^2=0.57$)	(-) 37.32 ($R^2=0.72$)	(-) 24.84 ($R^2=0.44$)
15-June	(-) 35.05 ($R^2=0.84$)	(-) 65.89 ($R^2=0.95$)	(-) 58.77 ($R^2=0.91$)	(-) 50.56 ($R^2=0.70$)	(-) 11.85 ($R^2=0.47$)	(-) 47.13 ($R^2=0.84$)	(-) 50.63 ($R^2=0.93$)	(-) 37.65 ($R^2=0.56$)
24-June	(-) 9.17 ($R^2=0.73$)	(-) 30.68 ($R^2=0.84$)	(-) 37.38 ($R^2=0.94$)	(-) 21.41 ($R^2=0.37$)	(-) 16.95 ($R^2=0.78$)	(-) 44.03 ($R^2=0.92$)	(-) 49.56 ($R^2=0.99$)	(-) 33.50 ($R^2=0.57$)
FIO-ESM model								
28-May	(-) 14.34 ($R^2=0.44$)	(-) 36.29 ($R^2=0.89$)	(-) 14.09 ($R^2=0.63$)	(-) 59.87 ($R^2=0.77$)	(-) 16.20 ($R^2=0.64$)	(-) 30.69 ($R^2=0.90$)	(-) 22.24 ($R^2=0.70$)	(-) 55.90 ($R^2=0.83$)
6-June	(+) 5.51 ($R^2=0.02$)	(+) 5.01 ($R^2=0.08$)	(-) 10.40 ($R^2=0.12$)	(-) 74.46 ($R^2=0.61$)	(-) 1.54 ($R^2=0$)	(-) 36.31 ($R^2=0.67$)	(-) 14.66 ($R^2=0.18$)	(-) 50.98 ($R^2=0.67$)
15-June	(+) 3.64 ($R^2=0.02$)	(-) 15.79 ($R^2=0.77$)	(-) 7.36 ($R^2=0.11$)	(-) 70.98 ($R^2=0.67$)	(-) 4.82 ($R^2=0.04$)	(-) 6.97 ($R^2=0.53$)	(-) 18.87 ($R^2=0.25$)	(-) 57.83 ($R^2=0.59$)
24-June	(+) 22.13 ($R^2=0.37$)	(+) 4.38 ($R^2=0.08$)	(-) 11.66 ($R^2=0.27$)	(-) 40.54 ($R^2=0.65$)	(+) 14.28 ($R^2=0.45$)	(-) 5.31 ($R^2=0.29$)	(-) 2.35 ($R^2=0.04$)	(-) 38.04 ($R^2=0.60$)
IPSL-CM5A-MR model								
28-May	(-) 17.30 ($R^2=0.73$)	(-) 8.38 ($R^2=0.29$)	(-) 22.58 ($R^2=0.58$)	(-) 44.02 ($R^2=0.79$)	(-) 12.95 ($R^2=0.65$)	(-) 11.84 ($R^2=0.82$)	(-) 22.58 ($R^2=0.58$)	(-) 49.72 ($R^2=0.87$)
6-June	(+) 3.16 ($R^2=0.03$)	(-) 12.91 ($R^2=0.20$)	(-) 23.38 ($R^2=0.29$)	(-) 48.50 ($R^2=0.48$)	(-) 5.75 ($R^2=0.14$)	(-) 2.69 ($R^2=0.07$)	(-) 23.38 ($R^2=0.29$)	(-) 48.65 ($R^2=0.72$)
15-June	(-) 25.70 ($R^2=0.48$)	(-) 46.71 ($R^2=0.77$)	(-) 35.17 ($R^2=0.48$)	(-) 84.62 ($R^2=0.85$)	(-) 12.52 ($R^2=0.32$)	(-) 27.96 ($R^2=0.66$)	(-) 35.17 ($R^2=0.48$)	(-) 65.77 ($R^2=0.83$)
24-June	(-) 8.17 ($R^2=0.07$)	(-) 21.45 ($R^2=0.59$)	(-) 5.97 ($R^2=0.04$)	(-) 60.54 ($R^2=0.86$)	(-) 9.38 ($R^2=0.15$)	(-) 22.49 ($R^2=0.61$)	(-) 5.97 ($R^2=0.04$)	(-) 66.39 ($R^2=0.82$)
Ensemble model								
28-May	(-) 10.60 ($R^2=0.82$)	(-) 9.60 ($R^2=0.40$)	(-) 7.93 ($R^2=0.21$)	(-) 55.67 ($R^2=0.93$)	(-) 6.41 ($R^2=0.61$)	(-) 12.98 ($R^2=0.56$)	(-) 14.31 ($R^2=0.49$)	(-) 52.28 ($R^2=0.96$)
6-June	(-) 8.70 ($R^2=0.18$)	(-) 20.90 ($R^2=0.60$)	(-) 9.38 ($R^2=0.14$)	(-) 58.91 ($R^2=0.87$)	(-) 6.03 ($R^2=0.66$)	(-) 12.29 ($R^2=0.50$)	(-) 8.81 ($R^2=0.26$)	(-) 41.62 ($R^2=0.77$)
15-June	(-) 9.30 ($R^2=0.28$)	(-) 2.53 ($R^2=0.01$)	(-) 10.47 ($R^2=0.07$)	(-) 67.43 ($R^2=0.97$)	(-) 4.46 ($R^2=0.40$)	(-) 16.16 ($R^2=0.30$)	(-) 22.75 ($R^2=0.34$)	(-) 54.05 ($R^2=0.92$)
24-June	(-) 8.06 ($R^2=0.08$)	(-) 4.0 ($R^2=0.16$)	(-) 0.89 ($R^2=0$)	(-) 34.70 ($R^2=0.85$)	(-) 3.16 ($R^2=0.04$)	(-) 2.78 ($R^2=0.04$)	(-) 7.06 ($R^2=0.08$)	(-) 53.94 ($R^2=0.97$)

* Slope of curve = Kg ha^{-1} per year

In Amritsar similar results were obtained for both the maize cultivars under the four sowing dates (Table 4.6). Maximum decrease rate (kg ha^{-1}) of yield was observed on 6th June (-26.24, 70.51 and -80.13) under all the scenarios except RCP8.5 where maximum decrease rate was observed on 15th June (-103.39 kg ha^{-1}) for PMH1. The decrease rate was high for the scenarios RCP4.5, RCP6.0 and RCP8.5 with high correlation of coefficient while the decrease rate was low for RCP2.6. The yield decline for the region ranged between -0.13 kg ha^{-1} to 103.39 kg ha^{-1} . The other cultivar PMH2 showed a maximum decrease rate in yield on different dates except under RCP4.5; RCP8.5 which depicted the maximum decrease on 24th June (-44.64 kg ha^{-1} ; 81.31 kg ha^{-1}). The decline range for PMH2 was from -1.2 kg ha^{-1} to -81.31 kg ha^{-1} . The maximum decline rate range was for RCP8.5 and RCP6.0 with high coefficient of determination while the other two scenarios had a lower decrease rate. The R^2 values for all the dates of sowing and scenarios depicted a strong linear decrease of simulated yield with date of sowing.

In Patiala the model projected decrease in the yield under all the scenarios and sowing dates (Table 4.7). The maximum decrement rate (kg ha^{-1}) for PMH1 was observed on 6th June (-17.15, 79.96 and 78.73) under RCP2.6, RCP4.5 and RCP6.0 respectively while RCP8.5 observed it on 15th June (-114.42 kg ha^{-1}). The decline rate ranged between -16.72 kg ha^{-1} to -114.42 kg ha^{-1} . Maximum linear decrease was observed under RCP4.5, RCP6.0 and RCP8.5 with high R^2 values. Similarly PMH2 showed yield decline (Table 4.7) under all the scenarios and sowing dates which ranged between -12.13 kg ha^{-1} to -86.44 kg ha^{-1} . The decline was high for RCP4.5, RCP6.0 and RCP8.5 during 28th May while RCP2.6 showed lower decrease rate for 16th June and 24th June. The model projected high linear decrease with high R^2 values.

FIO-ESM model

The model simulated an increase in yield (kg ha^{-1}) for PMH1 (Table 4.5) in Ludhiana under RCP2.6 for three dates of sowing; 6th, 15th and 24th June with fair coefficient of determination ($R^2 = 0.37$) for fourth date of sowing. Under RCP4.5 too an increase in yield (kg ha^{-1}) was simulated for 6 and 24 June with low R^2 (0.08) value. Simulated yield (kg ha^{-1}) under RCP 8.5 depicted maximum decrement. The yield decline ranged between -7.36 kg ha^{-1} to -74.46 kg ha^{-1} . The coefficient of determination was found to be high for 28th May under all four RCPs. The yield pattern for PMH2 under RCP2.6 (Table 4.5) showed an increase on fourth date of sowing with a fair coefficient of determination ($R^2 = 0.45$). The decrement rate of maize yield ranged between -1.54 kg ha^{-1} to -57.83 kg ha^{-1} . Other dates of sowing represented decrease in yield with maximum (-16.20 kg ha^{-1}) on 28 May with strong relation ($R^2 = 0.64$). Under the other three RCPs 4.5, 6.0 and 8.5 the maximum (kg ha^{-1}) yield reduction/ coefficient of determination were found on 6th June (-36.31/ $R^2 = 0.67$), 28th May (-22.24/ $R^2 = 0.70$) and 15th June (-57.83/ $R^2 = 0.59$). The R^2 values for RCP 8.5 were high representing a high yield decrease with different dates of sowing.

The simulated yield trend for PMH1 (Table 4.6) in Amritsar depicted an increase under RCP2.6 and RCP4.5 for the four sowing dates except 6th June (-0.93 kg ha⁻¹) under RCP4.5. However, the linear increase in the yield trend was weak with low R² values under RCP 4.5 and strong with fair R² values for RCP2.5. The other two scenarios RCP6.0 and RCP8.5 showed decreased yield rate ranging between -21.51 kg ha⁻¹ to -82.83 kg ha⁻¹ with maximum under RCP8.5. Also, a strong linear decrement relationship could be seen between the yield and sowing dates under these scenarios with high R² values. The range for yield decrease was obtained between -0.93 kg ha⁻¹ to -82.83 kg ha⁻¹. The simulated yield for PMH2 (Table 4.6) under the four dates of sowing depicted a significant increase under RCP2.6 with maximum on 15th June (+14.89 kg ha⁻¹) with fairly well R² values. RCP4.5 showed decrease in yield but in not so significant amount and a weak relationship existed between the yield and dates of sowing. The other two scenarios observed a significant decreased yield ranging between -12.55 kg ha⁻¹ to -65.98 kg ha⁻¹ with maximum on 15th June (-32.09 kg ha⁻¹ and -65.98 kg ha⁻¹) for RCP6.0 and RCP8.5, respectively. Also, the two scenarios showed a strong linear decrease over the years with high R² values.

The Patiala observed an increase (Table 4.7) in the yield on 6th June (2.21 kg ha⁻¹) under RCP2.6 and on 15th June (5.90 kg ha⁻¹, 1.02 kg ha⁻¹) under RCP2.6, RCP4.5, respectively. The yield decline ranged between -6.28 kg ha⁻¹ to -89.32 kg ha⁻¹. RCP8.5 observed a significant linear decrease in the grain yield. PMH2 (Table 4.7) observed an increase in yield on 6th June (3.23 kg ha⁻¹), 15th June (10.61 kg ha⁻¹) and 24th June (3.33 kg ha⁻¹). The yield decline ranged -0.73 kg ha⁻¹ to -77.12 kg ha⁻¹. Maximum decrease was observed under RCP8.5 with high R² values.

IPSL-CM5A-MR model

Maximum reduction (kg ha⁻¹) in yield/good coefficient of determination (Table 4.5) was obtained under the four scenarios RCP 2.6, 4.5, 6.0 and 8.5 on 15 June (-25.70/ R²=0.48, -46.71/ R²=0.77, -35.17/ R²=0.48 and -84.62/ R²=0.85), respectively for PMH1 representing a linear decrease in yield with date of sowing over the years for all the scenarios. However, an increase (+3.16 kg ha⁻¹) was observed for second sowing date under RCP2.6. High decrease rate was obtained for all the dates of sowing under RCP 8.5 with high coefficient of determination. The decline in yield for the cultivar ranged between -5.97 kg ha⁻¹ to -84.62 kg ha⁻¹. The yield reduction for PMH2 (Table 4.5) under RCP2.6 was low for 15 June (-12.52 kg ha⁻¹) and 24 (-9.38 kg ha⁻¹) June in comparison to other three scenarios. The decline lied between the ranges -2.69 kg ha⁻¹ to -65.77 kg ha⁻¹. Maximum decrease (kg ha⁻¹) in yield/coefficient of determination under RCP 4.5, 6.0 and 8.5 was (-27.96/ R²=0.66, -35.17/ R²=0.48 and -65.77/ R²=0.83) as depicted on 15 June. Highest R² values under RCP8.5 for all four date of sowing represents a linear decrease in yield over the years.

Table 4.6: Impact of projected temperature and rainfall by four GCMs on the rate of change in yield (kg ha⁻¹) of maize cultivars under four dates of sowing and four RCP scenarios during 2010-2095 at Amritsar, Punjab

Date of sowing	PMH1				PMH2			
	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
CSIRO-Mk3-6-0 model								
28-May	(-) 16.1* (R ² =0.62)	(-) 46.03 (R ² =0.91)	(-) 51.93 (R ² =0.84)	(-) 68.23 (R ² =0.93)	(-) 22.62 (R ² =0.70)	(-) 44.46 (R ² =0.91)	(-) 53.20 (R ² =0.90)	(-) 70.74 (R ² =0.94)
6-June	(-) 26.24 (R ² =0.66)	(-) 70.51 (R ² =0.87)	(-) 80.13 (R ² =0.87)	(-) 79.94 (R ² =0.86)	(-) 4.02 (R ² =0.19)	(-) 47.00 (R ² =0.86)	(-) 44.44 (R ² =0.74)	(-) 54.52 (R ² =0.85)
15-June	(-) 26.07 (R ² =0.66)	(-) 68.80 (R ² =0.84)	(-) 71.41 (R ² =0.89)	(-) 103.39 (R ² =0.93)	(-) 14.65 (R ² =0.44)	(-) 38.12 (R ² =0.82)	(-) 45.54 (R ² =0.84)	(-) 77.35 (R ² =0.90)
24-June	(-) 0.13 (R ² =0.00)	(-) 39.06 (R ² =0.95)	(-) 37.50 (R ² =0.88)	(-) 75.31 (R ² =0.95)	(-) 1.22 (R ² =0.05)	(-) 44.64 (R ² =0.94)	(-) 41.30 (R ² =0.82)	(-) 81.31 (R ² =0.94)
FIO-ESM model								
28-May	(+) 13.40 (R ² =0.52)	(+) 2.26 (R ² =0.02)	(-) 21.51 (R ² =0.69)	(-) 64.29 (R ² =0.78)	(+) 2.51 (R ² =0.04)	(-) 3.21 (R ² =0.06)	(-) 28.99 (R ² =0.88)	(-) 60.30 (R ² =0.81)
6-June	(+) 8.89 (R ² =0.42)	(-) 0.93 (R ² =0.00)	(-) 29.35 (R ² =0.65)	(-) 82.83 (R ² =0.70)	(+) 11.84 (R ² =0.61)	(+) 5.43 (R ² =0.20)	(-) 12.55 (R ² =0.59)	(-) 49.10 (R ² =0.65)
15-June	(+) 5.33 (R ² =0.15)	(+) 4.66 (R ² =0.08)	(-) 30.37 (R ² =0.72)	(-) 77.97 (R ² =0.68)	(+) 14.89 (R ² =0.38)	(-) 0.78 (R ² =0.00)	(-) 32.09 (R ² =0.66)	(-) 65.98 (R ² =0.69)
24-June	(+) 2.06 (R ² =0.07)	(+) 1.76 (R ² =0.03)	(-) 22.82 (R ² =0.72)	(-) 54.55 (R ² =0.79)	(+) 3.00 (R ² =0.12)	(+) 2.13 (R ² =0.03)	(-) 17.58 (R ² =0.46)	(-) 50.25 (R ² =0.67)
IPSL-CM5A-MR model								
28-May	(-) 11.22 (R ² =0.29)	(+) 1.04 (R ² =0.01)	(-) 31.86 (R ² =0.67)	(-) 55.59 (R ² =0.87)	(-) 6.02 (R ² =0.23)	(-) 7.00 (R ² =0.28)	(-) 35.49 (R ² =0.80)	(-) 60.21 (R ² =0.93)
6-June	(-) 12.24 (R ² =0.32)	(-) 17.07 (R ² =0.47)	(-) 53.83 (R ² =0.66)	(-) 77.50 (R ² =0.82)	(-) 2.01 (R ² =0.02)	(+) 6.32 (R ² =0.31)	(-) 26.20 (R ² =0.50)	(-) 51.36 (R ² =0.79)
15-June	(-) 8.51 (R ² =0.13)	(-) 33.07 (R ² =0.60)	(-) 52.33 (R ² =0.78)	(-) 93.87 (R ² =0.87)	(-) 20.97 (R ² =0.39)	(-) 18.99 (R ² =0.58)	(-) 47.09 (R ² =0.95)	(-) 65.84 (R ² =0.88)
24-June	(-) 11.71 (R ² =0.27)	(-) 19.15 (R ² =0.75)	(-) 38.79 (R ² =0.93)	(-) 65.47 (R ² =0.96)	(-) 10.42 (R ² =0.22)	(-) 19.54 (R ² =0.64)	(-) 36.55 (R ² =0.86)	(-) 71.80 (R ² =0.90)
Ensemble model								
28-May	(-) 9.24 (R ² =0.42)	(-) 15.38 (R ² =0.59)	(-) 27.94 (R ² =0.79)	(-) 51.09 (R ² =0.87)	(-) 7.82 (R ² =0.36)	(-) 16.15 (R ² =0.75)	(-) 27.28 (R ² =0.82)	(-) 44.52 (R ² =0.92)
6-June	(+) 6.53 (R ² =0.11)	(-) 22.58 (R ² =0.42)	(-) 41.80 (R ² =0.80)	(-) 78.79 (R ² =0.87)	(-) 7.00 (R ² =0.50)	(-) 7.27 (R ² =0.35)	(-) 15.61 (R ² =0.68)	(-) 46.10 (R ² =0.79)
15-June	(-) 0.94 (R ² =0.00)	(-) 25.38 (R ² =0.60)	(-) 30.09 (R ² =0.70)	(-) 66.25 (R ² =0.81)	(-) 3.41 (R ² =0.05)	(-) 22.98 (R ² =0.66)	(-) 36.29 (R ² =0.71)	(-) 54.88 (R ² =0.85)
24-June	(-) 24.39 (R ² =0.78)	(-) 38.95 (R ² =0.84)	(-) 29.67 (R ² =0.68)	(-) 49.61 (R ² =0.83)	(-) 7.54 (R ² =0.44)	(-) 18.56 (R ² =0.84)	(-) 16.83 (R ² =0.57)	(-) 50.18 (R ² =0.80)

* Slope of curve = Kg ha⁻¹ per year

The model data for PMH1 (Table 4.6) in Amritsar simulated a decrease rate over the years for all four dates of sowing and under all four RCP scenarios except an increase (+1.04) was seen on 28th May under RCP4.5 with no significant coefficient of determination. The maximum decrease rate (kg ha⁻¹) was observed on 6th June (-12.24 and -53.83) for RCP2.6 and RCP6.0, respectively. The RCP4.5 and RCP8.5 showed maximum decrease rate (kg ha⁻¹) on 15th June (-33.07 and -93.87), respectively. The relationship for sowing dates and yield depicted a strong linear decrease over the years for almost all sowing dates and scenarios with highest R² values for RCP8.5. The yield decline for the cultivar ranged between -8.51 kg ha⁻¹ to -93.87 kg ha⁻¹. Similarly for PMH2 (Table 4.6) the maximum decrease rate (kg ha⁻¹) was observed on 15th June (-20.97 and -47.09) under RCP2.6 and RCP6.0, respectively while that for RCP4.5 (-19.54) and RCP8.5 (-71.80) on 24th June. The decrement rate was further supported by strong linear decrease as depicted by fairly strong R² values with strongest for RCP6.0 and RCP8.5. The range for the yield decrement was obtained between -2.01 kg ha⁻¹ to -71.80 kg ha⁻¹.

The model projected decline in yield for all the four scenarios and sowing dates and for both maize cultivars. PMH1 (Table 4.7) showed a slight increase on 15th June (2.58 kg ha⁻¹) while the range for the decline was -2.04 kg ha⁻¹ to -104.84 kg ha⁻¹. RCP4.5, RCP6.0 and RCP8.5 observed significant linear yield decline with high R² values. PMH2 (Table 4.7) observed a yield increment on 6th June (1.44 kg ha⁻¹) and 24th June (3.64 kg ha⁻¹). The decline in yield ranged -5.82 to -84.05 kg ha⁻¹. RCP8.5 observed a significant decline rate in yield for both the varieties.

Ensemble model

The projected yield trend (kg ha⁻¹) for PMH1 (Table 4.5) in Ludhiana under RCP 2.6 indicated maximum decrease on 28th May with high R² value (0.82) and minimum decrease on 24 June with very low R² (0.08) value. Under RCP 4.5 maximum decrease in yield is projected to occur on 6 June (-20.90 kg ha⁻¹) with good R² (0.60) and minimum decrease occurred on 15 June (-2.53 kg ha⁻¹) with no significant relation. Under RCP 6.0 and 8.5 maximum decrease (kg ha⁻¹) occurred on 15 June (-10.47 and -67.43), respectively. The decrease in yield ranged between -0.89 kg ha⁻¹ to -67.43 kg ha⁻¹ for PMH1 and -2.78 kg ha⁻¹ to -54.05 kg ha⁻¹ for PMH2. The regression model was found to be strong under RCP 8.5 with R² value ranging from 0.85-0.97. For PMH2 (Table 4.5) under the RCP 2.6 maximum reduction (kg ha⁻¹) in yield was observed on 28th May (-6.41) while for 4.5, 6.0 and 8.5 it was observed on 15 June (-16.16, -22.75 and -54.05), respectively. The lowest reduction (kg ha⁻¹) was indicated on 24 June (-3.16, -2.78 and -7.06) for RCP 2.6, 4.5 and 6.0 respectively while 6 June (-41.62 kg ha⁻¹) for RCP 8.5. High coefficient of determination was obtained for RCP 2.6, 4.5, 6.0 and 8.5 under all dates of sowing except 24th June for RCP 2.6, 4.5 and 6.0.

Table 4.7: Impact of projected temperature and rainfall by four GCMs on the rate of change in yield (kg ha⁻¹) of maize cultivars under four dates of sowing and four RCP scenarios during 2010-2095 at Patiala, Punjab

Date of sowing	PMH1				PMH2			
	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
CSIRO-Mk3-6-0 model								
28-May	(-) 16.72* (R ² =0.74)	(-) 58.91 (R ² =0.93)	(-) 54.98 (R ² =0.89)	(-) 76.48 (R ² =0.96)	(-) 23.22 (R ² =0.88)	(-) 48.56 (R ² =0.95)	(-) 49.54 (R ² =0.95)	(-) 71.62 (R ² =0.98)
6-June	(-) 17.15 (R ² =0.40)	(-) 79.96 (R ² =0.90)	(-) 78.73 (R ² =0.85)	(-) 86.58 (R ² =0.84)	(-) 12.13 (R ² =0.82)	(-) 51.84 (R ² =0.87)	(-) 47.63 (R ² =0.81)	(-) 61.50 (R ² =0.89)
15-June	(-) 13.85 (R ² =0.36)	(-) 72.54 (R ² =0.88)	(-) 72.54 (R ² =0.80)	(-) 114.42 (R ² =0.92)	(-) 20.74 (R ² =0.54)	(-) 49.60 (R ² =0.85)	(-) 55.72 (R ² =0.84)	(-) 86.44 (R ² =0.92)
24-June	(-) 17.16 (R ² =0.52)	(-) 38.22 (R ² =0.85)	(-) 41.71 (R ² =0.85)	(-) 67.61 (R ² =0.93)	(-) 13.22 (R ² =0.34)	(-) 39.21 (R ² =0.81)	(-) 39.54 (R ² =0.73)	(-) 73.72 (R ² =0.91)
FIO-ESM model								
28-May	(-) 6.52 (R ² =0.41)	(-) 20.41 (R ² =0.83)	(-) 33.41 (R ² =0.91)	(-) 75.31 (R ² =0.83)	(-) 8.55 (R ² =0.60)	(-) 17.45 (R ² =0.91)	(-) 31.06 (R ² =0.96)	(-) 62.74 (R ² =0.87)
6-June	(+) 2.21 (R ² =0.03)	(-) 4.32 (R ² =0.09)	(-) 28.61 (R ² =0.85)	(-) 89.32 (R ² =0.68)	(+) 3.23 (R ² =0.21)	(-) 11.41 (R ² =0.59)	(-) 19.12 (R ² =0.53)	(-) 64.31 (R ² =0.73)
15-June	(+) 5.90 (R ² =0.25)	(+) 1.02 (R ² =0.0)	(-) 27.80 (R ² =0.58)	(-) 79.40 (R ² =0.72)	(+) 10.61 (R ² =0.21)	(-) 10.02 (R ² =0.09)	(-) 18.90 (R ² =0.25)	(-) 77.12 (R ² =0.74)
24-June	(-) 25.90 (R ² =0.73)	(-) 6.28 (R ² =0.23)	(-) 25.92 (R ² =0.73)	(-) 55.20 (R ² =0.78)	(+) 3.33 (R ² =0.09)	(-) 0.73 (R ² =0.0)	(-) 16.00 (R ² =0.59)	(-) 53.33 (R ² =0.76)
IPSL-CM5A-MR model								
28-May	(-) 8.70 (R ² =0.41)	(-) 20.81 (R ² =0.80)	(-) 30.02 (R ² =0.70)	(-) 68.61 (R ² =0.84)	(-) 5.82 (R ² =0.41)	(-) 21.34 (R ² =0.79)	(-) 29.46 (R ² =0.91)	(-) 59.62 (R ² =0.92)
6-June	(-) 2.04 (R ² =0.0)	(-) 33.12 (R ² =0.69)	(-) 36.43 (R ² =0.64)	(-) 77.92 (R ² =0.79)	(+) 1.44 (R ² =0.02)	(-) 14.03 (R ² =0.85)	(-) 12.44 (R ² =0.45)	(-) 53.74 (R ² =0.77)
15-June	(+) 2.58 (R ² =0.04)	(-) 39.83 (R ² =0.66)	(-) 57.74 (R ² =0.70)	(-) 104.84 (R ² =0.85)	(-) 11.62 (R ² =0.27)	(-) 35.42 (R ² =0.66)	(-) 53.72 (R ² =0.79)	(-) 84.05 (R ² =0.96)
24-June	(-) 7.72 (R ² =0.15)	(-) 32.14 (R ² =0.76)	(-) 39.66 (R ² =0.65)	(-) 69.52 (R ² =0.76)	(+) 3.64 (R ² =0.05)	(-) 30.95 (R ² =0.66)	(-) 33.71 (R ² =0.58)	(-) 72.51 (R ² =0.85)
Ensemble model								
28-May	(-) 9.74 (R ² =0.60)	(-) 11.17 (R ² =0.64)	(-) 20.92 (R ² =0.78)	(-) 68.73 (R ² =0.90)	(-) 5.86 (R ² =0.41)	(-) 21.34 (R ² =0.79)	(-) 29.45 (R ² =0.91)	(-) 59.61 (R ² =0.92)
6-June	(-) 33.53 (R ² =0.75)	(-) 18.44 (R ² =0.71)	(-) 33.48 (R ² =0.75)	(-) 89.47 (R ² =0.79)	(+) 1.45 (R ² =0.02)	(-) 14.06 (R ² =0.85)	(-) 12.48 (R ² =0.45)	(-) 53.72 (R ² =0.77)
15-June	(+) 0.40 (R ² =0.00)	(-) 26.85 (R ² =0.70)	(-) 32.45 (R ² =0.54)	(-) 82.73 (R ² =0.89)	(-) 11.62 (R ² =0.27)	(-) 35.47 (R ² =0.66)	(-) 53.74 (R ² =0.79)	(-) 84.00 (R ² =0.96)
24-June	(+) 1.26 (R ² =0.03)	(-) 26.43 (R ² =0.85)	(-) 35.34 (R ² =0.72)	(-) 58.64 (R ² =0.90)	(+) 3.60 (R ² =0.05)	(-) 30.92 (R ² =0.66)	(-) 33.73 (R ² =0.58)	(-) 72.53 (R ² =0.85)

* Slope of curve = Kg ha⁻¹ per year

The yield trend for Amritsar under RCP2.6 and RCP4.5 was observed for PMH1 (Table 4.6) with maximum decrement (kg ha^{-1}) on 24th June (-24.39 and -38.95), respectively while for RCP6.0 and RCP8.5 it was observed on 6th June (-41.80 and -78.79), respectively. The yield decrease ranged between -0.94 kg ha^{-1} to $-78.79 \text{ kg ha}^{-1}$ with high R^2 values for all the scenarios. Under RCP2.6 the model simulated an increase by $+6.53 \text{ kg ha}^{-1}$ on 6th June with low R^2 (0.11). For PMH2 (Table 4.6) the model simulated maximum decrease rate of yield on 15th June (-22.98, -36.29 and -54.88) under RCP4.5, RCP6.0 and RCP8.5, respectively. The model depicts the decrement range for PMH2 to lie between -3.41 kg ha^{-1} to $-54.88 \text{ kg ha}^{-1}$. The linear regression model for all the four scenarios and dates of sowing depicted a strong linear decrease with high R^2 values.

The Ensemble model for Patiala projected yield decline under the four dates of sowing and the four scenarios. PMH1 (Table 4.7) observed an increase in yield on 15th June ($+0.40 \text{ kg ha}^{-1}$) and 24th June ($+1.26 \text{ kg ha}^{-1}$) under RCP2.6. The yield decline was observed between -9.74 kg ha^{-1} to $-89.47 \text{ kg ha}^{-1}$. Maximum decline rate was observed under RCP8.5 with highly significant linear decline. PMH2 (Table 4.7) observed an increase in yield on 6th June ($+1.45 \text{ kg ha}^{-1}$) and 24th June ($+3.60 \text{ kg ha}^{-1}$) under RCP2.6. The yield decline for the cultivar ranged between -5.86 kg ha^{-1} to 84.00 kg ha^{-1} . RCP4.5, RCP6.0 and RCP8.5 observed a significant linear decline in yield under all the scenarios and sowing dates.

Prabhjyot-Kaur *et al* (2020) showed change in maximum ($^{\circ}\text{C}$) and minimum temperature ($^{\circ}\text{C}$) on an average to be high for Ludhiana (+0.7, +1.7, +1.8 and +3.4) and (+3.2, +3.4, +4.6 and +6.4); Amritsar (+0.6, +1.7, +1.8 and +3.5) and (+3.2, +4.3, +4.6 and +6.4); Patiala (+1.0, +2.0, +2.1, +3.7) and (+2.4, +3.7, +3.8 and +5.5) under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively while the rainfall was predicted to show high variability at all locations for the end-century during the *kharif* season. The variability of rainfall and rise of minimum and maximum temperature impacted the future yield with maximum decline observed in Patiala district of this zone.

Agroclimatic zone IV (Bathinda)

CSIRO Mk-36-0 model

The yield pattern as predicted by the model showed a significant decreasing trend in yield over the period of 85 years. Under RCP2.6 the model determined a yield increment (kg ha^{-1}) for the cultivars PMH1 (Table 4.8) and PMH2 (Table 4.8) on 24th June ($+0.96$ and $+5.38$), respectively. The maximum decrease (kg ha^{-1}) in yield was obtained on 6th June (-10.55 and -42.52), respectively under RCP2.6 and RCP6.0 while under RCP4.5 and RCP8.5 it was observed on 15th June ($-29.19 \text{ kg ha}^{-1}$ and $-47.33 \text{ kg ha}^{-1}$), respectively. The coefficient of determination was high for all the scenarios and sowing dates depicting a strong linear relationship. For PMH2 the maximum decrease in yield was observed on 15th June

(-9.16 kg ha⁻¹ and -31.83 kg ha⁻¹) under RCP2.6 and RCP4.5, respectively while on 28th May (-32.78 kg ha⁻¹) under RCP6.0 and on 15th June (-38.18 kg ha⁻¹) under RCP8.5. The decrease in yield trend was supported by high coefficient of determination indicating a strong linear relation. RCP8.5 depicted a significant decrease in yield under the four dates of sowing. The range of yield decline -8.7 to -47.3 kg ha⁻¹ and -4.7 to -38.2 kg ha⁻¹ for PMH1 and PMH2, respectively.

FIO-ESM model

The model projected increase (kg ha⁻¹) in yield under RCP2.6 on all the four dates of sowing for both cultivars PMH1 and PMH2 except on 28th May (-1.00) for PMH1 (Table 4.8). A significant decrease (kg ha⁻¹) in yield under all the four scenarios ranging between -1.33 to -47.17 was obtained. Also, the model predicted a slight increase (kg ha⁻¹) on 6th June (+2.67 kg ha⁻¹) under RCP4.5. Maximum decrease (kg ha⁻¹) in yield was observed on 24th June (-10.73) under RCP4.5 and on 15th June (-19.13 and -47.17) under RCP6.0 and RCP8.5, respectively. The coefficient of determination was high for RCP8.5 depicting a linear decrease while weak for RCP4.5. For PMH2 (Table 4.8) the yield trend depicted an increase on 24th June (+1.73 kg ha⁻¹) while maximum decrease on 28th May (-2.90 kg ha⁻¹). The other two scenarios observed maximum decrease (-15.71 kg ha⁻¹ and -33.17 kg ha⁻¹) on 15th June under RCP6.0 and RCP8.5, respectively. The decline in yield ranged between -11.4 kg ha⁻¹ to -35.1 kg ha⁻¹. The high R² values for RCP6.0 and RCP8.5 represented linear decrease in yield while RCP4.5 showed weak linear relationship.

IPSL-CM5A-MR model

The model observed maximum reduction (kg ha⁻¹) in yield/good coefficient of determination (Table 2) under the four scenarios RCP 2.6, 4.5, 6.0 and 8.5 on 15 June (-13.83/ R²=0.30, -16.95/ R²=0.90, -25.61/ R²=0.69 and -27.75/ R²=0.68), respectively for PMH1 (Table 4.8) representing a linear decrease in yield with date of sowing over the years for all the scenarios. However, an increase (+2.22 kg ha⁻¹) was observed for second sowing date under RCP4.5 but with a weak coefficient of determination. High decrease rate was obtained for all dates of sowing under RCP 8.5 and RCP6.0 with high coefficient of determination. The yield reduction for PMH2 (Table 4.8) was observed to increase on 24th June (+3.23 kg ha⁻¹) under RCP2.6 and on 28th May (+0.63 kg ha⁻¹) under RCP4.5 with weak coefficient of determination. Maximum yield decrease was observed on 28th May (-4.79 kg ha⁻¹ and -29.18 kg ha⁻¹) for RCP2.6 and RCP8.5, respectively while the other scenarios showed the maximum decrease on 15th June for RCP4.5 (-3.61 kg ha⁻¹) and RCP6.0 (-21.83 kg ha⁻¹). The coefficient of determination was depicted to be higher for RCP6.0 and RCP8.5 while weaker for the other two scenarios. The decline range for PMH1 was -1.6 to -25.6 kg ha⁻¹ and for PMH2 was -1.2 to -29.2 kg ha⁻¹.

Ensemble model

The yield trend as projected by the model depicted a slight increase with no significant coefficient of determination in yield on 28th May (+0.23 kg ha⁻¹) and 24th June (+0.80 kg ha⁻¹) for PMH1 (Table 4.8) under RCP2.6. Maximum decrease in the yield was observed on 15th June (-1.77 kg ha⁻¹) for RCP2.6 and on 6th June (-9.43 kg ha⁻¹) for RCP4.5

Table 4.8: Impact of projected temperature and rainfall by four GCMs on the rate of change in yield (kg ha⁻¹) of maize cultivars under four dates of sowing and four RCP scenarios during 2010-2095 at Bathinda, Punjab

Date of sowing	PMH1				PMH2			
	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
CSIRO-Mk3-6-0 model								
28-May	(-) 9.31* (R ² =0.32)	(-) 18.57 (R ² =0.91)	(-) 37.04 (R ² =0.95)	(-) 39.32 (R ² =0.94)	(-) 6.28 (R ² =0.24)	(-) 22.20 (R ² =0.89)	(-) 32.78 (R ² =0.92)	(-) 36.34 (R ² =0.89)
6-June	(-) 10.55 (R ² =0.40)	(-) 8.67 (R ² =0.28)	(-) 42.52 (R ² =0.90)	(-) 36.10 (R ² =0.83)	(-) 4.68 (R ² =0.29)	(-) 7.99 (R ² =0.37)	(-) 8.81 (R ² =0.53)	(-) 33.88 (R ² =0.92)
15-June	(-) 10.30 (R ² =0.39)	(-) 29.19 (R ² =0.88)	(-) 36.38 (R ² =0.96)	(-) 47.33 (R ² =0.93)	(-) 9.16 (R ² =0.35)	(-) 31.83 (R ² =0.81)	(-) 25.01 (R ² =0.83)	(-) 38.18 (R ² =0.86)
24-June	(+) 0.96 (R ² =0.04)	(-) 13.32 (R ² =0.77)	(-) 23.18 (R ² =0.83)	(-) 24.25 (R ² =0.84)	(+) 5.38 (R ² =0.24)	(-) 27.36 (R ² =0.92)	(-) 25.40 (R ² =0.96)	(-) 36.92 (R ² =0.84)
FIO-ESM model								
28-May	(+) 4.17 (R ² =0.15)	(-) 1.88 (R ² =0.01)	(-) 16.34 (R ² =0.54)	(-) 37.35 (R ² =0.64)	(-) 1.00 (R ² =0.01)	(-) 2.90 (R ² =0.04)	(-) 14.45 (R ² =0.60)	(-) 35.11 (R ² =0.68)
6-June	(+) 5.54 (R ² =0.22)	(+) 2.67 (R ² =0.02)	(-) 17.82 (R ² =0.30)	(-) 36.61 (R ² =0.60)	(+) 3.15 (R ² =0.10)	(-) 1.74 (R ² =0.03)	(-) 14.00 (R ² =0.49)	(-) 29.83 (R ² =0.68)
15-June	(+) 8.77 (R ² =0.18)	(-) 1.33 (R ² =0.00)	(-) 19.13 (R ² =0.32)	(-) 47.17 (R ² =0.61)	(+) 7.23 (R ² =0.20)	(-) 2.80 (R ² =0.03)	(-) 15.71 (R ² =0.48)	(-) 33.17 (R ² =0.55)
24-June	(+) 2.75 (R ² =0.09)	(-) 10.73 (R ² =0.75)	(-) 2.33 (R ² =0.08)	(-) 12.03 (R ² =0.76)	(+) 9.80 (R ² =0.37)	(+) 1.73 (R ² =0.02)	(-) 11.43 (R ² =0.57)	(-) 23.45 (R ² =0.71)
IPSL-CM5A-MR model								
28-May	(-) 6.15 (R ² =0.15)	(-) 1.85 (R ² =0.02)	(-) 22.10 (R ² =0.76)	(-) 22.66 (R ² =0.62)	(-) 4.79 (R ² =0.16)	(+) 0.63 (R ² =0)	(-) 16.94 (R ² =0.78)	(-) 29.18 (R ² =0.76)
6-June	(-) 1.26 (R ² =0.01)	(+) 2.22 (R ² =0.05)	(-) 20.55 (R ² =0.60)	(-) 27.16 (R ² =0.64)	(-) 1.18 (R ² =0.02)	(-) 1.31 (R ² =0.05)	(-) 14.48 (R ² =0.53)	(-) 21.02 (R ² =0.75)
15-June	(-) 13.83 (R ² =0.30)	(-) 16.95 (R ² =0.90)	(-) 25.61 (R ² =0.69)	(-) 27.75 (R ² =0.68)	(-) 3.55 (R ² =0.06)	(-) 3.61 (R ² =0.04)	(-) 21.83 (R ² =0.80)	(-) 16.22 (R ² =0.54)
24-June	(-) 0.37 (R ² =0.00)	(-) 2.64 (R ² =0.07)	(-) 5.89 (R ² =0.27)	(-) 19.47 (R ² =0.64)	(+) 3.23 (R ² =0.05)	(-) 3.59 (R ² =0.12)	(-) 7.39 (R ² =0.30)	(-) 27.23 (R ² =0.70)
Ensemble model								
28-May	(+) 0.23 (R ² =0.00)	(-) 9.21 (R ² =0.43)	(-) 16.41 (R ² =0.61)	(-) 33.02 (R ² =0.88)	(-) 0.03 (R ² =0)	(-) 5.82 (R ² =0.33)	(-) 12.07 (R ² =0.59)	(-) 27.86 (R ² =0.85)
6-June	(-) 0.94 (R ² =0.01)	(-) 9.43 (R ² =0.47)	(-) 17.55 (R ² =0.50)	(-) 35.37 (R ² =0.78)	(-) 0.20 (R ² =0)	(-) 7.31 (R ² =0.39)	(-) 12.23 (R ² =0.47)	(-) 26.99 (R ² =0.78)
15-June	(-) 1.77 (R ² =0.01)	(-) 8.27 (R ² =0.15)	(-) 21.02 (R ² =0.58)	(-) 44.47 (R ² =0.84)	(-) 0.84 (R ² =0)	(+) 1.09 (R ² =0)	(-) 13.80 (R ² =0.40)	(-) 32.72 (R ² =0.72)
24-June	(+) 0.80 (R ² =0.04)	(-) 6.30 (R ² =0.68)	(-) 4.30 (R ² =0.39)	(-) 18.82 (R ² =0.83)	(+) 0.43 (R ² =0)	(-) 12.66 (R ² =0.76)	(-) 11.37 (R ² =0.64)	(-) 28.52 (R ² =0.86)

* Slope of curve = Kg ha⁻¹ per year

while it was observed to decrease on 24th June (-21.02 kg ha⁻¹ and -44.47 kg ha⁻¹) for RCP6.0 and RCP8.5, respectively.

The R² values were observed to be high for RCP4.5, RCP6.0 and RCP8.5 with strong linear relationship and weaker for the RCP2.6. The yield trend for PMH2 (Table 4.8) depicted an increase (kg ha⁻¹) on 24th June (+0.43) under RCP2.6 and on 15th June (+1.09) under RCP4.5. The maximum decrease in yield was observed on 15th June (-0.84, -13.80 and -32.72) for RCP2.6, RCP6.0 and RCP8.5, respectively and on 24th June (-12.66) under RCP4.5. Although, the coefficient of determination showed a strong linear relationship between the dates of sowing and scenarios with high R² values but for RCP2.6 these values were nil. The range for the yield decline was -0.2 to -21.0 kg ha⁻¹ and 0 to -28.5 kg ha⁻¹ for PMH1 and PMH2, respectively.

Prabhjyot-Kaur *et al* (2020) The end-century observed rise in maximum as well as minimum temperature under RCP2.6 (0.3°C and 2.8°C), RCP4.5 (1.3°C and 4.2°C), RCP6.0 (1.4°C and 4.2°C), RCP8.5 (3.1°C and 5.8°C), respectively while the rainfall was also projected to decrease during the *kharif* season depicting the high temperature and decreasing rainfall to impact the maize yield under future scenarios. The region was already experiencing lower rainfall and under future scenarios the models predict it to decrease which together with rising temperatures would shorten the maize crop thus affecting the yield.

Agroclimatic zone V (Abohar and Faridkot)

CSIRO Mk-36-0 model

At Abohar PMH1 observed (Table 4.9) significant decline in yield under all the scenarios ranging -4.2 kg ha⁻¹ to -31.3 kg ha⁻¹. The maximum decrease/ coefficient of determination was observed to be strong for 28th May (-33.5 kg ha⁻¹/0.81), 6th June (31.2 kg ha⁻¹/ 0.72), 15th June (39.2 kg ha⁻¹/ 0.79) and 24th June (20.8 kg ha⁻¹/ 0.72) under RCP8.5 scenario. The PMH2 (Table 4.9) cultivar depicted a yield decline ranging -11.7 kg ha⁻¹ to -45.7 kg ha⁻¹. The decrease trend observed for 15th (-6.2 kg ha⁻¹) and 24th June (-0.7 kg ha⁻¹) was lower but with no coefficient of determination under RCP2.6. The other three scenarios RCP4.5, RCP6.0 and RCP8.5 observed large decrease in yield with strong coefficient of determination.

A significant decrease in yield was observed at Faridkot under the four scenarios with high coefficient of determination for PMH1 (Table 4.10). The yield predictions showed the yield decrement in the range between -3.13 kg ha⁻¹ to -97.00 kg ha⁻¹. The results do depict almost complete failure of crop under RCP8.5 where no restriction on greenhouse gases will be there with a strong linear decline (R²=0.82). All the dates of sowing showed high reduction in yield under this scenario. The model predicted the yield to decline maximum on 15th June

(-17.75 kg ha⁻¹ and -97.00 kg ha⁻¹) under RCP2.6 and RCP8.5, respectively while under RCP4.5 and RCP6.0 these were obtained on 6th June (-82.00 kg ha⁻¹ and -79.61 kg ha⁻¹), respectively. A high coefficient of determination was found for the four scenarios depicting a strong linear decline in yield. The projected model yield depicted a significant decline in yield for PMH2 (Table 4.10) for all dates of sowing and scenarios except on 24th June when an increase (+1.82 kg ha⁻¹) was observed. A maximum yield decline was observed on 28th May under RCP2.6 (-16.47 kg ha⁻¹) and on 6th June for other three scenarios RCP4.5, RCP6.0 and RCP8.5, respectively. PMH2 showed significant decline in yield with high R² values determining a strong linear decrease in maize yield. Maximum decline was observed under RCP6.0 and RCP8.5. The yield decline for PMH2 was observed in the range -9.8 to 92.1 kg ha⁻¹.

FIO-ESM model

The PMH1 (Table 4.9) at Abohar showed a yield increase on 28th May (+2.3 kg ha⁻¹), and 6th June (+4.8 kg ha⁻¹) but with very weak coefficient of determination under RCP2.6. However the significant decline in yield ranged between -6.2 kg ha⁻¹ to 47.3 kg ha⁻¹. The yield decline trend was high and significant under RCP8.5 scenario. The PMH2 (Table 4.9) cultivar at Abohar observed decrement in yield ranging -7.9 kg ha⁻¹ to -40.7 kg ha⁻¹. The maximum decrease for PMH2 was observed under RCP8.5 with strong linear decline.

At Faridkot the model observed a slight increase (+10.39 kg ha⁻¹, +9.97 kg ha⁻¹ and +8.79 kg ha⁻¹) in maize cultivar PMH1 (Table 4.10) yield under RCP2.6 on 28th May, 6th June and 15th June, respectively while under RCP4.5 this increase (+5.27 kg ha⁻¹, +2.32 kg ha⁻¹, +16.90 kg ha⁻¹ and +1.19 kg ha⁻¹) was observed on the respective four sowing dates. The other two scenarios RCP6.0 and RCP8.5 depicted major decline ranging between -10.71 kg ha⁻¹ to -88.49 kg ha⁻¹ with strong coefficient of determination depicting strong linear decrease during these scenarios. For PMH2 (Table 4.10) the simulated maize yield was observed to increase (+5.07 kg ha⁻¹ and +11.12 kg ha⁻¹), respectively for 6th June and 15th June under RCP2.6. Similar slight increase was observed on 15th June (+4.30 kg ha⁻¹) under RCP4.5 and maximum decrease on 28th May (-7.89 kg ha⁻¹). The decrement range for the four RCPs for all the four sowing dates ranged between -1.38 kg ha⁻¹ to -86.01 kg ha⁻¹. This major decline in yield for scenarios RCP6.0 and RCP8.5 was supported by high R² value depicting a strong linear decline in yield. RCP2.6 and RCP4.5 showed a weak linear decrease.

IPSL-CM5A-MR model

The model projected significant yield increase on 24th June for PMH1 (+5.7 kg ha⁻¹) and PMH2 (+10.4 kg ha⁻¹) under RCP2.6. The yield decline observed for PMH1 (Table 4.9) ranged -6.2 kg ha⁻¹ to 32.1 kg ha⁻¹. The decline in yield was higher under RCP8.5 for all the

dates of sowing with good coefficient of determination. For PMH2 (Table 4.9) the yield decline ranged -5.3 kg ha^{-1} to 29.9 kg ha^{-1} . The yield decline was higher under RCP8.5 with strong coefficient of determination.

An increment in the maize yield of cultivar PMH1 (Table 4.10) for Faridkot was observed on the four dates of sowing 28th May ($+8.26 \text{ kg ha}^{-1}$), 6th June ($+0.99 \text{ kg ha}^{-1}$), 15th June ($+12.93 \text{ kg ha}^{-1}$) and 24th June ($+1.82 \text{ kg ha}^{-1}$) showed an increment ($+8.26 \text{ kg ha}^{-1}$, $+0.99$). The yield reduction for the other three scenarios ranged between -3.54 kg ha^{-1} to $-79.92 \text{ kg ha}^{-1}$ depicting significant yield decline with high coefficient of determination indicating a linear decline in yield. The lower decline in yield was observed on 24th June while maximum yield decline was observed under RCP8.5. The PMH2 (Table 4.10) cultivar observed a low decline in yield under RCP2.6 with weak coefficient of determination and slight increase ($+2.20 \text{ kg ha}^{-1}$ and $+2.02 \text{ kg ha}^{-1}$) was observed on 15th June and 24th June. The yield decline ranged between -1.55 kg ha^{-1} to $-72.74 \text{ kg ha}^{-1}$ with maximum for RCP2.6 and RCP4.5. The coefficient of determination was fairly high for RCP6.0 and RCP8.5 which depicted a strong linear decline while under RCP2.6 and RCP4.5 these values depicted a weak linear decline.

Ensemble model

The model projected a yield decrement for PMH1 (Table 4.9) ranging -3.8 kg ha^{-1} to -34.7 kg ha^{-1} . The RCP4.5, RCP6.0 and RCP8.5 showed significant yield decline with strong coefficient of determination. The PMH2 cultivar (Table 4.9) for the same location observed a significant yield decline under the same scenarios ranging -7.2 kg ha^{-1} to -28.9 kg ha^{-1} while RCP2.6 showed yield decline and increase but with very weak coefficient of determination.

The model observed yield increment (kg ha^{-1}) in PMH1 (Table 4.10) cultivar for Faridkot under RCP2.6 on 28th May ($+4.96 \text{ kg ha}^{-1}$), 6th June ($+6.80 \text{ kg ha}^{-1}$), 15th June ($+17.49 \text{ kg ha}^{-1}$) and 24th June ($+0.98 \text{ kg ha}^{-1}$). The yield decrease for the cultivar ranged between -9.30 to $-96.49 \text{ kg ha}^{-1}$. The coefficient of determination was fairly high for the three scenarios which observed decline in yield. Maximum decrease and high R^2 values were obtained under RCP8.5 for the four dates of sowing. PMH2 (Table 4.10) showed an increased yield on 6th June ($+5.86 \text{ kg ha}^{-1}$) and 15th June ($+7.37 \text{ kg ha}^{-1}$) under RCP2.6 and on 24th June ($+5.80 \text{ kg ha}^{-1}$) for RCP4.5. The observed yield decrement ranged between -0.51 kg ha^{-1} for RCP2.6 to $-91.35 \text{ kg ha}^{-1}$ for RCP8.5. The fairly good coefficient of determination for RCP4.5, RCP6.0 and RCP8.5 depicts a strong linear decrease in yield while weak R^2 values were observed for RCP2.6.

Prabhjyot-Kaur *et al* (2020) indicated that the end-century observed change in maximum as well as minimum temperature under RCP2.6 ($+0.5^{\circ}\text{C}$ and $+2.8^{\circ}\text{C}$), RCP4.5 ($+1.6^{\circ}\text{C}$ and $+4.1^{\circ}\text{C}$), RCP6.0 ($+1.6^{\circ}\text{C}$ and $+4.2^{\circ}\text{C}$), RCP8.5 ($+3.4^{\circ}\text{C}$ and $+5.9^{\circ}\text{C}$) at Abohar,

respectively and under RCP2.6 (+0.4°C and -0.4°C), RCP4.5 (+1.5°C and +0.8°C), RCP6.0 (+1.4°C and +1.0°C), RCP8.5 (+3.2°C and +2.7°C) at Faridkot, respectively while the rainfall was also projected to decrease during the *kharif* season at Faridkot and increase from the baseline at Abohar. The zone on an average receives <500mm of rainfall under current scenario and its high variability with temperature would impact the yield and critical stages of crop.

The four GCMs show a decrease in yield for all the scenarios under all the current experimental dates being followed except FIO-ESM which determined an increase in yield for all the zones. Srivastava *et al* (2021) evaluated the climate change impact on maize yield using CERES-Maize for the eastern India which is a tropical region and found that the projected results depicted the decline in yield under the four RCPs 2.6 (-15.20%), 4.5 (-18.54%), 6.0 (-24.75%) and 8.5 (-26.83%) to be higher under irrigated condition for the end century (2051-80). As per the hypothesis for the scenarios, under RCP8.5 a constant increase in temperature and greenhouse gas levels has been projected therefore a large decrease in yield was obtained for all the four GCMs under all the four dates of sowing with high coefficient of determination. Navneet-Kaur and Kaur (2019) reported the maize yield trend under special report on emission scenarios (SRES) for Punjab and found the yield decline to be higher by the end of 21st century under A1B scenario (55 to 83 kg ha⁻¹ per year) and A2 scenario (54 to 80 kg ha⁻¹ per year) as they are high emission scenario.

Table 4.9: Impact of projected temperature and rainfall by four GCMs on the rate of change in yield (kg ha⁻¹) of maize cultivars under four dates of sowing and four RCP scenarios during 2010-2095 at Abohar, Punjab

Date of sowing	PMH1				PMH2			
	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
CSIRO-Mk3-6-0 model								
28-May	(-) 14.89* (R ² =0.50)	(-) 22.22 (R ² =0.65)	(-) 24.57 (R ² =0.65)	(-) 33.49 (R ² =0.81)	(-) 11.74 (R ² =0.55)	(-) 25.62 (R ² =0.74)	(-) 22.95 (R ² =0.68)	(-) 29.29 (R ² =0.80)
6-June	(-) 27.61 (R ² =0.68)	(-) 29.36 (R ² =0.66)	(-) 31.23 (R ² =0.68)	(-) 31.22 (R ² =0.72)	(-) 20.42 (R ² =0.78)	(-) 23.40 (R ² =0.74)	(-) 24.21 (R ² =0.77)	(-) 28.32 (R ² =0.84)
15-June	(-) 12.79 (R ² =0.28)	(-) 16.76 (R ² =0.57)	(-) 25.35 (R ² =0.55)	(-) 39.18 (R ² =0.79)	(-) 6.24 (R ² =0.07)	(-) 33.51 (R ² =0.61)	(-) 40.79 (R ² =0.59)	(-) 39.86 (R ² =0.66)
24-June	(-) 5.73 (R ² =0.22)	(-) 4.18 (R ² =0.18)	(-) 10.42 (R ² =0.31)	(-) 20.82 (R ² =0.72)	(-) 0.68 (R ² =0.0)	(-) 23.42 (R ² =0.72)	(-) 27.51 (R ² =0.65)	(-) 45.58 (R ² =0.84)
FIO-ESM model								
28-May	(+) 2.32 (R ² =0.01)	(-) 2.30 (R ² =0.01)	(-) 16.3 (R ² =0.37)	(-) 35.2 (R ² =0.64)	(+) 0.43 (R ² =0.00)	(-) 3.15 (R ² =0.03)	(-) 15.88 (R ² =0.40)	(-) 40.72 (R ² =0.70)
6-June	(+) 4.80 (R ² =0.06)	(-) 1.04 (R ² =0.0)	(-) 21.22 (R ² =0.41)	(-) 36.37 (R ² =0.62)	(+) 1.79 (R ² =0.02)	(-) 3.37 (R ² =0.06)	(-) 18.54 (R ² =0.56)	(-) 31.58 (R ² =0.71)
15-June	(-) 5.08 (R ² =0.02)	(-) 7.47 (R ² =0.06)	(-) 21.11 (R ² =0.33)	(-) 47.29 (R ² =0.58)	(+) 0.27 (R ² =0.00)	(-) 7.94 (R ² =0.13)	(-) 4.93 (R ² =0.05)	(-) 36.92 (R ² =0.57)
24-June	(-) 2.11 (R ² =0.02)	(-) 3.97 (R ² =0.1)	(-) 6.17 (R ² =0.30)	(-) 12.68 (R ² =0.45)	(-) 10.39 (R ² =0.09)	(-) 9.35 (R ² =0.16)	(-) 10.24 (R ² =0.24)	(-) 28.70 (R ² =0.62)
IPSL-CM5A-MR model								
28-May	(-) 3.81 (R ² =0.03)	(-) 4.95 (R ² =0.12)	(-) 18.22 (R ² =0.48)	(-) 16.39 (R ² =0.41)	(-) 2.73 (R ² =0.02)	(-) 5.33 (R ² =0.16)	(-) 16.71 (R ² =0.47)	(-) 29.91 (R ² =0.73)
6-June	(-) 1.39 (R ² =0.01)	(-) 3.61 (R ² =0.11)	(-) 17.14 (R ² =0.33)	(-) 28.61 (R ² =0.65)	(-) 5.68 (R ² =0.20)	(-) 1.51 (R ² =0.05)	(-) 15.66 (R ² =0.52)	(-) 20.14 (R ² =0.71)
15-June	(-) 2.90 (R ² =0.01)	(-) 4.81 (R ² =0.09)	(-) 32.15 (R ² =0.78)	(-) 21.99 (R ² =0.50)	(+) 5.40 (R ² =0.08)	(-) 11.05 (R ² =0.17)	(-) 11.05 (R ² =0.26)	(-) 17.39 (R ² =0.40)
24-June	(+) 5.72 (R ² =0.25)	(-) 6.19 (R ² =0.19)	(-) 10.29 (R ² =0.36)	(-) 13.68 (R ² =0.46)	(+) 10.39 (R ² =0.31)	(-) 12.58 (R ² =0.41)	(-) 11.36 (R ² =0.28)	(-) 28.4 (R ² =0.67)
Ensemble model								
28-May	(-) 1.60 (R ² =0.01)	(-) 11.04 (R ² =0.32)	(-) 15.43 (R ² =0.41)	(-) 24.73 (R ² =0.69)	(-) 0.14 (R ² =0.00)	(-) 7.25 (R ² =0.30)	(-) 10.65 (R ² =0.41)	(-) 27.55 (R ² =0.75)
6-June	(+) 1.68 (R ² =0.01)	(-) 18.65 (R ² =0.44)	(-) 22.19 (R ² =0.47)	(-) 32.20 (R ² =0.68)	(-) 0.97 (R ² =0.01)	(-) 16.82 (R ² =0.62)	(-) 19.91 (R ² =0.63)	(-) 27.88 (R ² =0.79)
15-June	(-) 1.48 (R ² =0.01)	(-) 11.38 (R ² =0.32)	(-) 19.64 (R ² =0.47)	(-) 34.72 (R ² =0.74)	(-) 1.17 (R ² =0.01)	(-) 10.76 (R ² =0.28)	(-) 15.67 (R ² =0.38)	(-) 28.87 (R ² =0.65)
24-June	(-) 0.82 (R ² =0.03)	(+) 0.94 (R ² =0.01)	(-) 3.80 (R ² =0.14)	(-) 10.73 (R ² =0.57)	(+) 5.65 (R ² =0.26)	(-) 8.52 (R ² =0.35)	(-) 11.12 (R ² =0.33)	(-) 28.24 (R ² =0.71)

* Slope of curve = Kg ha⁻¹ per year

Table 4.10: Impact of projected temperature and rainfall by four GCMs on the rate of change in yield (kg ha⁻¹) of maize cultivars under four dates of sowing and four RCP scenarios during 2010-2095 at Faridkot, Punjab

Date of sowing	PMH1				PMH2			
	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
CSIRO-Mk3-6-0 model								
28-May	(-) 20.07* (R ² =0.36)	(-) 58.20 (R ² =0.76)	(-) 56.49 (R ² =0.67)	(-) 81.88 (R ² =0.85)	(-) 16.47 (R ² =0.28)	(-) 55.73 (R ² =0.79)	(-) 55.05 (R ² =0.69)	(-) 80.35 (R ² =0.86)
6-June	(-) 10.51 (R ² =0.17)	(-) 82.00 (R ² =0.79)	(-) 79.61 (R ² =0.71)	(-) 91.03 (R ² =0.78)	(-) 14.53 (R ² =0.27)	(-) 75.68 (R ² =0.80)	(-) 74.11 (R ² =0.72)	(-) 92.07 (R ² =0.83)
15-June	(-) 17.75 (R ² =0.20)	(-) 61.02 (R ² =0.69)	(-) 59.86 (R ² =0.60)	(-) 97.00 (R ² =0.82)	(-) 9.84 (R ² =0.12)	(-) 54.20 (R ² =0.71)	(-) 54.20 (R ² =0.68)	(-) 87.64 (R ² =0.83)
24-June	(-) 3.13 (R ² =0.19)	(-) 27.45 (R ² =0.57)	(-) 23.24 (R ² =0.41)	(-) 55.40 (R ² =0.79)	(+) 1.82 (R ² =0.22)	(-) 20.61 (R ² =0.41)	(-) 15.34 (R ² =0.22)	(-) 63.16 (R ² =0.74)
FIO-ESM model								
28-May	(+) 10.39 (R ² =0.17)	(+) 5.27 (R ² =0.03)	(-) 15.12 (R ² =0.22)	(-) 71.87 (R ² =0.64)	(-) 1.38 (R ² =0.00)	(-) 7.89 (R ² =0.05)	(-) 26.17 (R ² =0.38)	(-) 74.99 (R ² =0.66)
6-June	(+) 9.97 (R ² =0.13)	(+) 2.32 (R ² =0.01)	(-) 20.07 (R ² =0.30)	(-) 88.49 (R ² =0.64)	(+) 5.07 (R ² =0.04)	(-) 1.78 (R ² =0.00)	(-) 24.86 (R ² =0.49)	(-) 86.01 (R ² =0.67)
15-June	(+) 8.79 (R ² =0.06)	(+) 16.90 (R ² =0.26)	(-) 10.71 (R ² =0.12)	(-) 68.44 (R ² =0.56)	(+) 11.12 (R ² =0.15)	(+) 4.30 (R ² =0.02)	(-) 22.19 (R ² =0.30)	(-) 67.54 (R ² =0.59)
24-June	(-) 0.16 (R ² =0.00)	(+) 1.19 (R ² =0.02)	(-) 13.67 (R ² =0.87)	(-) 37.62 (R ² =0.74)	(-) 5.12 (R ² =0.34)	(-) 2.56 (R ² =0.21)	(-) 8.76 (R ² =0.64)	(-) 40.78 (R ² =0.69)
IPSL-CM5A-MR model								
28-May	(+) 8.26 (R ² =0.11)	(-) 6.93 (R ² =0.03)	(-) 25.07 (R ² =0.41)	(-) 61.79 (R ² =0.67)	(-) 4.99 (R ² =0.02)	(-) 11.55 (R ² =0.18)	(-) 29.91 (R ² =0.50)	(-) 58.14 (R ² =0.71)
6-June	(+) 0.99 (R ² =0.00)	(-) 5.89 (R ² =0.05)	(-) 21.76 (R ² =0.40)	(-) 79.92 (R ² =0.69)	(-) 2.01 (R ² =0.00)	(-) 4.85 (R ² =0.03)	(-) 24.45 (R ² =0.51)	(-) 72.74 (R ² =0.67)
15-June	(+) 12.93 (R ² =0.23)	(-) 20.97 (R ² =0.22)	(-) 23.17 (R ² =0.23)	(-) 76.16 (R ² =0.70)	(+) 2.20 (R ² =0.00)	(-) 12.12 (R ² =0.14)	(-) 23.06 (R ² =0.34)	(-) 61.25 (R ² =0.72)
24-June	(+) 1.82 (R ² =0.02)	(-) 12.93 (R ² =0.27)	(-) 3.54 (R ² =0.02)	(-) 47.43 (R ² =0.68)	(+) 2.02 (R ² =0.16)	(-) 1.55 (R ² =0.01)	(-) 5.61 (R ² =0.30)	(-) 49.90 (R ² =0.56)
Ensemble model								
28-May	(+) 4.96 (R ² =0.04)	(-) 18.07 (R ² =0.30)	(-) 18.54 (R ² =0.24)	(-) 77.37 (R ² =0.88)	(-) 0.51 (R ² =0.00)	(-) 22.31 (R ² =0.37)	(-) 26.93 (R ² =0.39)	(-) 73.58 (R ² =0.90)
6-June	(+) 6.80 (R ² =0.08)	(-) 16.19 (R ² =0.26)	(-) 23.68 (R ² =0.35)	(-) 96.49 (R ² =0.84)	(+) 5.86 (R ² =0.06)	(-) 13.53 (R ² =0.26)	(-) 22.96 (R ² =0.36)	(-) 91.35 (R ² =0.86)
15-June	(+) 17.49 (R ² =0.35)	(-) 18.12 (R ² =0.17)	(-) 20.09 (R ² =0.27)	(-) 83.24 (R ² =0.86)	(+) 7.37 (R ² =0.08)	(-) 21.73 (R ² =0.37)	(-) 27.67 (R ² =0.38)	(-) 75.65 (R ² =0.88)
24-June	(+) 0.98 (R ² =0.10)	(-) 9.30 (R ² =0.84)	(-) 10.14 (R ² =0.63)	(-) 37.37 (R ² =0.86)	(-) 2.65 (R ² =0.42)	(+) 5.80 (R ² =0.75)	(+) 6.92 (R ² =0.55)	(-) 35.66 (R ² =0.65)

* Slope of curve = Kg ha⁻¹ per year

4.4 Predicted deviations in yield, phenology and LAI for different agroclimatic zones of Punjab

The predicted deviations were evaluated from the baseline (2010-2020) for yield, phenology and LAI of cultivars PMH1 and PMH2. These were analysed for the selected GCMs for mid-century (2021-2051) and end-century (2066-2095)

Agroclimatic zone II (Ballowal Saunkhri)

CSIRO Mk-36-0 model

The cultivar PMH1 depicted the yield decrease (Table 4.11) to be low during the mid-century for all the dates of sowing. Also, on 15th June the cultivar obtained an increase of 20.6%, 13.2%, 12.8% and 7.6% during mid-century under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively from the baseline (5566.8 kg ha⁻¹). Under RCP2.6 a slight increase of 2.7% was observed during end-century. The decrease in the maize yield during mid-century ranged from 1.1% to 28.4%. The end-century showed a large decline in yield which ranged from 12.4 % to 96.6%. The yield decrement under RCP8.5 and RCP4.5 was very high with the maximum yield reaching upto 1149.1 kg ha⁻¹ and 2893.1 kg ha⁻¹, respectively during end-century. PMH2 (Table 4.11) observed a yield decline under all the scenarios during mid-century and end-century except on 15th June and 24th June. On 15th June a yield increment of 2.9%, 2.8% and 9.6% was observed under RCP2.6, RCP6.0 and RCP8.5, respectively while on 24th June a yield increment of 13.0%, 5.6%, 14.0% and 12.9% was observed under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively for mid-century from the baseline 5094.9 kg ha⁻¹. A slight increase of 3.2% was observed during end-century under RCP2.6.

The anthesis days shortened by 3-5 days for PMH1 (Table 4.12) during mid-century and by 6-8 days during end-century in comparison to the baseline under all the four dates of sowing and scenarios with maximum decline during end-century under RCP8.5. Further if maturity days were observed they too shortened by 7-9 days under all the dates of sowing and scenarios during mid-century and by 9-33 days during end-century. The maximum decline was seen under RCP8.5 and the early dates that are 28th May and 6th June were the dates with maximum shortening of maturity. The LAI for the crop cultivar was found to be higher from the baseline. For PMH2 (Table 4.13) the shortened anthesis days were by 1-3 days under all the four scenarios and dates of sowing while the maturity days shortened by 6-7 days during mid-century. Similarly, the end-century observed the shortening by 3-6 days and 10-19 days for anthesis and maturity, respectively. The LAI for the cultivar was on the higher side from the baseline.

Table 4.11: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Ballowal Saunkhri, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5754.3	4283.9 (-25.6)*	4356.0 (-24.3)	4604.8 (-20.0)	4119.3 (-28.4)	5732.9	3859.3 (-32.7)	3908.0 (-31.8)	4238.8 (-26.1)	4236.3 (-26.1)
	End-century (2051-95)		3790.7 (-34.1)	1948.1 (-66.1)	2234.1 (-61.1)	803.8 (-86.0)		3303.7 (-42.4)	2089.2 (-63.6)	2348.5 (-59.0)	2090.5 (-63.5)
06-June	Mid-century (2021-50)	5496.3	5147.7 (-6.3)	4961.7 (-9.7)	5147.9 (-6.3)	4592.7 (-16.4)	5196.6	3801.3 (-26.9)	3774.1 (-27.4)	3935.2 (-24.3)	3956.9 (-23.9)
	End-century (2051-95)		4502.2 (-18.1)	501.4 (-90.9)	1221.4 (-77.8)	188.2 (-96.6)		3468.2 (-33.3)	1141.7 (-78.0)	1698.5 (-67.3)	1012.0 (-80.5)
15-June	Mid-century (2021-50)	5566.8	6713.9 (20.6)	6302.4 (13.2)	6276.7 (12.8)	5990.9 (7.6)	5380.7	5537.0 (2.9)	5354.4 (-0.5)	5531.7 (2.8)	5897.6 (9.6)
	End-century (2051-95)		5710.0 (2.6)	2793.0 (-49.8)	2921.9 (-47.5)	849.4 (-84.7)		4453.3 (-17.2)	2411.4 (-55.2)	2733.8 (-49.2)	2238.7 (-58.4)
24-June	Mid-century (2021-50)	5093.6	4827.2 (-5.2)	4542.0 (-10.8)	5035.6 (-1.1)	4428.8 (-13.0)	5094.9	5757.8 (13.0)	5379.8 (5.6)	5805.6 (14.0)	5753.2 (12.9)
	End-century (2051-95)		4459.8 (-12.4)	2893.1 (-43.2)	2987.0 (-41.4)	1149.1 (-77.4)		5258.6 (3.2)	3378.3 (-33.7)	3691.6 (-27.5)	2704.6 (-46.9)

*% deviation from baseline value

Table 4.12: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Ballawal Saunkhri, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	64	60 (-4)*	60 (-4)	61 (-3)	60 (-4)	104	97 (-7)	96 (-8)	98 (-6)	96 (-8)	3.05	3.49	3.51	3.60	3.51
	End-century (2051-95)		59 (-5)	58 (-6)	58 (-6)	57 (-7)		95 (-9)	83 (-21)	86 (-18)	81 (-23)		3.51	3.48	3.55	2.70
06-June	Mid-century (2021-50)	64	60 (-4)	60 (-4)	60 (-4)	60 (-4)	105	96 (-9)	96 (-9)	97 (-8)	96 (-9)	2.78	3.63	3.67	3.60	3.65
	End-century (2051-95)		59 (-5)	58 (-6)	58 (-6)	57 (-7)		95 (-10)	75 (-30)	80 (-25)	72 (-33)		3.71	3.54	3.55	3.32
15-June	Mid-century (2021-50)	65	60 (-5)	60 (-5)	60 (-5)	60 (-5)	106	98 (-8)	97 (-9)	98 (-8)	97 (-9)	2.83	4.03	4.08	3.93	4.07
	End-century (2051-95)		59 (-6)	58 (-7)	58 (-7)	57 (-8)		96 (-10)	93 (-13)	93 (-13)	84 (-22)		4.09	4.15	4.15	4.09
24-June	Mid-century (2021-50)	62	58 (-4)	59 (-3)	59 (-3)	58 (-4)	105	97 (-8)	96 (-9)	97 (-8)	96 (-9)	2.15	3.05	3.12	3.19	3.13
	End-century (2051-95)		58 (-4)	57 (-5)	57 (-5)	55 (-7)		96 (-9)	92 (-13)	93 (-12)	87 (-18)		3.00	3.25	3.28	3.39

*Deviation from baseline in DAS

Table 4.13: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Ballawal Saunkhri, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
	Anthesis						Maturity					LAI				
28-May	Mid-century (2021-50)	59	57 (-2)*	57 (-2)	58 (-1)	58 (-1)	102	96 (-6)	96 (-6)	96 (-6)	96 (-6)	2.84	3.22	3.24	3.19	3.26
	End-century (2051-95)		57 (-2)	55 (-4)	56 (-3)	54 (-5)		94 (-8)	85 (-17)	88 (-14)	83 (-19)		3.26	3.16	3.22	2.69
06-June	Mid-century (2021-50)	60	56 (-4)	56 (-4)	57 (-3)	56 (-4)	102	95 (-7)	95 (-7)	96 (-6)	95 (-7)	2.44	3.04	3.04	3.00	3.04
	End-century (2051-95)		55 (-5)	54 (-6)	55 (-5)	54 (-6)		93 (-9)	77 (-25)	82 (-20)	75 (-27)		3.05	3.01	3.00	3.04
15-June	Mid-century (2021-50)	60	58 (-2)	58 (-2)	58 (-2)	58 (-2)	104	97 (-7)	97 (-7)	97 (-7)	97 (-7)	2.50	3.57	3.58	3.51	3.59
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	55 (-5)		95 (-9)	93 (-11)	93 (-11)	91 (-13)		3.62	3.55	3.54	3.66
24-June	Mid-century (2021-50)	58	55 (-3)	55 (-3)	56 (-2)	55 (-3)	102	95 (-7)	95 (-7)	96 (-6)	95 (-7)	1.82	2.64	2.63	2.77	2.71
	End-century (2051-95)		55 (-3)	54 (-4)	54 (-4)	54 (-4)		94 (-8)	92 (-10)	92 (-10)	91 (-11)		2.63	2.87	2.81	2.99

*Deviation from baseline in DAS

FIO-ESM model

The yield decrease (Table 4.14) for PMH1 was observed to be low during the mid-century for early sowing 28th May which ranged from 3.1 to 21.1%. Further the other three dates of sowing showed a yield increase for mid-century which ranged from 0.9 to 37.4% from the baseline (5093.6 kg ha⁻¹ to 5754.3 kg ha⁻¹) for the four RCPs. During end-century the yield decline ranged from 4.3 to 82.7% with maximum decline observed during early date of sowing i.e. 28th May and 6th June. The later dates of sowing i.e. 15th June showed an increase in yield by 29.8%, 27.2% and 0.6% during end-century under RCP2.6, RCP4.5 and RCP6.0, respectively and 24th June showed an increase under RCP2.6 by 13.1% depicting the late sowing to be a better option for good production of maize crop. Similarly, for PMH2 (Table 4.14) the yield decline was observed only for first date of sowing as in PMH2 which ranged 12.4% to 73.5%. The other dates of sowing during mid-century observed a yield increase which ranged 3.3% to 28.8% under all the scenarios except RCP8.5 which showed a yield decline between -44.9% to -73.5%. RCP8.5 being the high emission scenario observed a large decline in yield. The later dates of sowing i.e. 15th June and 24th June were observed to show a good yield increase depicting late sowing to be a good measure for better production of maize.

The cultivar PMH1 (Table 4.15) observed the shortening of anthesis days by 2-4 days during the mid-century while a shortening by 2-6 days was observed during end-century from the baseline (62-64 DAS). The maturity days for this cultivar were predicted to be shortened by 4-8 days during mid-century and by 5-28 days during end-century. The maximum decrease was obtained during early sowing dates (28th May and 6th June) under the high emission scenarios (RCP8.5) from the baseline (104-106 DAS). The LAI was observed to be higher from the baseline. The cultivar PMH2 (Table 4.16) observed a decline in anthesis days from the baseline (58-60 DAS) by 1-5 days during mid-century and by 2-6 days during end-century. The maturity days for the same cultivar were observed to decline by 4-12 days during mid-century and by 4-25 days during end-century. The maximum decrease in the maturity days was observed under RCP8.5. The LAI of the cultivar was found higher than the baseline under all the scenarios and sowing dates.

Table 4.14: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by FIO-ESM model during 21st century at Ballawal Saunkhri, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5754.3	4543.5 (-21.0)*	5351.6 (-7.0)	5199.9 (-9.6)	5576.1 (-3.1)	5732.9	4674.0 (-18.5)	4858.4 (-15.2)	4725.2 (-17.6)	5019.9 (-12.4)
	End-century (2051-95)		5390.2 (-6.3)	4959.4 (-13.8)	4118.4 (-28.4)	1680.8 (-70.8)		4799.4 (-16.3)	4374.5 (-23.7)	3719.3 (-35.1)	1519.7 (-73.5)
06-June	Mid-century (2021-50)	5496.3	5543.8 (0.9)	5677.7 (3.3)	5864.9 (6.7)	6276.8 (14.2)	5196.6	5369.6 (3.3)	5123.5 (-1.4)	5320.1 (2.4)	4776.6 (-8.1)
	End-century (2051-95)		6028.4 (-7.1)	5103.8 (-7.1)	4435.3 (-19.3)	951.8 (-82.7)		5137.6 (-1.1)	4119.0 (-20.7)	3726.9 (-28.3)	1275.8 (-75.4)
15-June	Mid-century (2021-50)	5566.8	6781.2 (21.8)	7646.7 (37.4)	7029.0 (26.3)	7228.6 (29.9)	5380.7	6567.6 (22.1)	6928.7 (28.8)	6553.1 (21.8)	6852.4 (27.3)
	End-century (2051-95)		7222.8 (29.8)	7082.6 (27.2)	5602.7 (0.6)	3051.8 (-45.2)		6835.1 (27.0)	6002.0 (11.6)	5547.0 (3.1)	2438.8 (-54.7)
24-June	Mid-century (2021-50)	5093.6	5169.7 (1.5)	5730.5 (12.5)	5259.0 (3.2)	5194.8 (2.00)	5094.9	5643.0 (10.7)	6242.7 (22.5)	5645.8 (10.8)	5793.7 (13.7)
	End-century (2051-95)		5762.2 (13.1)	4872.6 (-4.3)	3565.5 (-30.0)	2384.4 (-53.2)		6056.2 (18.9)	5843.7 (14.7)	4659.9 (-8.5)	2808.4 (-44.9)

*% deviation from baseline value

Table 4.15: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by FIO-ESM model during 21st century at Ballawal Saunkhri, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
	Anthesis						Maturity					LAI				
28-May	Mid-century (2021-50)	64	60 (-4)*	62 (-2)	62 (-2)	61 (-3)	104	97 (-7)	99 (-5)	100 (-4)	99 (-5)	3.05	3.37	3.55	3.49	3.54
	End-century (2051-95)		62 (-2)	61 (-3)	60 (-4)	58 (-6)		99 (-5)	99 (-5)	96 (-8)	84 (-20)		3.50	3.60	3.58	3.41
06-June	Mid-century (2021-50)	64	60 (-4)	60 (-4)	60 (-4)	60 (-4)	105	97 (-8)	98 (-7)	99 (-6)	98 (-7)	2.78	3.61	3.51	3.58	3.62
	End-century (2051-95)		61 (-3)	59 (-5)	59 (-5)	58 (-6)		99 (-6)	97 (-8)	96 (-9)	77 (-28)		3.48	3.62	3.78	3.72
15-June	Mid-century (2021-50)	65	60 (-5)	61 (-4)	62 (-3)	61 (-4)	106	98 (-8)	100 (-6)	101 (-5)	100 (-6)	2.83	4.03	4.07	4.18	4.27
	End-century (2051-95)		61 (-4)	61 (-4)	60 (-5)	58 (-7)		100 (-6)	99 (-7)	97 (-9)	93 (-13)		3.99	4.14	4.30	4.18
24-June	Mid-century (2021-50)	62	59 (-3)	59 (-3)	59 (-3)	59 (-3)	105	98 (-7)	99 (-6)	99 (-6)	99 (-6)	2.15	3.01	3.13	3.24	3.21
	End-century (2051-95)		60 (-2)	59 (-3)	58 (-4)	56 (-6)		100 (-5)	98 (-7)	92 (-13)	92 (-13)		3.12	3.22	3.35	3.44

*Deviation from baseline in DAS

Table 4.16: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by FIO-ESM model during 21st century at Ballawal Saunkhri, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	59	58 (-1)*	58 (-1)	58 (-1)	58 (-1)	102	97 (-5)	97 (-5)	97 (-5)	98 (-4)	2.84	3.27	3.31	3.30	3.34
	End-century (2051-95)		58 (-1)	57 (-2)	57 (-2)	55 (-4)		97 (-5)	96 (-6)	95 (-7)	77 (-25)		3.24	3.36	3.39	3.14
06-June	Mid-century (2021-50)	60	58 (-2)	58 (-2)	58 (-2)	58 (-2)	102	98 (-4)	98 (-4)	98 (-4)	98 (-4)	2.44	3.05	2.96	3.05	3.06
	End-century (2051-95)		58 (-2)	58 (-2)	56 (-4)	54 (-6)		98 (-4)	97 (-5)	94 (-8)	77 (-25)		2.95	3.02	3.12	3.12
15-June	Mid-century (2021-50)	60	58 (-2)	58 (-2)	58 (-2)	58 (-2)	104	98 (-6)	98 (-6)	98 (-6)	98 (-6)	2.50	3.55	3.42	3.55	3.65
	End-century (2051-95)		57 (-3)	57 (-3)	57 (-3)	55 (-5)		99 (-5)	97 (-7)	96 (-8)	92 (-12)		3.35	3.45	3.67	3.58
24-June	Mid-century (2021-50)	58	57 (-1)	56 (-2)	57 (-1)	56 (-2)	102	98 (-4)	97 (-5)	98 (-4)	97 (-5)	1.82	2.77	2.68	2.81	2.88
	End-century (2051-95)		57 (-1)	55 (-3)	55 (-3)	54 (-4)		99 (-3)	95 (-7)	94 (-8)	92 (-10)		2.70	2.80	2.93	3.01

*Deviation from baseline in DAS

IPSL-CM5A-MR model

The PMH1 cultivar observed a yield decline (Table 4.17) ranging 1.3% to 25.3% during mid-century for 28th May, 6th June and 24th June while 15th June observed an increase by 30.7%, 10.4%, 22.6% and 6.4%, respectively for RCP2.6, RCP4.5, RCP6.0 and RCP8.5 from the baseline (5093.6 kg ha⁻¹ to 5754.3 kg ha⁻¹). During the end-century the yield decline ranged 2.1% to 70.6% under the four RCPs with maximum decrease observed under RCP8.5. This depicts the influence of high emission scenario on the yield and phenology of maize. The cultivar PMH2 (Table 4.17) showed the yield decline within the range 5.9% to 33.0% under all the scenarios and dates of sowing during mid-century. An increase in yield was observed on 15th June under RCP2.6 from the baseline (5380.7 kg ha⁻¹) and RCP4.5 by 16.6% and 5.7%, respectively while 24th June observed an increase from the baseline (5094.9 kg ha⁻¹) by 14%, 9.2%, 9.5% and 7.2%, respectively for RCP2.6, RCP4.5, RCP6.0 and RCP8.5 during mid-century. The end-century showed a yield decline ranging 5.1% to 76.9% except RCP2.6 which observed a yield increment by 6.5%. The maximum decrease in yield was observed during early sowing 28th May and 6th June under RCP8.5. The model depicted late sowing to be an adaptive measure for better performance of the crop.

The anthesis days for PMH1 (Table 4.18) shortened by 2-5 days and 2-7 days during mid-century and end-century, respectively from the baseline range (62-64 DAS). The projected shortened days for the maturity of the cultivar were by 4-10 days during mid-century and by 4-31 days during end-century from the baseline range (104-106 DAS). The maximum shortening of crop anthesis was observed under RCP8.5 due to its being a high emission scenario. The projected LAI for the 85 years period was higher than the baseline. For PMH2 (Table 4.19) the phenology of maize was such that its anthesis days were observed to shorten by 1-3 days from the baseline range of anthesis (58-60 DAS). The maturity observed a similar shortening by 6-25 days from the baseline maturity range (102-104 DAS). The LAI was observed to be higher than the baseline LAI range for PMH2. The maximum shortening in the phenological days of the crop was observed under RCP8.5 while the RCP2.6 and RCP4.5 observed the minimum shortening during both mid and end-century.

Table 4.17: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Ballawal Saunkhri, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5754.3	5211.8 (-9.4)*	4298.6 (-25.3)	4978.5 (-13.5)	4481.5 (-22.1)	5732.9	4882.8 (-14.8)	3838.2 (-33.0)	4513.3 (-21.3)	4028.7 (-29.7)
	End-century (2051-95)		4594.6 (-20.1)	4039.5 (-29.8)	3700.5 (-35.7)	1689.5 (-70.6)		4256.9 (-25.8)	3419.1 (-40.4)	3240.3 (-43.5)	1712.8 (-70.1)
06-June	Mid-century (2021-50)	5496.3	5408.1 (-1.6)	4963.3 (-9.7)	5423.3 (-1.3)	5058.5 (-8.0)	5196.6	4859.9 (-6.5)	3512.4 (-32.4)	4112.2 (-20.9)	3924.0 (-24.5)
	End-century (2051-95)		5378.7 (-2.1)	3415.3 (-37.9)	3524.8 (-35.9)	327.8 (-94.0)		3795.3 (-27.0)	3361.8 (-35.3)	3155.2 (-39.3)	1201.4 (-76.9)
15-June	Mid-century (2021-50)	5566.8	7276.1 (30.7)	6144.1 (10.4)	6825.0 (22.6)	5924.8 (6.4)	5380.7	6276.3 (16.6)	5064.9 (-5.9)	5689.4 (5.7)	4972.7 (-7.6)
	End-century (2051-95)		6412.0 (15.2)	4696.0 (-15.6)	4421.8 (-20.6)	1963.0 (-64.7)		5103.2 (-5.1)	3360.5 (-37.5)	3425.2 (-36.3)	1742.7 (-67.6)
24-June	Mid-century (2021-50)	5093.6	4962.0 (-2.6)	4430.9 (-13.0)	4455.1 (-12.5)	4669.5 (-8.3)	5094.9	5807.8 (14.0)	5562.6 (9.2)	5578.1 (9.5)	5462.1 (7.2)
	End-century (2051-95)		4201.3 (-17.5)	3280.8 (-35.6)	3144.5 (-38.3)	1763.0 (-65.4)		5424.2 (6.5)	3938.3 (-22.7)	3904.2 (-23.4)	1910.8 (-62.5)

*% deviation from baseline value

Table 4.18: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Ballawal Saunkhri, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	64	62 (-2)*	61 (-3)	61 (-3)	59 (-5)	104	100 (-4)	97 (-7)	98 (-6)	96 (-8)	3.05	3.54	3.46	3.48	3.53
	End-century (2051-95)		61 (-3)	58 (-6)	58 (-6)	58 (-6)		98 (-6)	94 (-10)	94 (-10)	83 (-21)		3.47	3.53	3.52	2.83
06-June	Mid-century (2021-50)	64	60 (-4)	60 (-4)	60 (-4)	60 (-4)	105	98 (-7)	96 (-9)	97 (-8)	96 (-9)	2.78	3.60	3.60	3.59	3.71
	End-century (2051-95)		60 (-4)	59 (-6)	59 (-6)	58 (-7)		97 (-8)	95 (-10)	94 (-11)	74 (-31)		3.64	3.66	3.67	3.33
15-June	Mid-century (2021-50)	65	62 (-3)	60 (-5)	61 (-4)	60 (-5)	106	100 (-6)	97 (-9)	100 (-6)	96 (-10)	2.83	4.13	4.03	4.11	4.00
	End-century (2051-95)		61 (-4)	59 (-6)	59 (-6)	58 (-7)		99 (-7)	95 (-11)	95 (-11)	91 (-15)		4.07	4.17	4.13	4.05
24-June	Mid-century (2021-50)	62	59 (-3)	59 (-3)	59 (-3)	59 (-3)	105	98 (-7)	96 (-9)	98 (-7)	96 (-9)	2.15	3.02	3.09	3.10	3.21
	End-century (2051-95)		62 (-2)	61 (-3)	61 (-3)	59 (-5)		100 (-4)	97 (-7)	98 (-6)	96 (-8)		3.20	3.32	3.10	3.19

*Deviation from baseline in DAS

Table 4.19: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Ballawal Saunkhri, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	59	58 (-1)*	58 (-1)	58 (-1)	57 (-2)	102	97 (-5)	96 (-6)	97 (-5)	96 (-6)	2.84	3.31	3.17	3.22	3.29
	End-century (2051-95)		57 (-2)	56 (-3)	57 (-2)	54 (-5)		96 (-6)	94 (-8)	93 (-9)	83 (-19)		3.20	3.19	3.23	2.47
06-June	Mid-century (2021-50)	60	58 (-2)	57 (-3)	57 (-3)	56 (-4)	102	98 (-4)	96 (-6)	97 (-5)	94 (-8)	2.44	3.02	2.97	2.99	3.07
	End-century (2051-95)		57 (-3)	55 (-5)	55 (-5)	54 (-6)		96 (-6)	92 (-10)	92 (-10)	77 (-25)		3.02	3.05	3.07	2.81
15-June	Mid-century (2021-50)	60	58 (-2)	58 (-2)	58 (-2)	57 (-3)	104	98 (-6)	96 (-8)	97 (-7)	96 (-8)	2.50	3.47	3.50	3.50	3.61
	End-century (2051-95)		58 (-2)	56 (-4)	57 (-3)	54 (-6)		97 (-7)	94 (-10)	94 (-10)	90 (-14)		3.50	3.62	3.63	3.51
24-June	Mid-century (2021-50)	58	56 (-2)	56 (-2)	55 (-3)	55 (-3)	102	97 (-5)	96 (-6)	95 (-7)	94 (-8)	1.82	2.65	2.75	2.71	2.79
	End-century (2051-95)		55 (-3)	55 (-3)	55 (-3)	53 (-5)		95 (-7)	93 (-9)	92 (-10)	88 (-14)		2.76	2.88	2.76	2.85

*Deviation from baseline in DAS

Ensemble model

The yield decrease during mid-century for PMH1 (Table 4.20) was observed ranging 4.5% to 29.8% under all the scenarios and sowing dates except 15th June when an increase by 11.4%, 12.0%, 16.0% and 20.2% under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively was observed. During end-century the yield declined in the range 5.1% to 82.5%. The largest decline in yield was indicated under RCP8.5 which is a high emission scenario. However, 15th June indicated good yield increase from the baseline 5566.8 kg ha⁻¹. Similar results were obtained for PMH2 (Table 4.20) where the yield decline from baseline range (5094.9 kg ha⁻¹ to 5732.90 kg ha⁻¹) was observed between 0.3% to 28.5% during mid-century under the four dates of sowing and the climatic scenarios. The decrement was found to be higher during the end-century which ranged 3.7% to 81.3%. The scenario RCP8.5 showed maximum yield decline. During mid-century, 15th June observed an increment by 6.7%, 6.15 and 14.3% under RCP2.6, RCP6.0 and RCP8.5, respectively and 24th June by 13.0% and 15.1%, respectively for RCP6.0 and RCP8.5 while during the end-century yield increment was obtained on 15th June by 16.4% under RCP4.5 and by 3.4% under RCP2.6. The maximum percentage of decline was obtained under RCP8.5, the high emission scenario.

The cultivar PMH1 (Table 4.21) showed shortening of anthesis (Fig. 4.6) by 2-4 days during mid-century and by 2-7 days during end-century from the baseline (62-65 DAS) under the four dates of sowing and scenarios. Similarly, the maturity days (Fig. 4.7) shortened by 5-8 days during mid-century and by 5-25 days during end-century from the baseline ranged (104-106 DAS). The LAI (Fig. 4.8) for the 85 year period was found to be higher than the baseline. PMH2 (Table 4.22) represented the shortened anthesis (Fig. 4.9) from the baseline range (58-60 DAS) and maturity (Fig. 4.10) from the baseline range (102-104 DAS) by 1-4 days and 4-8 days, respectively during mid-century and by 1-6 days and 5-27 days, respectively during end-century under all the four dates of sowing and scenarios. The LAI (Fig. 4.11) was observed to be higher than the baseline. The model projected the yield decline and phenological impact on the crop under RCP8.5 scenario. The shortening of days occurred maximum under the high emission scenario RCP8.5 and minimum under RCP2.6.

Table 4.20: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by Ensemble model during 21st century at Ballawal Saunkhri, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5754.3	5114.2 (-11.1)*	4872.6 (-15.3)	5207.5 (-9.5)	4759.1 (-17.3)	5732.9	4730.6 (-17.5)	4409.6 (-23.1)	4247.5 (-25.9)	4097.1 (-28.5)
	End-century (2051-95)		4719.5 (-18.0)	4162.1 (-27.7)	4028.2 (-30.0)	1812.0 (-68.5)		4510.4 (-21.3)	3765.3 (-34.3)	2078.6 (-63.7)	1875.1 (-67.3)
06-June	Mid-century (2021-50)	5496.3	5249.1 (-4.5)	4878.4 (-11.2)	5408.8 (-1.6)	4837.9 (-12.0)	5196.6	5182.7 (-0.3)	3980.9 (-23.4)	3989.5 (-23.2)	3827.9 (-26.3)
	End-century (2051-95)		5212.9 (-5.1)	3739.4 (-32.0)	4265.2 (-22.4)	959.5 (-82.5)		4045.1 (-22.2)	3262.3 (-37.2)	1400.4 (-73.0)	969.9 (-81.3)
15-June	Mid-century (2021-50)	5566.8	6200.0 (11.4)	6232.8 (12.0)	6457.3 (16.0)	6689.4 (20.2)	5380.7	5742.0 (6.7)	5160.7 (-4.1)	5708.6 (6.1)	6151.7 (14.3)
	End-century (2051-95)		6441.4 (15.7)	5923.9 (6.4)	5408.4 (-2.8)	2783.4 (-50.0)		5677.2 (-5.5)	6261.7 (16.4)	2487.8 (-53.8)	2098.4 (-61.0)
24-June	Mid-century (2021-50)	5093.6	3775.3 (-25.9)	3574.0 (-29.8)	4004.3 (-21.4)	4262.3 (-16.3)	5094.9	4816.6 (-5.4)	4976.6 (-2.3)	5757.3 (13.0)	5863.3 (15.1)
	End-century (2051-95)		3893.6 (-23.6)	3933.1 (-22.8)	3948.1 (-22.5)	2409.4 (-52.7)		5267.7 (3.4)	4907.5 (-3.7)	3347.8 (-34.3)	2537.7 (-50.2)

*% deviation from baseline value

Table 4.21: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by Ensemble model during 21st century at Ballawal Saunkhri, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	64	62 (-2)*	60 (-4)	62 (-2)	60 (-4)	104	99 (-5)	98 (-6)	99 (-5)	97 (-7)	3.05	3.47 (13.88)	3.47 (13.88)	3.52 (15.31)	3.52 (15.41)
	End-century (2051-95)		62 (-2)	59 (-5)	59 (-5)	58 (-6)		99 (-5)	95 (-9)	95 (-9)	83 (-21)		3.38 (10.91)	3.60 (17.93)	3.56 (16.73)	2.94 (-3.58)
06-June	Mid-century (2021-50)	64	61 (-3)	60 (-4)	60 (-4)	60 (-4)	105	98 (-7)	98 (-7)	98 (-7)	97 (-8)	2.78	3.52 (26.57)	3.52 (26.57)	3.53 (26.97)	3.65 (31.20)
	End-century (2051-95)		60 (-4)	59 (-5)	59 (-5)	58 (-6)		98 (-7)	95 (-10)	95 (-10)	80 (-25)		3.43 (23.47)	3.65 (31.33)	3.66 (31.52)	3.60 (29.32)
15-June	Mid-century (2021-50)	65	62 (-3)	61 (-4)	62 (-3)	61 (-4)	106	100 (-6)	99 (-7)	100 (-6)	98 (-8)	2.83	4.05 (43.27)	4.05 (43.27)	3.98 (40.54)	4.14 (46.23)
	End-century (2051-95)		61 (-4)	59 (-6)	59 (-6)	58 (-7)		100 (-6)	96 (-10)	95 (-11)	93 (-13)		3.99 (41.11)	4.17 (47.34)	4.11 (45.31)	4.22 (49.18)
24-June	Mid-century (2021-50)	62	59 (-3)	59 (-3)	59 (-3)	59 (-3)	105	98 (-7)	98 (-7)	98 (-7)	97 (-8)	2.15	3.01 (39.89)	3.06 (42.17)	3.11 (44.45)	3.01 (39.89)
	End-century (2051-95)		59 (-3)	59 (-3)	59 (-3)	56 (-6)		98 (-7)	96 (-9)	95 (-10)	91 (-14)		2.98 (38.43)	2.92 (35.67)	3.00 (39.53)	3.33 (55.00)

*Deviation from baseline in DAS

Table 4.22: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by Ensemble model during 21st century at Ballawal Saunkhri, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	59	58 (-1)*	58 (-1)	58 (-1)	58 (-1)	102	97 (-5)	97 (-5)	96 (-6)	96 (-6)	2.84	3.27 (15.11)	3.21 (13.14)	3.21 (13.14)	3.29 (15.73)
	End-century (2051-95)		58 (-1)	57 (-2)	55 (-4)	54 (-5)		97 (-5)	95 (-7)	86 (-16)	82 (-20)		3.24 (14.28)	3.34 (17.70)	3.16 (11.42)	2.57 (-9.77)
06-June	Mid-century (2021-50)	60	58 (-2)	57 (-3)	57 (-3)	56 (-4)	102	98 (-4)	96 (-6)	96 (-6)	94 (-8)	2.44	3.00 (23.26)	3.02 (23.97)	3.00 (23.26)	3.02 (23.97)
	End-century (2051-95)		56 (-4)	55 (-5)	54 (-6)	54 (-6)		95 (-7)	93 (-9)	80 (-22)	75 (-27)		2.93 (20.16)	3.11 (27.55)	3.03 (24.02)	3.03 (24.02)
15-June	Mid-century (2021-50)	60	58 (-2)	58 (-2)	58 (-2)	58 (-2)	104	98 (-6)	97 (-7)	97 (-7)	97 (-7)	2.50	3.42 (36.71)	3.48 (39.31)	3.49 (39.73)	3.57 (42.64)
	End-century (2051-95)		58 (-2)	57 (-3)	56 (-4)	54 (-6)		98 (-6)	96 (-8)	92 (-12)	91 (-13)		3.39 (35.44)	3.62 (44.65)	3.57 (42.79)	3.67 (46.87)
24-June	Mid-century (2021-50)	58	56 (-2)	56 (-2)	56 (-2)	55 (-3)	102	98 (-4)	96 (-6)	96 (-6)	95 (-7)	1.82	2.55 (40.16)	2.61 (43.70)	2.68 (47.25)	2.67 (46.72)
	End-century (2051-95)		56 (-2)	55 (-3)	54 (-4)	54 (-4)		97 (-5)	93 (-9)	91 (-11)	90 (-12)		2.53 (38.85)	2.57 (41.45)	2.92 (60.53)	3.02 (66.13)

*Deviation from baseline in DAS

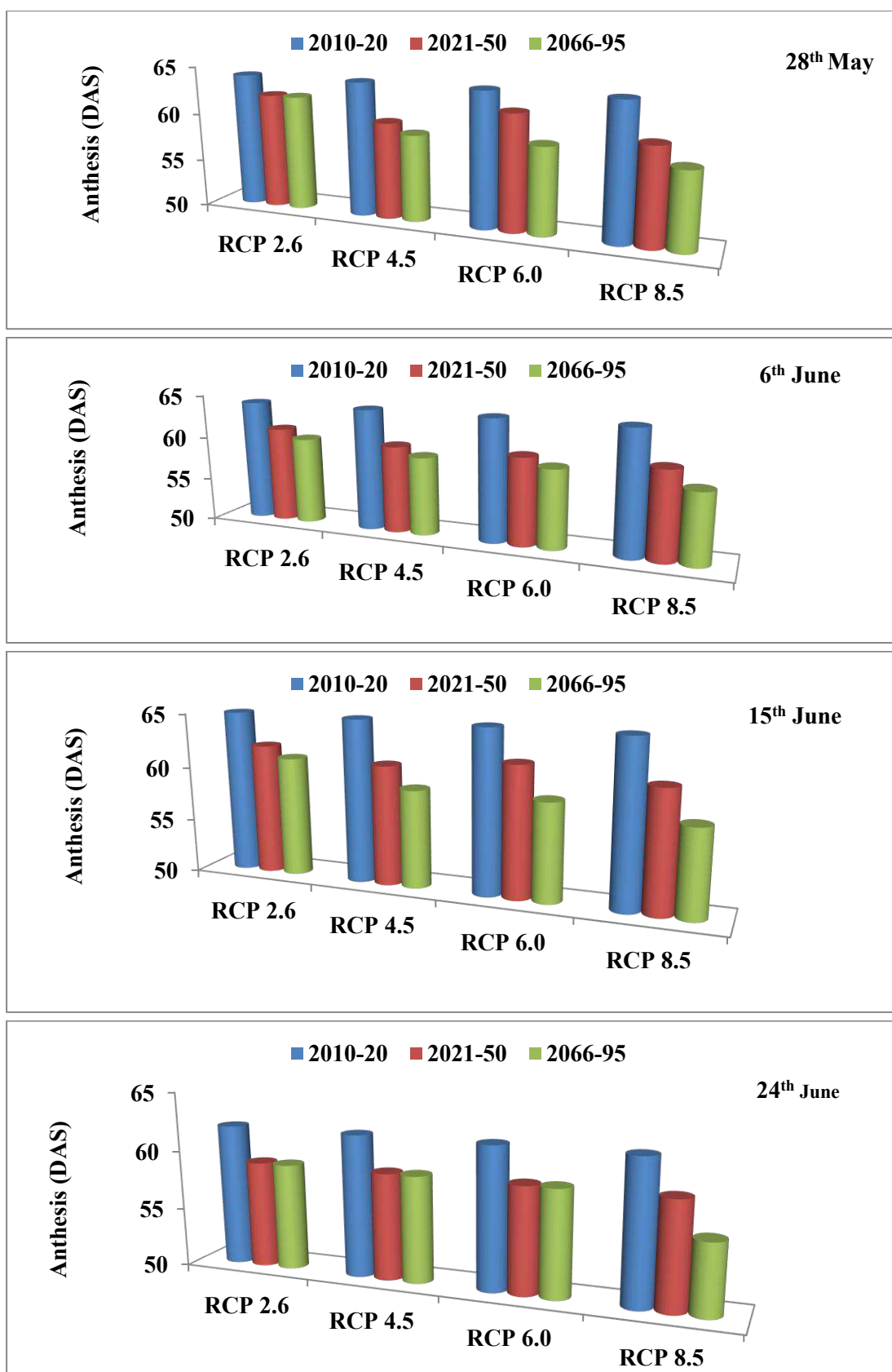


Fig. 4.6: Simulated changes in anthesis (DAS) of PMH1 by Ensemble model at agroclimatic zone II (Ballowal Saunkhri)

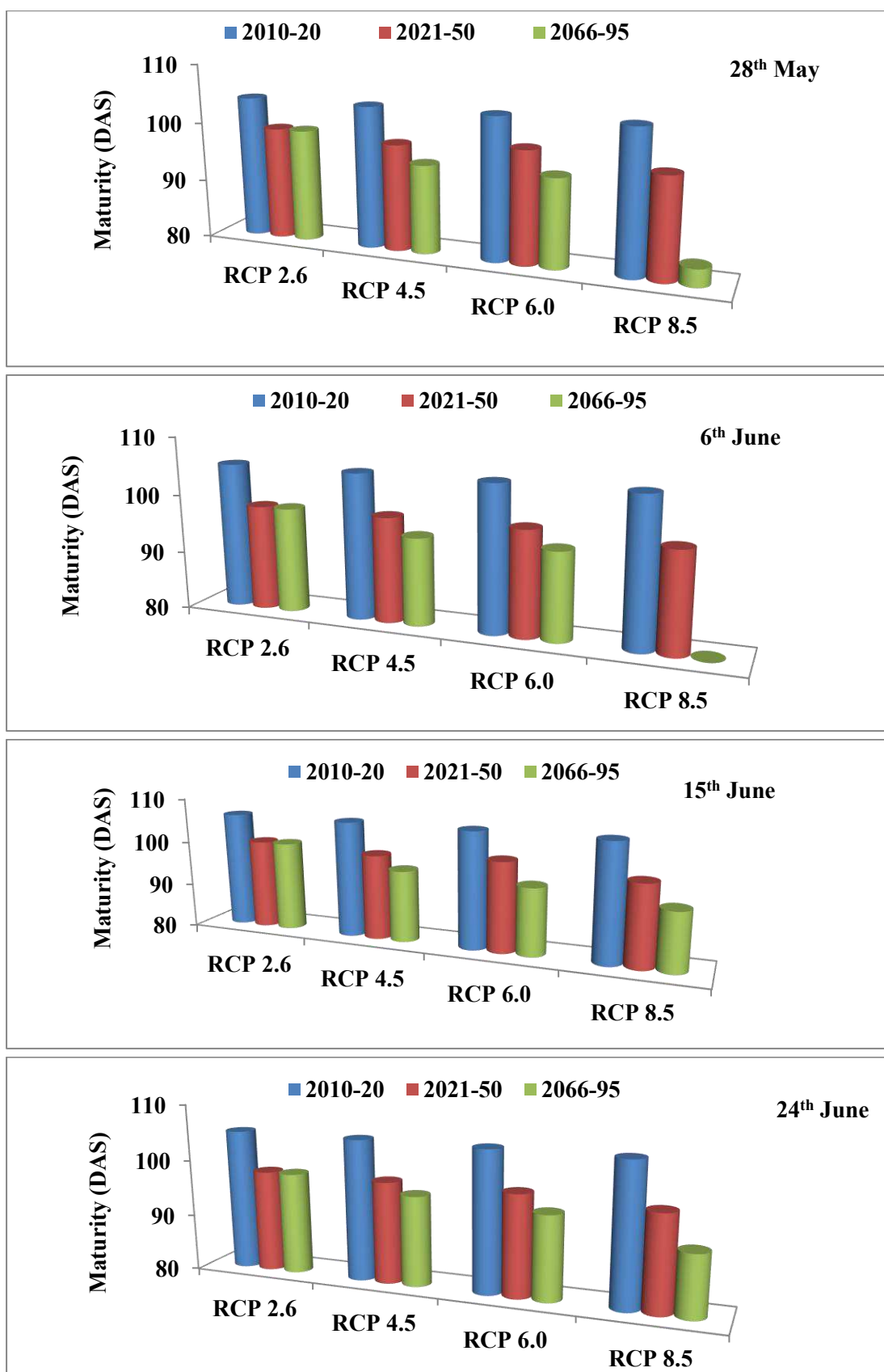


Fig. 4.7: Simulated changes in maturity (DAS) of PMH1 by Ensemble model at agroclimatic zone II (Ballowal Saunkhri)

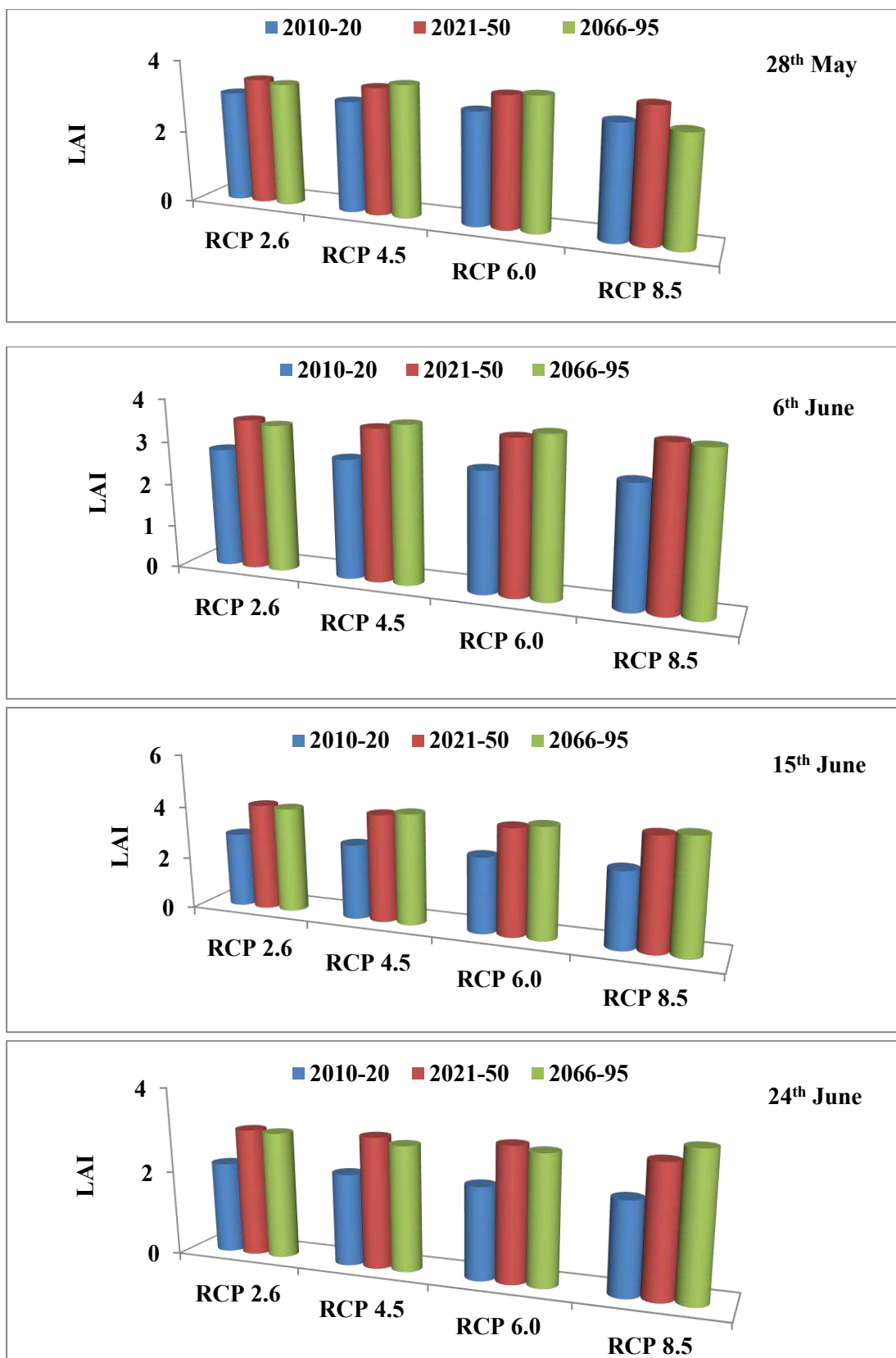


Fig. 4.8: Simulated changes in LAI of PMH1 by Ensemble model at agroclimatic zone II (Ballawal Saunkhri)

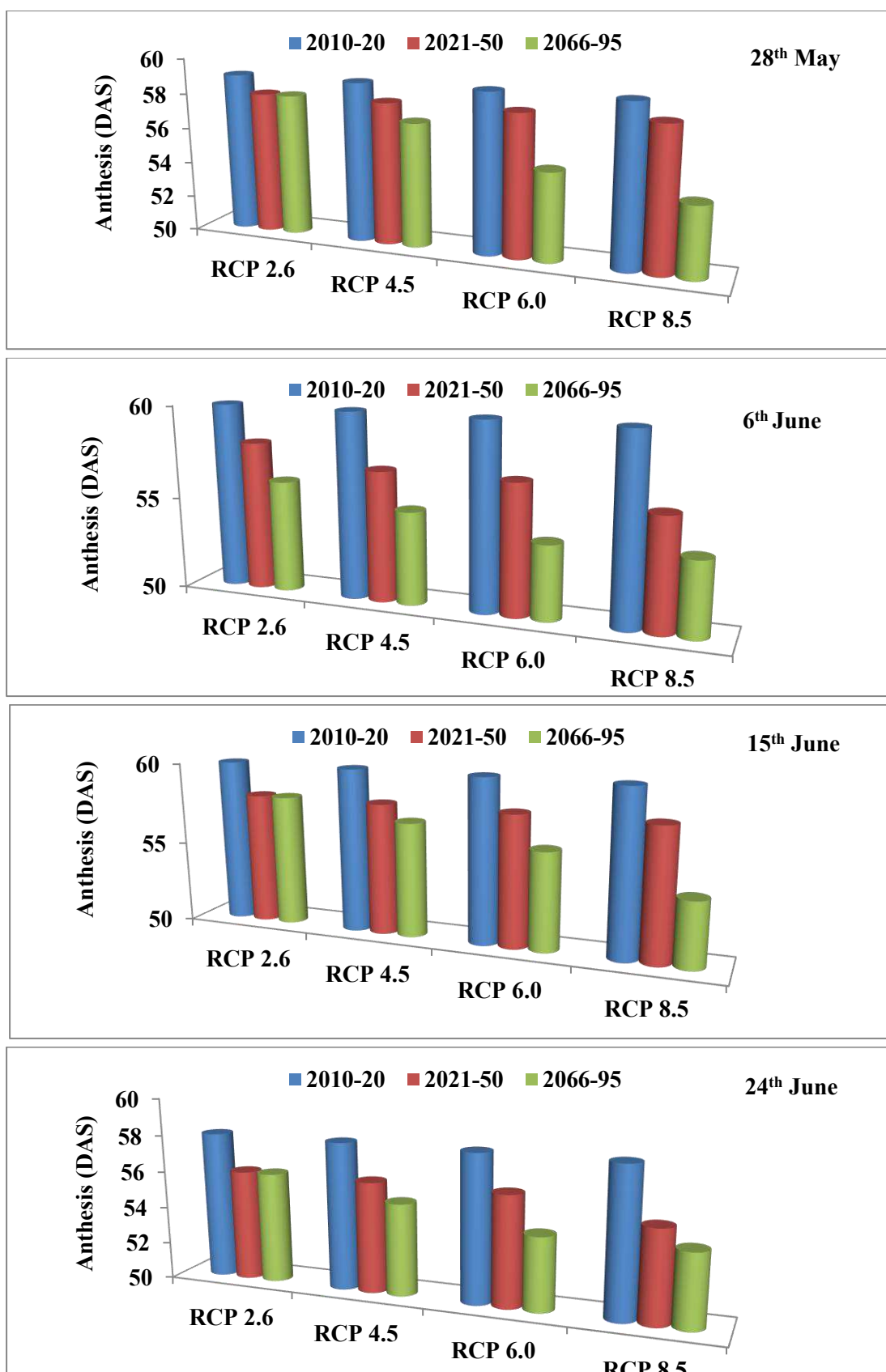


Fig. 4.9: Simulated changes in anthesis (DAS) of PMH2 by Ensemble model at agroclimatic zone II (Ballawal Saunkhri)

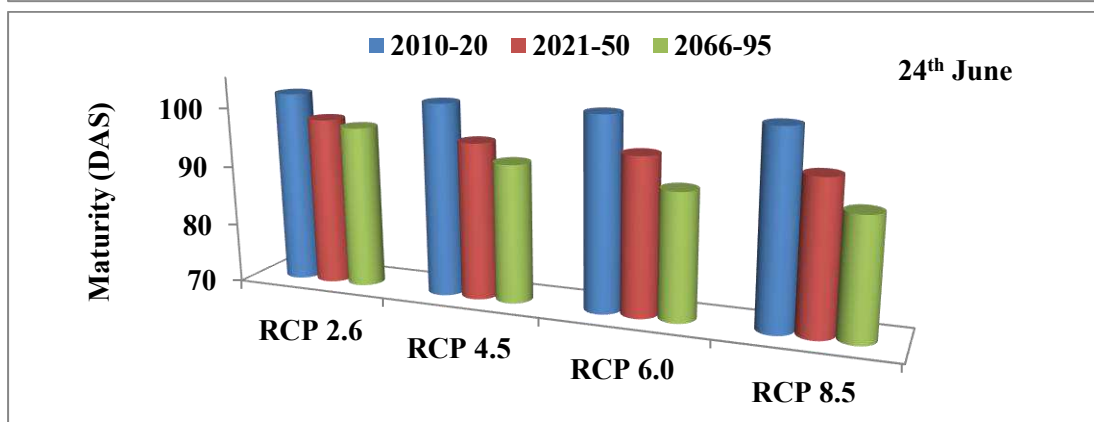
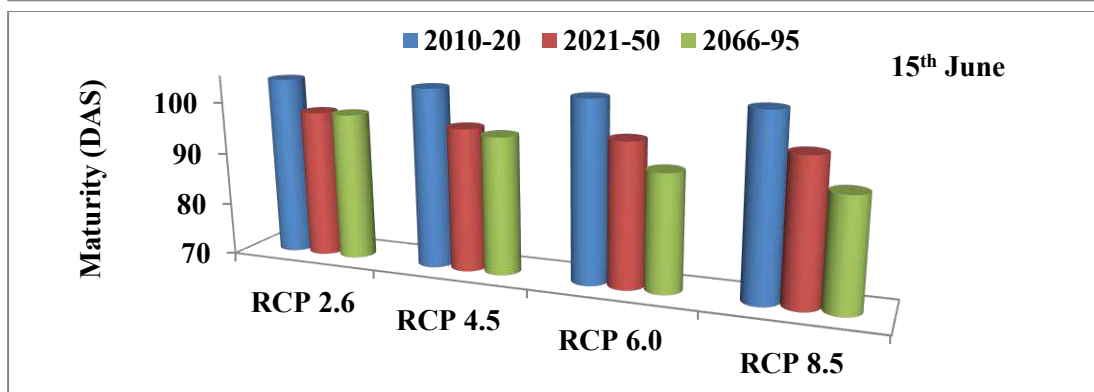
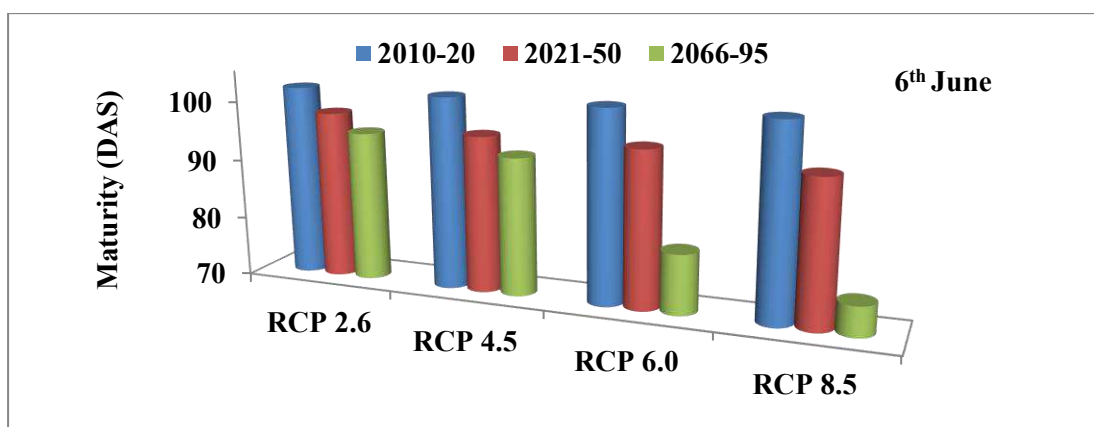
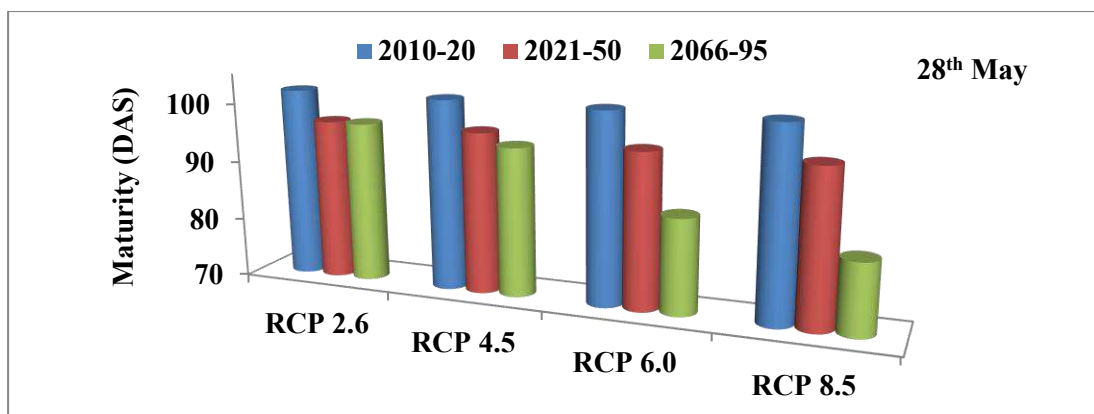


Fig. 4.10: Simulated changes in maturity (DAS) of PMH2 by Ensemble model at agroclimatic zone II (Ballowal Saunkhri)

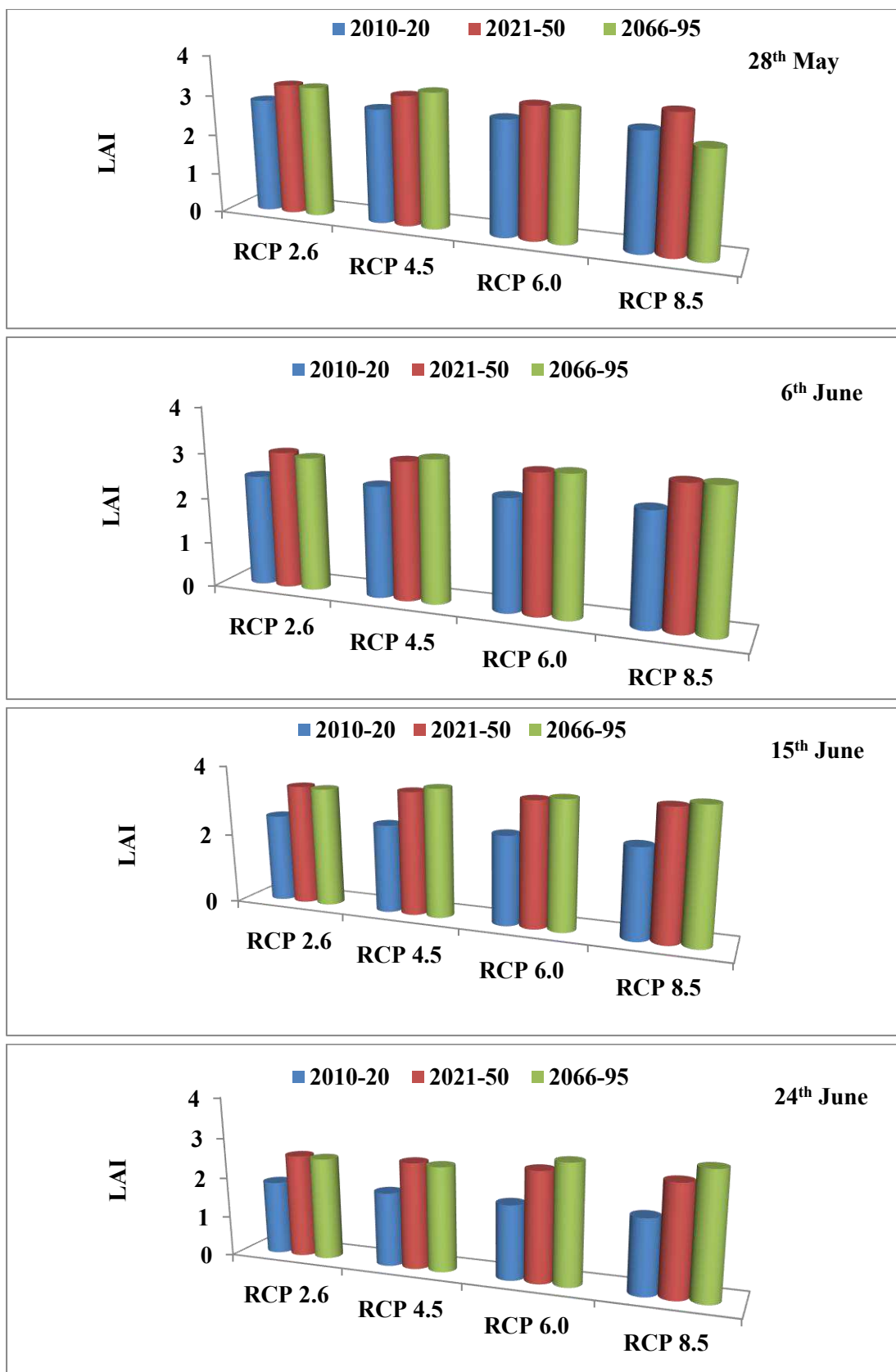


Fig. 4.11: Simulated changes in LAI of PMH2 by Ensemble model at agroclimatic zone II (Ballawal Saunkhri)

Agroclimatic zone III (Ludhiana, Amritsar and Patiala)

CSIRO Mk-36-0 model

In Ludhiana a significant decline (Table 4.23) in yield was observed on all the dates of sowing and scenarios as projected by the model for PMH1. The yield decline for both the centuries varied from 40.8% to 98.0% with the maximum yield ranging within 3000 kg ha⁻¹ for all the four scenarios. The major decline in yield was observed under RCP8.5 and RCP4.5 where the lowest simulated yield was 238.9 kg ha⁻¹ and 197.2 kg ha⁻¹, respectively during the end-century when the temperatures are predicted to increase. The significant loss in yield was observed from the baseline yield range (5164.7 kg ha⁻¹ to 5561.2 kg ha⁻¹). The PMH2 cultivar showed similar significant yield decline (Table 4.3 from the baseline range (4791.8 kg ha⁻¹ to 5409.6 kg ha⁻¹). The decline in yield was observed to range within 29.6% to 98.9% with the maximum yield of the variety to be lower than 3000 kg ha⁻¹. The declined yield was higher for RCP8.5 reaching low upto 386.3 kg ha⁻¹ during mid-century. Also, during mid-century 15th June under RCP4.5 and RCP6.0 saw a high decline by 98.3% and 98.9% which depicts the current sowing dates to be unsuccessful for maize crop in Ludhiana. The high significant declination in yield of the maize crop under variations in temperature and precipitation indicates the fate and adaptation of measures to avoid the same.

The anthesis days for PMH1 variety (Table 4.24) in Ludhiana region shortened by 2-5 days during mid-century and 3-7 days during end-century from the baseline (60-62 DAS) while maturity shortened by 6-20 days during mid-century and by 7-29 days during end-century from baseline range (99-101 DAS). LAI was found to be higher than the baseline except on 28th May for both the maize cultivars. For PMH2 (Table 4.25) the shortened anthesis days ranged 1-2 days during mid-century and 2-5 days during end-century from the baseline (56-57 DAS) while the maturity days were shortened in range from 4-22 days during mid-century and by 7-30 days from the baseline (96-99 DAS). The maximum shortening under all the scenarios and dates of sowing was observed under RCP8.5 during both the centuries. The variations in temperature and rainfall may be the cause of shortening of the phenological stages of the two varieties leading to crop losses in the region.

Amritsar observed a yield decline for PMH1 cultivar (Table 4.26) which ranged 5.3% to 36.2% during the mid-century and 16.8% to 98% during the end-century from the baseline range (5507.1 kg ha⁻¹ to 6237.9 kg ha⁻¹). During mid-century an increase was observed on 15th June by 1.3%, 5.3% and 8.5% under RCP2.6, RCP4.5 and RCP6.0, respectively and on 24th June for both mid and end-century by 1.9% under RCP2.6. This depicts the later sowing dates to perform better under the future climatic conditions. The high emission scenario RCP8.5 observed highest decline amongst the other scenarios specifically for the end-century when temperatures would rise. Similarly, PMH2 (Table 4.26) observed a yield decrement ranged 8.6% to 42.7% and 28.9% to 97.7% during mid and end-century, respectively from the

baseline range (5374.6 kg ha⁻¹ to 6315.4 kg ha⁻¹). The decrease was lower for 24th June which showed an increase by 2.5%, 0.7%, 3.8% under RCP2.6, RCP4.5 and RCP6.0, respectively during mid-century and by 0.9% under RCP2.6 during end-century. RCP8.5 observed maximum decline and highest particularly during the end-century.

The anthesis and maturity days for PMH1 cultivar (Table 4.27) in Amritsar observed shortening by 1-3 days from the baseline (61-62 DAS) and 3-7 days from baseline (101 DAS), respectively during mid-century while during end-century this shortening was by 3-6 days and 5-29 days, respectively. LAI was found higher than the baseline for the four RCPs and dates of sowing. Similarly, for PMH2 (Table 4.28), anthesis observed a shortening by 1-3 days and 2-5 days from the baseline (57-59 DAS) during mid and end-century, respectively while maturity observed this shortening by 2-6 days and 5-31 days from the baseline (99-100 DAS) during mid and end-century, respectively. The LAI for the cultivar was observed to be higher than the baseline for all the dates of sowing except 28th May.

Patiala observed a yield decline (Table 4.29) for PMH1 was observed ranging between 6.4% to 23.9% and 7.0% to 93.6% during mid and end century, respectively from the baseline (5485.8 kg ha⁻¹ to 5990.0 kg ha⁻¹). Mid-century observed a yield increase by 29.6%, 24.4%, 32.1% and 15.8%, respectively under RCP2.6, RCP4.5, RCP6.0 and RCP8.5 on 15th June while increment by 12.1%, 2.2% and 13.2% was observed on 24th June under RCP2.6, RCP4.5 and RCP6.0, respectively. The end-century also observed an increase but only on 15th June by 13.8%. The maximum decline in yield was observed under RCP8.5 during the end-century when temperatures will be high. During the end-century the maize yield ranged within 2032 kg ha⁻¹. PMH2 (Table 4.29) observed a yield decline ranging between 1.3% to 31.2% and 14.3% to 89.4% during the mid and end-century, respectively from the baseline (5419.0 kg ha⁻¹ to 5506.4 kg ha⁻¹). The increase in maize grain yield was obtained on 24th June by 20.1%, 10.2%, 20.0% and 6.2%, respectively under RCP2.6, RCP4.5, RCP6.0 and RCP8.5 during the mid-century and under RCP2.6 by 1.2% during the end-century. 15th June also observed an increase under RCP2.6 and RCP6.0 by 4.2% and 10.7%, respectively during the mid-century. Late dates of sowing observed an increase during the mid-century but the end-century showed maximum decrement under RCP8.5 as it does not follow any mitigation strategy. The yield for the end-century under RCP8.5 ranged within 1960 kg ha⁻¹.

The anthesis days in Patiala for PMH1 cultivar shortened (Table 4.30) by 0-3 days and 1-5 days during mid and end-century, respectively from the baseline (59-60 DAS) while the maturity period for PMH1 shortened by 2-5 days and 4-27 days during mid and end-century, respectively from the baseline (97-101 DAS). The shortening of the period for maturity and anthesis was observed under all dates of sowing and scenarios. The LAI for the 85 years period was found to be higher than the baseline.

Table 4.23: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Ludhiana, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5164.7	2033.3 (-60.6)*	2134.5 (-58.7)	2618.1 (-49.3)	1927.0 (-62.7)	4939.8	2190.5 (-55.7)	2250.5 (-54.4)	2560.4 (-48.2)	2034.6 (-58.8)
	End-century (2051-95)		1483.9 (-71.3)	394.3 (-92.4)	946.1 (-81.7)	958.2 (-81.4)		1559.3 (-68.4)	517.0 (-89.5)	753.6 (-84.7)	386.3 (-92.2)
06-June	Mid-century (2021-50)	5208.6	1151.1 (-77.9)	1300.6 (-75.0)	2468.1 (-52.6)	1078.8 (-79.3)	4791.8	970.9 (-79.7)	1083.6 (-77.4)	1792.7 (-62.6)	876.7 (-81.7)
	End-century (2051-95)		1255.5 (-75.9)	197.2 (-96.2)	237.6 (-95.4)	238.9 (-95.4)		502.1 (-89.5)	442.1 (-90.8)	473.8 (-90.1)	481.7 (-90.0)
15-June	Mid-century (2021-50)	5561.2	2814.2 (-49.4)	2859.2 (-48.6)	3348.5 (-39.8)	2453.3 (-55.9)	5409.6	2279.0 (-57.9)	2248.4 (-58.4)	2655.7 (-50.9)	1930.2 (-64.3)
	End-century (2051-95)		1480.4 (-73.4)	202.6 (-96.4)	112.2 (98.0)	500.5 (-91.0)		2127.2 (-60.7)	91.1 (-98.3)	62.4 (-98.9)	545.4 (-89.9)
24-June	Mid-century (2021-50)	5310.4	2988.4 (-43.7)	2981.3 (-43.9)	3146.2 (-40.8)	2800.1 (-42.3)	5293.4	3408.5 (-35.6)	3312.9 (-37.4)	3727.6 (-29.6)	3026.0 (-42.8)
	End-century (2051-95)		2427.7 (-54.3)	1349.6 (-74.6)	1285.0 (-75.8)	1737.6 (-67.3)		2867.7 (-45.8)	1421.8 (-73.1)	1390.9 (-73.7)	1948.6 (-63.2)

*% deviation from baseline value

Table 4.24: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Ludhiana, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	62	57 (-5)*	57 (-5)	57 (-5)	57 (-5)	101	84 (-17)	84 (-17)	88 (-13)	84 (-17)	2.85	2.78	2.71	2.89	2.58
	End-century (2051-95)		56 (-6)	57 (-5)	56 (-6)	55 (-7)		81 (-20)	76 (-25)	82 (-19)	81 (-20)		2.58	2.46	1.71	2.31
06-June	Mid-century (2021-50)	61	59 (-2)	59 (-2)	59 (-2)	59 (-2)	100	80 (-20)	81 (-19)	89 (-11)	80 (-20)	2.78	3.38	3.30	3.40	3.27
	End-century (2051-95)		57 (-4)	58 (-3)	58 (-3)	57 (-4)		80 (-20)	73 (-27)	73 (-27)	72 (-28)		2.70	2.86	2.88	3.11
15-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	57 (-3)	99	92 (-7)	92 (-7)	93 (-6)	90 (-9)	2.94	3.89	3.74	3.94	3.79
	End-century (2051-95)		56 (-4)	56 (-4)	56 (-4)	55 (-5)		81 (-18)	72 (-27)	70 (-29)	74 (-25)		2.58	3.63	3.77	3.68
24-June	Mid-century (2021-50)	61	58 (-3)	58 (-3)	58 (-3)	58 (-3)	101	95 (-6)	95 (-6)	95 (-6)	94 (-7)	2.36	2.80	2.53	2.95	2.66
	End-century (2051-95)		58 (-3)	56 (-5)	56 (-5)	55 (-6)		94 (-7)	90 (-11)	90 (-11)	89 (-12)		2.88	2.75	3.12	2.96

*Deviation from baseline in DAS

Table 4.25: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Ludhiana, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	56	54 (-2)*	53 (-3)	54 (-2)	53 (-3)	96	84 (-12)	85 (-11)	88 (-8)	84 (-12)	2.65	2.50	2.42	2.64	2.29
	End-century (2051-95)		52 (-4)	52 (-4)	52 (-4)	51 (-5)		81 (-15)	74 (-22)	77 (-19)	69 (-27)		2.25	1.42	1.34	2.03
06-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	55 (-2)	55 (-2)	98	77 (-21)	78 (-20)	84 (-14)	76 (-22)	2.38	2.85	2.78	2.91	2.74
	End-century (2051-95)		55 (-2)	54 (-3)	54 (-3)	53 (-4)		72 (-26)	73 (-25)	73 (-25)	72 (-26)		2.79	2.37	2.38	2.61
15-June	Mid-century (2021-50)	56	55 (-1)	55 (-1)	55 (-1)	54 (-2)	97	92 (-5)	92 (-5)	93 (-4)	89 (-8)	2.62	3.36	3.22	3.39	3.25
	End-century (2051-95)		55 (-1)	52 (-4)	52 (-4)	52 (-4)		91 (-6)	67 (-30)	67 (-30)	71 (-26)		3.41	3.06	3.27	3.21
24-June	Mid-century (2021-50)	57	55 (-1)	55 (-1)	55 (-1)	54 (-2)	99	92 (-7)	92 (-7)	93 (-6)	92 (-7)	1.96	2.50	2.24	2.57	2.37
	End-century (2051-95)		54 (-2)	53 (-3)	53 (-3)	52 (-4)		92 (-7)	89 (-10)	90 (-9)	88 (-11)		2.64	2.50	2.77	2.58

*Deviation from baseline in DAS

Table 4.26: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by CSIRO-Mk3-6-0 model during 21st century at Amritsar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5980.6	4364.6 (-27.0)*	4002.4 (-33.1)	4903.6 (-18.0)	4117.4 (-31.1)	6315.4	4033.9 (-36.1)	3744.4 (-40.7)	4612.1 (-27.0)	3621.0 (-42.7)
	End-century (2051-95)		3673.7 (-38.6)	1806.3 (-69.8)	1922.2 (-67.9)	685.3 (-88.5)		3128.5 (-50.5)	1645.0 (-74.0)	1736.9 (-72.5)	224.3 (-96.4)
06-June	Mid-century (2021-50)	6091.7	4308.1 (-29.3)	4180.9 (-31.4)	5148.8 (-15.5)	3886.7 (-36.2)	5374.6	3606.5 (-32.9)	3419.0 (-36.4)	3801.2 (-29.3)	3330.0 (-38.0)
	End-century (2051-95)		3508.4 (-42.4)	606.8 (-90.0)	833.5 (-86.3)	342.9 (-94.4)		3357.4 (-37.5)	920.3 (-82.9)	1130.8 (-79.0)	428.2 (-92.0)
15-June	Mid-century (2021-50)	6237.9	6321.1 (+1.3)	6569.2 (+5.3)	6766.3 (+8.5)	5318.7 (-14.7)	5626.3	4676.4 (-16.9)	4535.8 (-19.4)	5143.2 (-8.6)	4246.6 (-24.5)
	End-century (2051-95)		5192.9 (-16.8)	2766.5 (-55.7)	2843.4 (-54.4)	126.3 (-98.0)		4003.5 (-28.8)	2679.1 (-52.4)	2775.2 (-50.7)	128.7 (-97.7)
24-June	Mid-century (2021-50)	5507.1	5614.2 (+1.9)	5213.6 (-5.3)	5534.5 (-5.3)	5091.6 (-7.5)	5662.4	5802.6 (+2.5)	5699.2 (+0.7)	5876.1 (+3.8)	5382.8 (-4.9)
	End-century (2051-95)		5609.0 (+1.9)	3536.6 (-35.8)	3572.3 (-35.1)	1195.6 (-78.3)		5714.4 (+0.9)	3425.8 (-39.5)	3517.3 (-37.9)	1037.2 (-81.7)

*% deviation from baseline value

Table 4.27: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Amritsar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	62	61 (-1)*	60 (-2)	61 (-1)	60 (-2)	101	98 (-3)	97 (-4)	98 (-3)	95 (-6)	3.25	3.55	3.54	3.58	3.47
	End-century (2051-95)		61 (-1)	58 (-4)	58 (-4)	57 (-5)		96 (-5)	84 (-17)	85 (-16)	83 (-18)		3.48	3.06	3.10	1.74
06-June	Mid-century (2021-50)	62	59 (-3)	60 (-2)	60 (-2)	59 (-3)	101	96 (-5)	96 (-5)	97 (-4)	94 (-7)	3.21	3.62	3.50	3.60	3.65
	End-century (2051-95)		59 (-3)	58 (-4)	58 (-4)	57 (-5)		95 (-6)	75 (-26)	77 (-24)	74 (-27)		3.69	3.52	3.50	2.60
15-June	Mid-century (2021-50)	62	59 (-3)	60 (-2)	60 (-2)	60 (-2)	101	97 (-4)	97 (-4)	98 (-3)	96 (-5)	3.31	3.95	3.94	3.91	4.02
	End-century (2051-95)		59 (-3)	58 (-4)	58 (-4)	57 (-5)		96 (-5)	93 (-8)	93 (-8)	72 (-29)		4.06	4.10	4.09	3.76
24-June	Mid-century (2021-50)	61	59 (-2)	59 (-2)	59 (-2)	59 (-2)	101	97 (-4)	97 (-4)	98 (-3)	96 (-5)	2.57	3.09	2.94	3.14	3.21
	End-century (2051-95)		58 (-3)	57 (-4)	57 (-4)	55 (-6)		96 (-5)	92 (-9)	93 (-8)	86 (-16)		3.11	3.29	3.35	23.25

*Deviation from baseline in DAS

Table 4.28: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Amritsar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	58	57 (-1)*	57 (-1)	57 (-1)	57 (-1)	99	95 (-4)	95 (-4)	96 (-3)	94 (-5)	3.27	3.23	3.23	3.27	3.14
	End-century (2051-95)		57 (-1)	56 (-2)	56 (-2)	54 (-4)		94 (-5)	84 (-15)	85 (-14)	70 (-29)		3.15	2.89	2.85	1.45
06-June	Mid-century (2021-50)	59	56 (-3)	56 (-3)	58 (-1)	56 (-3)	99	95 (-4)	94 (-5)	97 (-2)	93 (-6)	2.74	3.07	3.01	3.03	3.10
	End-century (2051-95)		55 (-4)	54 (-5)	55 (-4)	54 (-5)		93 (-6)	75 (-24)	77 (-)	95 (-5)		3.14	3.00	2.99	2.18
15-June	Mid-century (2021-50)	59	58 (-1)	57 (-2)	58 (-1)	57 (-2)	100	97 (-3)	96 (-4)	97 (-3)	93 (-4)	2.88	3.44	3.39	3.35	3.50
	End-century (2051-95)		57 (-2)	55 (-4)	55 (-4)	54 (-5)		95 (-5)	91 (-9)	91 (-9)	69 (-31)		3.61	3.52	3.54	3.24
24-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	55 (-2)	55 (-2)	99	95 (-4)	94 (-5)	96 (-3)	94 (-5)	2.21	2.69	2.58	2.68	2.79
	End-century (2051-95)		55 (-2)	54 (-3)	54 (-3)	53 (-4)		94 (-5)	91 (-8)	91 (-8)	84 (-15)		2.75	2.98	2.98	2.85

*Deviation from baseline in DAS

Table 4.29: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by CSIRO-Mk3-6-0 model during 21st century at Patiala, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5881.6	5045.8 (-14.2)*	5106.2 (-13.2)	5266.4 (-10.4)	4672.3 (-20.6)	5506.4	4311.1 (-21.7)	4351.7 (-21.0)	4639.1 (-15.8)	3960.3 (-28.1)
	End-century (2051-95)		4416.1 (-24.9)	2009.2 (-65.8)	2357.3 (-59.9)	893.7 (-84.8)		3449.6 (-37.3)	2006.9 (-63.5)	2196.5 (-60.1)	582.4 (-89.4)
06-June	Mid-century (2021-50)	5936.4	4880.8 (-17.8)	4868.7 (-18.0)	5553.3 (-6.4)	4516.0 (-23.9)	5419.0	4043.2 (-25.4)	4013.8 (-25.9)	4164.7 (-23.1)	3727.3 (-31.2)
	End-century (2051-95)		4515.6 (-23.9)	693.3 (-88.3)	1395.4 (-76.5)	381.7 (-93.6)		3524.4 (-35.0)	1085.6 (-80.0)	1668.7 (-69.2)	598.6 (-88.9)
15-June	Mid-century (2021-50)	5990.0	7765.4 (+29.6)	7449.8 (+24.4)	7914.2 (+32.1)	6934.2 (+15.8)	5464.1	5692.3 (+4.2)	5390.1 (-1.3)	6046.9 (+10.7)	4990.1 (-8.7)
	End-century (2051-95)		6814.2 (+13.8)	3378.2 (-43.6)	3510.4 (-41.4)	816.9 (-86.4)		4682.9 (-14.3)	2926.7 (-46.4)	2922.4 (-46.5)	624.9 (-88.5)
24-June	Mid-century (2021-50)	5485.8	6152.2 (+12.1)	5608.4 (+2.2)	6209.8 (+13.2)	5386.8 (-30.2)	5496.4	6604.3 (+20.1)	6058.3 (+10.2)	6598.5 (+20.0)	5835.8 (+6.2)
	End-century (2051-95)		5102.0 (-7.0)	3769.6 (-31.3)	3829.8 (-30.2)	2032.5 (-63.0)		5561.6 (+1.2)	3987.1 (-27.4)	4132.7 (-24.8)	1957.8 (-64.4)

*% deviation from baseline value

Table 4.30: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Patiala, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	59	58 (-1)*	57 (-2)	58 (-1)	57 (-2)	97	94 (-3)	94 (-3)	95 (-2)	93 (-4)	3.23	3.69	3.72	3.70	3.70
	End-century (2051-95)		57 (-2)	56 (-3)	56 (-3)	55 (-4)		93 (-4)	82 (-15)	85 (-12)	80 (-17)		3.72	3.31	3.40	2.44
06-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	58 (-2)	57 (-3)	98	94 (-4)	94 (-4)	95 (-3)	94 (-4)	3.15	3.63	3.64	3.60	3.62
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	55 (-5)		93 (-5)	73 (-25)	79 (-19)	71 (-27)		3.62	3.54	3.56	3.14
15-June	Mid-century (2021-50)	60	58 (-2)	58 (-2)	59 (-1)	58 (-2)	99	95 (-4)	95 (-4)	96 (-3)	94 (-5)	3.03	4.29	4.25	4.22	4.19
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	55 (-5)		94 (-5)	91 (-8)	91 (-8)	77 (-22)		4.08	4.10	4.10	3.84
24-June	Mid-century (2021-50)	60	59 (-1)	59 (-1)	60 (0)	59 (-1)	101	98 (-3)	97 (-4)	98 (-3)	97 (-4)	2.42	3.24	3.13	3.18	3.08
	End-century (2051-95)		59 (-1)	56 (-4)	57 (-3)	55 (-5)		96 (-5)	92 (-9)	93 (-8)	88 (-13)		2.90	3.15	3.15	3.33

*Deviation from baseline in DAS

Table 4.31: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Patiala, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	55	55 (0)*	55 (0)	55 (0)	55 (0)	95	93 (-2)	93 (-2)	94 (-1)	93 (-2)	2.87	3.21	3.24	3.16	3.21
	End-century (2051-95)		55 (0)	52 (-3)	53 (-2)	51 (-4)		92 (-3)	82 (-13)	85 (-10)	72 (-23)		3.25	2.93	2.98	2.08
06-June	Mid-century (2021-50)	56	53 (-3)	53 (-3)	54 (-2)	53 (-3)	96	92 (-4)	92 (-4)	94 (-2)	92 (-4)	2.70	3.02	3.05	2.98	3.04
	End-century (2051-95)		53 (-3)	52 (-4)	52 (-4)	51 (-5)		91 (-5)	73 (-23)	78 (-18)	71 (-25)		3.05	3.04	3.06	2.70
15-June	Mid-century (2021-50)	56	56 (0)	56 (0)	56 (0)	56 (0)	97	95 (-2)	94 (-3)	95 (-2)	94 (-3)	2.61	3.64	3.63	3.56	3.58
	End-century (2051-95)		55 (-1)	52 (-4)	53 (-3)	52 (-4)		94 (-3)	89 (-8)	90 (-7)	72 (-25)		3.54	3.55	3.56	3.41
24-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	55 (-2)	55 (-2)	99	95 (-4)	95 (-4)	96 (-3)	94 (-5)	2.06	2.93	2.83	2.86	2.76
	End-century (2051-95)		55 (-2)	54 (-3)	54 (-3)	52 (-5)		94 (-5)	92 (-7)	92 (-7)	87 (-12)		2.56	2.89	2.87	2.90

*Deviation from baseline in DAS

For PMH2 (Table 4.31) the model projected the anthesis days to shorten by 0-3 days and 0-5 days during mid and end-century, respectively from the baseline (55-57 DAS). The mid-century on 5th June observed no shortening in anthesis. The maturity for the cultivar decreased by 1-5 days and 3-25 days, respectively during mid and end-century from the baseline (95-99 DAS). The maximum shortening of days was observed during the end-century under RCP8.5 for both the cultivars. The LAI for all the scenarios and dates of sowing was found higher than the baseline.

FIO-ESM model

The Ludhiana region observed yield of crop cultivar PMH1 to decrease (Table 4.32) by a range from 4.2% to 24.6% during mid-century and from 3.1% to 76.9% during end century. Under RCP8.5 an increase was observed during mid-century for 28th May (3.1%), 6th June (14.4%), 15th June (39.0%) and 24th June (10%) while under RCP6.0 observed the increase for 6th June (8.7%), 15th June (38.4%) and 24th June (13.8%). The later dates of sowing 15th and 24th June indicated yield increment during end-century by 7.8% from baseline (5561.2 kg ha⁻¹) and 12.9 % from baseline (5310.4 kg ha⁻¹), respectively. RCP8.5 obtained a major decrease during end-century for all the dates of sowing. The PMH2 (Table 4.32) cultivar also showed a yield decline (Table) ranging 1.9% to 43.5% during mid-century and ranging 7.9% to 87.5% during end-century from the baseline (4791.8 kg ha⁻¹ – 5409.6 kg ha⁻¹). During mid-century the percent deviation of the yield was higher for 28th May, 6th June and 15th June under RCP2.6 and RCP4.5. The model also projected a yield increase for PMH2 under RCP6.0 on 6th June (3.2%), 15th June (25.1%) and 24th June (13.3%) and under RCP8.5 on 15th June (26.8%) and 24th June (12.3%) during mid-century. The fourth date of sowing showed a yield increase under all the scenarios during mid-century. The location depicted a high decrease in yield under RCP4.5 and RCP8.5.

In Ludhiana the shortening of anthesis and maturity days occurred for PMH1 and PMH2 cultivar of maize impacting the phenology of the crop. PMH1 (Table 4.33) observed the shortening by 0-5 days under the four scenarios and dates of sowing during the mid-century while the end-century observed the shortening by 1-6 days from the baseline (60-62 DAS). Under RCP6.0, 28th May and 15th June observed 0 days shortening while maximum shortening of anthesis was observed under RCP8.5. Similarly, the shortening of maturity days ranged 1-8 days during mid-century while for the end-century this ranged 0-22 days from the baseline (99-101 DAS). The maximum shortening of maturity days were observed under RCP8.5. The LAI for all the dates of sowing and under all four RCPs for the period of 85 years was found to be higher than the baseline. For PMH2 (Table 4.34) the shortening of anthesis ranged 0-2 days during the mid-century for the four RCPs and dates of sowing while

0-3 days during end-century from the baseline range 56-57 DAS. During mid-century RCP6.0 and RCP8.5 observed 0 day shortening too. The maturity days declined 0-5 days during mid-century and 3-26 days during end-century from the baseline range 96-99 DAS. The maximum shortening of days was observed under RCP8.5. The LAI for all the scenarios and dates of sowing was on the higher side from the baseline.

The model projected a decline in yield of maize cultivars in Amritsar (Table 4.35). The decrease in yield was observed in the range 2.6% to 20.8% during mid-century while during end-century this decrease was in the range 5.9% to 85.0% from the baseline range (5507.1 kg ha⁻¹ to 6237.9 kg ha⁻¹). An increase in yield was obtained under RCP2.6 on 6th June by 3.4% from the baseline (6091.7 kg ha⁻¹) during end-century. Most of the scenarios showed higher yield than baseline on 15th June by 20.3%, 23.2% and 25.3% under RCP2.6, RCP6.0 and RCP8.5, respectively and 24th June by 11.2%, 13.4%, 10.6% and 11.6% under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively during the mid-century. The end-century on the same dates observed an increase under RCP2.6, RCP4.5 by 11.2%, 13.4% and 11.9%, 12.7, respectively. The highest deviation was observed for RCP8.5. Almost similar results were obtained for PMH2 cultivar (Table 4.35) where the yield decrease was observed to range 16.5% to 27.1% during mid-century and 5% to 76.3% during end-century from the baseline range (5374.6 kg ha⁻¹ to 6315.4 kg ha⁻¹). The late dates of sowing i.e. 15th June and 24th June observed an increase in yield by 11.4% and 9.8%; 13.9% and 16.9%; 10% and 17.5%; 17.8% and 18.9% under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively during the mid-century. The end-century also showed an increase under RCP2.6 and RCP4.5 by 20.2% and 4.1%, respectively on 15th June and by 14.0% and 14.3%, respectively on 24th June. This increase on later dates for both the varieties suggests it to be the adaptive measure for better production under increasing temperatures.

The anthesis and maturity period for PMH1 (Table 4.36) in Amritsar shortened by 0-2 days from the baseline (61-62 DAS) and by 0-3 days from the baseline (101DAS), respectively during mid-century while during end-century the shortening was observed by 0-4 days for anthesis and by 0-23 days for maturity. Under RCP2.6 on 15th and 24th June during both the centuries no shortening of days have been observed for anthesis and maturity. The shortening by highest number of days was obtained under RCP8.5 during the end-century. The LAI for the 85years period under all the four dates of sowing and RCPs lied on the higher side from the baseline. For PMH2 cultivar (Table 4.37) the shortening of anthesis period was observed by 0-1 days during mid-century and by 0-5 days during end-century from the baseline (57-59 DAS) and for maturity this shortened period was by 0-3 days during mid-century and by 0-21 days during end-century from the baseline (99-100 DAS). Maximum

shortened period for both anthesis and maturity was found to be under RCP8.5 during end-century). The LAI was found to be on the higher side from the baseline.

At Patiala the maize cultivar PMH1 observed the deviation (Table 4.38) ranging 1.5% to 9.9% and 0.5% to 84.9% during mid and end-century, respectively from the baseline (5485.8 kg ha⁻¹ to 5990.0 kg ha⁻¹) under the four scenarios and dates of sowing. A yield increase from baseline was observed on 15th and 24th June, respectively during mid-century by (35.7%, 40.0%, 36.6% and 39.1%) and (18.4%, 18.0%, 17.1% and 17.8%) under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively. The end-century also observed an increase under respective dates by (36.8%, 33.6% and 8.3%) under RCP2.6, RCP4.5 and RCP6.0, respectively and by (17.3% and 7.6%) under RCP2.6 and RCP4.5, respectively. Maximum decrement in yield was observed under RCP8.5 during the end-century. PMH2 cultivar also observed the deviation (Table 4.38) ranging 5.8% to 19.7% and 13.3% to 77.7% during mid and end-century, respectively from the baseline (5419.0 kg ha⁻¹ to 5506.4 kg ha⁻¹). The increment in grain yield was observed on 15th June by (30.9%, 39.9%, 32.8% and 38.1%) and on 24th June by (20.8%, 22.5%, 20.4% and 20.8%) under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively during the mid-century. During the end-century the respective dates showed an increase by (34.0%, 14.8% and 10.2%) and by (18.9%, 15.2% and 1.4%) under RCP2.6, RCP4.5 and RCP6.0, respectively. The end-century under RCP8.5 observed the maximum decline from baseline.

The anthesis period for the PMH1 cultivar (Table 4.39) in Patiala region shortened by 0-2 days and 0-4 days during mid and end-century, respectively from the baseline (59-60 DAS) while the maturity period observed the shortening by 0-2 days and 0-23 days for respective centuries from the baseline (97-101 DAS). Maximum shortening of maturity was observed on early sowing dates under RCP8.5 during the end-century. LAI was observed to be higher than the baseline for the 85 year time period under the four dates of sowing and the four scenarios. The PMH2 cultivar observed the shortening (Table 4.40) by 0-2 days and 0-4 days during mid and end-century, respectively from the baseline (55-57 DAS) while maturity of the cultivar observed the shortening by 0-2 days and 0-22 days during the respective centuries from the baseline (95-99 DAS). Maximum shortening was observed during the end-century under RCP8.5 on early sowing dates. The LAI was observed to be higher than the baseline.

Table 4.32: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by FIO-ESM model during 21st century at Ludhiana, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5164.7	3853.6 (-25.4)*	3538.1 (-31.5)	4947.1 (-4.2)	5323.6 (3.1)	4939.8	3416.4 (-30.8)	3218.9 (-34.8)	4844.5 (-1.9)	4832.9 (-2.2)
	End-century (2051-95)		3601.9 (-30.3)	1700.3 (67.1)	4095.8 (-20.7)	1697.2 (-67.1)		2945.0 (-40.4)	1626.9 (-67.1)	3388.9 (-31.4)	1519.6 (-69.2)
06-June	Mid-century (2021-50)	5208.6	3094.3 (-40.6)	3051.2 (-41.4)	5662.3 (8.7)	5961.2 (14.4)	4791.8	2840.0 (-40.7)	2707.8 (-43.5)	4945.2 (3.2)	4440.9 (-7.3)
	End-century (2051-95)		4371.2 (-16.1)	3504.5 (-32.7)	4507.4 (-13.5)	1201.3 (-76.9)		3279.2 (-31.6)	599.1 (-87.5)	3369.5 (-29.7)	1291.2 (-73.0)
15-June	Mid-century (2021-50)	5561.2	5165.2 (-7.1)	4908.8 (-11.7)	7698.4 (38.4)	7729.5 (39.0)	5409.6	3635.4 (-32.8)	3337.2 (-38.3)	6767.3 (25.1)	6861.9 (26.8)
	End-century (2051-95)		5996.4 (7.8)	4203.1 (-24.4)	6869.8 (23.5)	3252.0 (-41.5)		4037.7 (-25.4)	3021.6 (-44.1)	4984.4 (-7.9)	2821.4 (-47.8)
24-June	Mid-century (2021-50)	5310.4	4069.2 (-23.4)	4003.4 (-24.6)	6043.9 (13.8)	5843.9 (10.0)	5293.4	4710.4 (11.0)	4576.6 (13.5)	5997.1 (13.3)	5945.0 (12.3)
	End-century (2051-95)		5994.3 (12.9)	4203.1 (-16.1)	6869.8 (-3.1)	3252.0 (-34.3)		5877.5 (11.0)	4404.6 (-16.8)	5805.4 (9.7)	3674.6 (-30.6)

*% deviation from baseline value

Table 4.33: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by FIO-ESM model during 21st century at Ludhiana, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	62	57 (-5)*	57 (-5)	62 (0)	60 (-2)	101	93 (-8)	93 (-8)	100 (-1)	98 (-3)	2.85	3.21	3.08	3.23	3.25
	End-century (2051-95)		60 (-2)	57 (-5)	58 (-4)	56 (-6)		97 (-4)	81 (-20)	94 (-7)	84 (-17)		3.42	3.10	3.30	3.26
06-June	Mid-century (2021-50)	61	60 (-1)	60 (-1)	60 (-1)	60 (-1)	100	96 (-4)	96 (-4)	99 (-1)	98 (-2)	2.78	3.33	3.35	3.33	3.34
	End-century (2051-95)		60 (-1)	59 (-2)	59 (-2)	58 (-3)		96 (-4)	95 (-5)	96 (-4)	78 (-22)		3.30	3.43	3.39	3.40
15-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	60 (0)	59 (-1)	99	94 (-5)	94 (-5)	99 (0)	98 (-1)	2.94	3.91	3.80	3.98	4.04
	End-century (2051-95)		58 (-2)	57 (-3)	58 (-2)	56 (-4)		96 (-3)	93 (-6)	95 (-4)	91 (-8)		3.78	3.70	3.96	3.82
24-June	Mid-century (2021-50)	61	59 (-2)	59 (-2)	59 (-2)	59 (-2)	101	97 (-4)	96 (-5)	99 (-2)	99 (-2)	2.36	2.71	2.71	2.90	2.80
	End-century (2051-95)		58 (-3)	58 (-3)	58 (-3)	56 (-5)		97 (-4)	96 (-5)	97 (-4)	92 (-9)		2.71	2.70	2.96	3.08

*Deviation from baseline in DAS

Table 4.34: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by FIO-ESM model during 21st century at Ludhiana, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	56	55 (-1)*	55 (-1)	56 (0)	56 (0)	96	93 (-3)	93 (-3)	95 (-1)	95 (-1)	2.65	2.99	2.88	3.04	3.05
	End-century (2051-95)		55 (-1)	55 (-1)	55 (-1)	53 (-3)		93 (-3)	81 (-15)	93 (-3)	84 (-12)		3.09	2.90	3.06	2.97
06-June	Mid-century (2021-50)	57	56 (-1)	55 (-2)	58 (1)	57 (0)	98	94 (-4)	93 (-5)	98 (0)	97 (-1)	2.38	2.89	2.86	2.80	2.78
	End-century (2051-95)		57 (0)	55 (-2)	56 (-1)	54 (-3)		96 (-2)	72 (-26)	94 (-4)	78 (-20)		2.87	2.88	2.79	2.82
15-June	Mid-century (2021-50)	56	55 (-1)	55 (-1)	56 (0)	56 (0)	97	94 (-3)	93 (-4)	96 (-1)	96 (-1)	2.62	3.34	3.21	3.30	3.34
	End-century (2051-95)		55 (-1)	55 (-1)	55 (-1)	53 (-3)		94 (-3)	93 (-4)	94 (-3)	90 (-7)		3.12	3.10	3.26	3.19
24-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	57 (0)	56 (-1)	99	94 (-5)	94 (-5)	99 (0)	98 (-1)	1.96	2.36	2.36	2.45	2.46
	End-century (2051-95)		55 (-2)	55 (-2)	55 (-2)	54 (-3)		95 (-4)	93 (-6)	94 (-5)	92 (-7)		2.31	2.36	2.53	2.67

*Deviation from baseline in DAS

Table 4.35: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by FIO-ESM model during 21st century at Amritsar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5980.6	5601.8 (-13.8)*	5379.7 (-17.2)	5147.3 (-20.8)	5497.8 (-15.4)	6315.4	5274.9 (-16.5)	4963.4 (-21.4)	4865.4 (-23.0)	5141.0 (-18.6)
	End-century (2051-95)		6120.6 (-5.9)	5268.5 (-19.0)	3843.9 (-40.9)	1589.7 (-75.6)		5221.4 (-17.3)	4686.7 (-25.8)	3308.2 (-47.6)	1499.0 (-76.3)
06-June	Mid-century (2021-50)	6091.7	6024.5 (-1.1)	5859.5 (-3.8)	5936.3 (-2.6)	6115.4 (+0.4)	5374.6	4099.8 (-23.7)	4090.8 (-23.9)	3917.9 (-27.1)	4323.8 (+19.6)
	End-century (2051-95)		6301.4 (+3.4)	5324.8 (-12.6)	4283.3 (-29.7)	913.9 (-85.0)		4606.3 (-14.3)	4166.7 (-22.5)	3130.1 (-41.8)	1210.2 (-77.5)
15-June	Mid-century (2021-50)	6237.9	7505.6 (+20.3)	7689.3 (-23.3)	7683.8 (+23.2)	7815.6 (+25.3)	5626.3	6266.8 (+11.4)	6405.4 (+13.9)	6191.4 (+10.0)	6625.3 (+17.8)
	End-century (2051-95)		7617.3 (+22.1)	7575.5 (+21.4)	5747.0 (-7.9)	2770.4 (-55.6)		6765.3 (+20.2)	5858.4 (+4.1)	4141.9 (-26.4)	2405.0 (-57.2)
24-June	Mid-century (2021-50)	5507.1	6123.5 (+11.2)	6244.4 (+13.4)	6087.9 (+10.6)	6146.7 (+11.6)	5662.4	6214.1 (+9.8)	6440.1 (+16.9)	6470.8 (+17.5)	6548.8 (+18.9)
	End-century (2051-95)		6162.1 (+11.9)	6204.0 (+12.7)	4817.8 (-12.5)	3095.4 (-43.8)		6279.8 (+14.0)	6293.5 (+14.3)	5229.7 (-5.0)	3396.8 (-38.3)

*% deviation from baseline value

Table 4.36: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by FIO-ESM model during 21st century at Amritsar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	62	62 (0)*	62 (0)	62 (0)	61 (-1)	101	100 (-1)	99 (-2)	99 (-2)	99 (-2)	3.25	3.54	3.55	3.56	3.61
	End-century (2051-95)		62 (0)	61 (-1)	61 (-1)	58 (-4)		100 (-1)	99 (-2)	97 (-4)	85 (-16)		3.59	3.64	3.64	3.32
06-June	Mid-century (2021-50)	62	60 (-2)	60 (-2)	60 (-2)	60 (-2)	101	98 (-3)	98 (-3)	98 (-3)	98 (-3)	3.21	3.41	3.51	3.56	3.65
	End-century (2051-95)		62 (0)	59 (-3)	59 (-3)	58 (-4)		101 (0)	97 (-4)	95 (-6)	78 (-23)		3.42	3.42	3.55	3.43
15-June	Mid-century (2021-50)	62	62 (0)	61 (-1)	61 (-1)	61 (-1)	101	101 (0)	100 (-1)	100 (-1)	100 (-1)	3.31	3.82	3.95	3.97	4.04
	End-century (2051-95)		61 (-1)	61 (-1)	60 (-2)	58 (-4)		101 (0)	100 (-1)	97 (-4)	93 (-8)		3.80	3.85	4.01	3.89
24-June	Mid-century (2021-50)	61	61 (0)	59 (-2)	59 (-2)	59 (-2)	101	101 (0)	99 (-2)	98 (-3)	99 (-2)	2.57	3.08	3.09	3.13	3.13
	End-century (2051-95)		61 (0)	59 (-2)	58 (-3)	57 (-4)		102 (0)	98 (-3)	96 (-5)	93 (-8)		3.07	3.00	3.19	3.23

*Deviation from baseline in DAS

Table 4.37: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by FIO-ESM model during 21st century at Amritsar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	58	58 (0)*	58 (0)	58 (0)	57 (-1)	99	97 (-2)	97 (-2)	97 (-2)	96 (-3)	3.27	3.25	3.28	3.26	3.32
	End-century (2051-95)		58 (0)	57 (-1)	57 (-1)	55 (-3)		97 (-2)	96 (-3)	94 (-5)	85 (-14)		3.32	3.39	3.38	3.08
06-June	Mid-century (2021-50)	59	58 (-1)	58 (-1)	58 (-1)	58 (-1)	99	98 (-1)	98 (-1)	98 (-1)	97 (-2)	2.74	2.88	2.98	3.00	3.10
	End-century (2051-95)		58 (-1)	57 (-2)	57 (-2)	54 (-5)		98 (-1)	97 (-2)	95 (-4)	78 (-21)		2.88	2.91	3.03	2.95
15-June	Mid-century (2021-50)	59	58 (-1)	58 (-1)	58 (-1)	58 (-1)	100	98 (-2)	98 (-2)	98 (-2)	98 (-2)	2.88	3.29	3.36	3.41	3.51
	End-century (2051-95)		58 (-1)	57 (-2)	57 (-2)	55 (-4)		99 (-1)	97 (-3)	96 (-4)	90 (-10)		3.17	3.21	3.43	3.34
24-June	Mid-century (2021-50)	57	57 (0)	56 (-1)	56 (-1)	56 (-1)	99	99 (0)	98 (-1)	98 (-1)	97 (-2)	2.21	2.63	2.69	2.73	2.73
	End-century (2051-95)		57 (0)	56 (-1)	55 (-2)	54 (-3)		99 (0)	97 (-2)	94 (-5)	92 (-7)		2.59	2.62	2.75	2.81

*Deviation from baseline in DAS

Table 4.38: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by FIO-ESM model during 21st century at Patiala, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5881.6	5694.7 (-9.9)*	5993.8 (-5.1)	5765.8 (-8.8)	6093.6 (-3.6)	5506.4	4992.6 (-9.3)	5186.3 (-5.8)	4959.5 (-9.9)	5176.7 (-6.0)
	End-century (2051-95)		5534.6 (-12.4)	4884.4 (-22.7)	4161.6 (-34.1)	1825.8 (-71.1)		4771.1 (-13.3)	4357.1 (-20.9)	3558.8 (-35.4)	1702.6 (-69.1)
06-June	Mid-century (2021-50)	5936.4	5679.6 (+0.7)	6200.9 (+4.4)	5849.0 (-1.5)	6441.4 (+8.5)	5419.0	4348.9 (-19.7)	4639.7 (-14.4)	4671.9 (-13.8)	5055.2 (-6.7)
	End-century (2051-95)		6158.5 (+3.7)	5909.0 (-0.5)	4432.2 (-25.3)	897.4 (-84.9)		4635.0 (-14.5)	3948.4 (-27.1)	3593.2 (-33.7)	1207.7 (-77.7)
15-June	Mid-century (2021-50)	5990.0	8130.9 (+35.7)	8387.1 (40.0)	8185.1 (+36.6)	8334.9 (+39.1)	5464.1	7150.6 (+30.9)	7642.8 (+39.9)	7257.8 (+32.8)	7543.8 (+38.1)
	End-century (2051-95)		8196.3 (+36.8)	8000.0 (+33.6)	6490 (+8.3)	3520.6 (-41.2)		7322.7 (+34.0)	6273.9 (+14.8)	6024.6 (+10.2)	3031.3 (-44.5)
24-June	Mid-century (2021-50)	5485.8	6493.3 (+18.4)	6473.7 (+18.0)	6427.1 (+17.1)	6461.3 (+17.8)	5496.4	6641.5 (+20.8)	6732.2 (+22.5)	6620.3 (+20.4)	6637.7 (+20.8)
	End-century (2051-95)		6436.3 (+17.3)	5904.6 (+7.6)	4915.5 (-10.4)	3128.4 (-43.0)		6536.8 (+18.9)	6333.6 (+15.2)	5575.9 (+1.4)	3445.3 (-33.3)

*% deviation from baseline value

Table 4.39: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by FIO-ESM model during 21st century at Patiala, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	59	60 (-1)*	59 (0)	59 (0)	58 (-1)	97	97 (0)	97 (0)	97 (0)	96 (-1)	3.25	3.73	3.75	3.78	3.72
	End-century (2051-95)		59 (0)	59 (0)	58 (-1)	56 (-3)		97 (0)	96 (-1)	93 (-4)	82 (-15)		3.71	3.78	3.65	3.38
06-June	Mid-century (2021-50)	60	58 (-2)	58 (-2)	58 (-2)	58 (-2)	98	96 (-2)	96 (-2)	96 (-2)	96 (-2)	3.23	3.62	3.67	3.65	3.69
	End-century (2051-95)		57 (-3)	57 (-3)	57 (-3)	56 (-4)		98 (0)	94 (-4)	93 (-5)	75 (-23)		3.57	3.65	3.67	3.64
15-June	Mid-century (2021-50)	60	60 (0)	60 (0)	60 (0)	59 (-1)	99	99 (0)	99 (0)	98 (-1)	98 (-1)	3.15	4.23	4.31	4.24	4.25
	End-century (2051-95)		59 (-1)	59 (-1)	58 (-2)	56 (-4)		99 (0)	97 (-2)	95 (-4)	91 (-8)		4.24	4.32	4.25	3.99
24-June	Mid-century (2021-50)	60	60 (0)	60 (0)	60 (0)	60 (0)	101	99 (0)	99 (-2)	99 (-2)	99 (-2)	3.03	3.08	3.17	3.15	3.07
	End-century (2051-95)		60 (0)	59 (-1)	59 (-1)	56 (-4)		99 (0)	98 (-3)	97 (-4)	92 (-9)		3.03	3.25	3.20	3.12

*Deviation from baseline in DAS

Table 4.40: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by FIO-ESM model during 21st century at Patiala, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
	Anthesis						Maturity					LAI				
28-May	Mid-century (2021-50)	55	56 (1)	55 (0)	55 (0)	55 (0)	95	95 (0)	95 (0)	95 (0)	94 (-1)	2.87	3.24	3.30	3.31	3.28
	End-century (2051-95)		55 (0)	55 (0)	55 (0)	53 (-2)		95 (0)	94 (-1)	93 (-2)	82 (-13)		3.15	3.32	3.22	2.98
06-June	Mid-century (2021-50)	56	56 (0)	56 (0)	56 (0)	55 (-1)	96	96 (0)	96 (0)	96 (0)	95 (-1)	2.70	3.00	2.99	3.01	3.05
	End-century (2051-95)		55 (-1)	55 (-2)	54 (-2)	52 (-4)		96 (0)	94 (-2)	92 (-4)	74 (-22)		2.97	3.03	3.02	3.07
15-June	Mid-century (2021-50)	56	56 (0)	56 (0)	56 (0)	56 (0)	97	96 (-1)	96 (-1)	96 (-1)	96 (-1)	2.61	3.56	3.65	3.56	3.62
	End-century (2051-95)		55 (-1)	55 (-1)	55 (-1)	53 (-3)		96 (-1)	95 (-2)	94 (-3)	90 (-7)		3.56	3.66	3.64	3.58
24-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	55 (-2)	55 (-2)	99	97 (-2)	97 (-2)	97 (-2)	97 (-2)	2.06	2.86	2.89	2.83	2.80
	End-century (2051-95)		56 (-1)	55 (-2)	55 (-2)	54 (-3)		98 (-1)	95 (-4)	94 (-5)	91 (-8)		2.88	2.94	2.85	2.88

*Deviation from baseline in DAS

IPSL-CM5A-MR model

The crop cultivar PMH1 in Ludhiana observed a yield decline (Table 4.41) ranged 2.1 to 45.4% during mid-century under the four RCPs and dates of sowing while end-century observed a yield decline ranged 18.9 to 67.7% from the baseline range (5164.7 kg ha⁻¹ to 5561.2 kg ha⁻¹). Maximum declination in yield was observed under RCP8.5 during end-century which is due to increasing temperatures. Similarly for PMH2 the decline (Table 4.41) ranged 1.2% to 42.9% during mid-century and 14.8% to 86.1% during end-century from the baseline (4791.80 to 5409.6). The decrement was large for RCP8.5 under all the scenarios and dates of sowing during the end-century.

The shortening of anthesis and maturity as observed in Ludhiana depicted (Table 4.42) a shortening by 1-5 days during mid-century for PMH1 and by 2-7 days during end-century from the baseline (60-62 DAS). For maturity the cultivar depicted a decrease by 1-8 days and by 5-26 days during mid and end-century, respectively from the baseline range (99-101 DAS). The maximum shortening occurred under RCP8.5 during the end-century for both anthesis and maturity. The LAI for all the four scenarios and dates of sowing was found on the higher side from the baseline. Similarly, for PMH2 the shortening (Table 4.43) range for the anthesis was 0-3days during mid-century and 0-4 days during end-century. The anthesis shortening from the baseline range (56-57 DAS) was slight for the cultivar while maturity days shortened by 0-4 days and 4-24 days during mid and end-century, respectively from the baseline range (96-98 DAS). The cultivar showed large shortening for the 85 year period under RCP8.5. The LAI values lied higher from the baseline.

The observed yield for PMH1 in Amritsar decreased (Table 4.44) from the baseline range (5507.1 kg ha⁻¹ to 6237.9 kg ha⁻¹) by 3.9% to 30.8% during mid-century and by 12.7% to 91.7% during end-century for all the four dates of sowing and scenarios. An increase in yield as previous model projections was observed on 15th June by 14.2%, 1.1%, 12.1% and 2.7% under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively during mid-century. The maximum percent deviation was obtained for the high emission scenario RCP8.5 during end-century. Similarly, for PMH2 the yield decline (Table 4.44) was observed in the range 2.2% to 34.2% during mid-century and in range 4.2% to 84.8% during end-century from the baseline (5374.6 kg ha⁻¹ to 6315.4 kg ha⁻¹). A slight increase in yield has been obtained under RCP2.6 by 3.6% on 15th June and 3.9% on 24th June.

The PMH1 (Table 4.45) cultivar in Amritsar observed the shortening of anthesis period by 0-3 days and by 1-5 days during mid and end-century from the baseline (61-62 DAS). The shortening of maturity period was observed by 1-5days during mid-century and by

3-26 days during the end-century from the baseline (101 DAS). The maximum shortening for both anthesis and maturity was obtained under RCP8.5 during the end-century. The LAI for the variety was higher than the baseline. The anthesis and maturity days for PMH2 (Table 4.46) shortened by 0-4 days from the baseline (57-59 DAS) and by 1-5 days from the baseline (99-100 DAS) during mid-century. During the end-century the anthesis and maturity days shortened by 1-5 for anthesis and 3-24 days for maturity. The major shortening was observed under RCP8.5 during end-century. The LAI was higher than the baseline.

At Patiala the PMH1 cultivar (Table 4.47) observed a decrease ranging 5.6% to 19.1% and 6.7% to 88.5% during mid and end-century, respectively from the baseline (5485.8 kg ha⁻¹ to 5990.0 kg ha⁻¹). The model also projected an increase on 15th and 24th June, respectively during the mid-century by (37.8%, 25.1%, 36.6% and 28.4%) and by (17.7%, 3.9%, 16.0% and 4.2%) under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively. The end-century observed an increase under RCP2.6 by 35.1% and 5.0% on the respective dates. The maximum decrement was observed under RCP8.5 during the end-century where the yield ranged <2000 kg ha⁻¹. The cultivar PMH2 showed (Table 4.47) a decrease ranging 0.4% to 27.1% and 10.6% to 81.0% during the mid and end-century, respectively from the baseline (5419.0 kg ha⁻¹ to 5506.4 kg ha⁻¹). On 24th June the cultivar observed an increase by 24.5%, 19.8% and 4.7% under RCP2.6, RCP6.0 and RCP.5, respectively during mid-century and by 16.3% under RCP2.6 during the end-century while on 15th June by 20.1%, 11.7%, 17.1% and 9.8% under RCP2.6, RCP4.55, RCP6.0 and RCP8.5, respectively and by 17.3% under RCP2.6 during the respective centuries.

The anthesis days at Patiala for PMH1 shortened (Table 4.48) by 0-2 days and 0-4 days from the baseline (59-60 DAS) while maturity period shortened by 0-4 days and 1-25 days from the baseline (97-101 DAS) during mid and end-century, respectively. The shortening of the maturity was higher for the end-century under RCP8.5. The LAI for the cultivar was higher than the baseline. The PMH2 cultivar showed (Table 4.49) the shortening of anthesis by 0-2 days and 0-4 days from the baseline (55-57 DAS), respectively for mid and end- century while maturity period observed the shortening by 0-4 days and 1-23 days from the baseline (95-97 DAS) during the respective centuries. The maximum shortening was observed during the end-century under RCP8.5. The LAI for the cultivar was found higher than the baseline.

Table 4.41: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Ludhiana, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5164.7	3808.9 (-26.2)*	4709.6 (-8.8)	5057.7 (-2.1)	4621.6 (-10.5)	4939.8	3510.1 (-28.9)	4038.9 (-18.2)	5057.7 (2.4)	3743.6 (-24.2)
	End-century (2051-95)		3088.4 (-40.2)	4102.1 (-20.6)	3691.9 (-28.5)	2065.7 (-60.0)		2814.5 (-43.0)	3409.7 (-31.0)	3691.9 (-25.3)	1155.6 (-76.6)
06-June	Mid-century (2021-50)	5208.6	2863.4 (-45.0)	5044.3 (-3.1)	5095.9 (-2.1)	5047.8 (-3.1)	4791.8	2853.0 (-40.5)	3671.5 (-23.4)	5095.9 (6.3)	3688.7 (-23.0)
	End-century (2051-95)		3269.2 (-37.2)	3881.6 (-25.5)	3656.4 (-29.8)	1684.6 (-67.7)		2661.0 (-44.5)	3360.1 (-29.9)	3656.4 (-23.7)	664.6 (-86.1)
15-June	Mid-century (2021-50)	5561.2	4161.3 (-25.2)	7184.5 (29.2)	6877.3 (23.7)	6499.1 (16.9)	5409.6	3088.5 (-42.9)	5343.8 (-1.2)	6877.3 (27.1)	4802.6 (-11.2)
	End-century (2051-95)		3322.5 (-40.2)	4288.8 (-22.9)	4508.0 (-18.9)	1803.1 (-67.6)		2678.5 (-50.5)	3581.6 (-33.79)	4508.0 (-16.7)	1214.6 (-77.5)
24-June	Mid-century (2021-50)	5310.4	2899.5 (-45.4)	5439.7 (2.4)	4198.4 (-20.9)	5323.1 (0.2)	5293.4	3705.8 (-30.0)	6048.8 (14.3)	4198.4 (-20.7)	5831.8 (10.2)
	End-century (2051-95)		2915.2 (-45.1)	4060.4 (-23.5)	3728.7 (-29.8)	1894.5 (-64.3)		3524.2 (-33.4)	4510.5 (-14.8)	3728.7 (-29.6)	1902.7 (-64.1)

*% deviation from baseline value

Table 4.42: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Ludhiana, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	62	57 (-5)*	59 (-3)	59 (-3)	57 (-5)	101	93 (-8)	96 (-5)	96 (-5)	94 (-7)	2.85	3.08	3.17	3.23	3.29
	End-century (2051-95)		57 (-5)	56 (-6)	56 (-6)	55 (-7)		92 (-9)	92 (-9)	92 (-9)	83 (-18)		2.97	3.27	3.28	2.48
06-June	Mid-century (2021-50)	61	60 (-1)	60 (-1)	60 (-1)	60 (-1)	100	96 (-4)	97 (-3)	97 (-3)	96 (-4)	2.78	3.46	3.36	3.28	3.40
	End-century (2051-95)		59 (-2)	57 (-4)	59 (-2)	58 (-3)		95 (-5)	93 (-7)	94 (-6)	74 (-26)		3.47	3.30	3.47	3.08
15-June	Mid-century (2021-50)	60	57 (-3)	59 (-1)	59 (-1)	58 (-2)	99	94 (-5)	97 (-2)	98 (-1)	96 (-3)	2.94	4.06	3.90	3.82	3.90
	End-century (2051-95)		57 (-3)	56 (-4)	57 (-3)	56 (-4)		93 (-6)	92 (-7)	93 (-6)	83 (-16)		3.99	3.45	3.92	3.72
24-June	Mid-century (2021-50)	61	59 (-2)	59 (-2)	59 (-2)	59 (-2)	101	96 (-5)	97 (-4)	98 (-3)	97 (-4)	2.36	2.95	3.01	2.78	2.97
	End-century (2051-95)		58 (-3)	57 (-4)	59 (-2)	56 (-5)		95 (-6)	93 (-8)	95 (-6)	90 (-11)		3.09	3.15	2.79	3.01

*Deviation from baseline in DAS

Table 4.43: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Ludhiana, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	56	55 (-1)*	55 (-1)	59 (3)	55 (-1)	96	93 (-3)	94 (-2)	96 (0)	94 (-2)	2.65	2.88	2.88	3.23	2.99
	End-century (2051-95)		55 (1)	54 (2)	56 (0)	52 (-4)		92 (-4)	92 (-4)	92 (-4)	77 (-19)		2.76	2.91	3.28	2.19
06-June	Mid-century (2021-50)	57	56 (-1)	56 (-1)	60 (3)	56 (-1)	98	94 (-4)	95 (-3)	97 (-1)	94 (-4)	2.38	2.98	2.73	3.28	2.80
	End-century (2051-95)		55 (-2)	55 (-2)	59 (2)	54 (-3)		92 (-6)	93 (-5)	94 (-4)	74 (-24)		2.93	2.82	3.47	2.58
15-June	Mid-century (2021-50)	56	56 (0)	56 (0)	59 (3)	56 (0)	97	94 (-3)	95 (-2)	98 (-1)	94 (-3)	2.62	3.43	3.27	3.82	3.26
	End-century (2051-95)		55 (-1)	54 (-2)	57 (1)	52 (-4)		93 (-4)	91 (-6)	93 (-4)	81 (-16)		3.41	3.33	3.92	3.20
24-June	Mid-century (2021-50)	57	55 (-1)	56 (0)	59 (3)	55 (-1)	99	94 (-5)	96 (-3)	98 (-1)	95 (-4)	1.96	2.56	2.59	2.78	2.55
	End-century (2051-95)		55 (-1)	55 (-1)	59 (3)	53 (-3)		93 (-6)	93 (-6)	95 (-4)	89 (-10)		2.64	2.54	2.79	2.66

*Deviation from baseline in DAS

Table 4.44: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Amritsar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5980.6	5609.5 (-13.7)*	4413.9 (-32.1)	5045.7 (-22.4)	4498.2 (-30.8)	6315.4	5232.8 (-17.1)	4261.2 (-32.5)	4936.7 (-21.8)	4156.4 (-34.2)
	End-century (2051-95)		4804.0 (-26.1)	4410.1 (-32.2)	3458.3 (-46.8)	1394.3 (-78.6)		4774.1 (-24.4)	3793.7 (-39.9)	3085.3 (-51.1)	1099.2 (-82.6)
06-June	Mid-century (2021-50)	6091.7	5373.5 (-11.8)	4457.5 (-26.8)	5562.3 (-8.7)	4514.9 (-25.9)	5374.6	4075.1 (-24.2)	3540.3 (-34.1)	3839.7 (-28.6)	3826.5 (-28.8)
	End-century (2051-95)		4777.9 (-21.6)	3813.9 (-37.4)	2515.7 (-58.7)	506.8 (-91.7)		3933.7 (-26.8)	3746.5 (-30.3)	2651.0 (-50.7)	817.4 (-84.8)
15-June	Mid-century (2021-50)	6237.9	7125.2 (+14.2)	6306.0 (+1.1)	6990.1 (+12.1)	6404.4 (+2.7)	5626.3	5828.1 (+3.6)	4570.1 (-18.8)	5365.8 (-4.6)	4529.1 (-19.5)
	End-century (2051-95)		6652.2 (+6.6)	4097.2 (-34.3)	4066.8 (-34.8)	1084.0 (-82.6)		4861.3 (-13.6)	3395.7 (-39.7)	3296.1 (-41.4)	974.7 (-82.7)
24-June	Mid-century (2021-50)	5507.1	5252.2 (-4.6)	4817.1 (-12.5)	5293.9 (-3.9)	4625.5 (-16.0)	5662.4	5881.4 (+3.9)	5278.1 (-4.2)	5595.1 (+1.6)	5386.5 (-2.2)
	End-century (2051-95)		4806.2 (-12.7)	3661.2 (-33.5)	3294.0 (-40.2)	1262.5 (-77.1)		5278.0 (-4.2)	4038.2 (-4.2)	3620.2 (-34.3)	1366.5 (-75.2)

*% deviation from baseline value

Table 4.45: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Amritsar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	62	62 (0)*	61 (-1)	62 (0)	60 (-2)	101	99 (-2)	98 (-3)	99 (-2)	96 (-5)	3.25	3.58	3.61	3.56	3.54
	End-century (2051-95)		61 (-1)	58 (-4)	58 (-4)	58 (-4)		98 (-3)	94 (-7)	91 (-10)	84 (-17)		3.62	3.39	3.40	2.08
06-June	Mid-century (2021-50)	62	60 (-2)	60 (-2)	60 (-2)	59 (-3)	101	98 (-3)	96 (-5)	97 (-4)	96 (-5)	3.21	3.59	3.57	3.53	3.63
	End-century (2051-95)		60 (-2)	59 (-3)	59 (-3)	58 (-4)		96 (-5)	95 (-6)	89 (-12)	75 (-26)		3.57	3.64	3.44	2.83
15-June	Mid-century (2021-50)	62	62 (0)	60 (-2)	61 (-1)	59 (-3)	101	100 (-1)	98 (-3)	100 (-1)	96 (-5)	3.31	4.06	3.96	4.00	4.10
	End-century (2051-95)		60 (-2)	59 (-3)	59 (-3)	58 (-4)		98 (-3)	95 (-6)	94 (-7)	88 (-13)		3.98	4.09	3.96	3.78
24-June	Mid-century (2021-50)	61	59 (-2)	59 (-2)	59 (-2)	59 (-2)	101	98 (-3)	97 (-4)	98 (-3)	96 (-5)	2.57	3.29	3.12	3.18	3.25
	End-century (2051-95)		59 (-2)	59 (-2)	58 (-3)	56 (-5)		97 (-4)	96 (-5)	94 (-7)	88 (-13)		3.18	3.27	3.27	3.18

*Deviation from baseline in DAS

Table 4.46: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Amritsar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	58	57 (-1)*	57 (-1)	57 (-1)	57 (-1)	99	95 (-4)	95 (-4)	96 (-3)	94 (-5)	3.27	3.23	3.23	3.27	3.14
	End-century (2051-95)		57 (-1)	56 (-2)	56 (-2)	54 (-4)		94 (-5)	84 (-15)	85 (-14)	70 (-29)		3.15	2.89	2.85	1.45
06-June	Mid-century (2021-50)	59	56 (-3)	56 (-3)	58 (-1)	56 (-3)	99	95 (-4)	94 (-5)	97 (-2)	93 (-6)	2.74	3.07	3.01	3.03	3.10
	End-century (2051-95)		55 (-4)	54 (-5)	55 (-4)	54 (-5)		93 (-6)	75 (-24)	77 (-)	95 (-5)		3.14	3.00	2.99	2.18
15-June	Mid-century (2021-50)	59	58 (-1)	57 (-2)	58 (-1)	57 (-2)	100	97 (-3)	96 (-4)	97 (-3)	93 (-4)	2.88	3.44	3.39	3.35	3.50
	End-century (2051-95)		57 (-2)	55 (-4)	55 (-4)	54 (-5)		95 (-5)	91 (-9)	91 (-9)	69 (-31)		3.61	3.52	3.54	3.24
24-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	55 (-2)	55 (-2)	99	95 (-4)	94 (-5)	96 (-3)	94 (-5)	2.21	2.69	2.58	2.68	2.79
	End-century (2051-95)		55 (-2)	54 (-3)	54 (-3)	53 (-4)		94 (-5)	91 (-8)	91 (-8)	84 (-15)		2.75	2.98	2.98	2.85

*Deviation from baseline in DAS

Table 4.47: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Patiala, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5881.6	5964.5 (-5.6)*	5110.5 (-19.1)	5822.5 (-7.9)	5745.4 (-9.1)	5506.4	5367.2 (-2.5)	4442.7 (-19.3)	4943.9 (-10.2)	4836.6 (-12.2)
	End-century (2051-95)		5463.1 (-13.5)	4094.5 (-35.2)	4091.2 (-35.3)	1627.6 (-74.2)		4921.4 (-10.6)	3563.2 (-35.3)	3450.8 (-37.3)	1544.4 (-72.0)
06-June	Mid-century (2021-50)	5936.4	6129.9 (+3.3)	4889.6 (-17.6)	5958.1 (+0.4)	5636.9 (-8.4)	5419.0	4395.8 (-18.9)	3949.5 (-27.1)	4168.2 (-23.1)	4426.9 (-18.3)
	End-century (2051-95)		5538.3 (-6.7)	3452.1 (-41.8)	3652.7 (-38.5)	681.4 (-88.5)		4487.8 (-17.2)	3253.3 (-40.0)	3537.0 (-34.7)	1027.0 (-81.0)
15-June	Mid-century (2021-50)	5990.0	8252.4 (+37.8)	7493.7 (+25.1)	8183.6 (+36.6)	7694.1 (+28.4)	5464.1	6803.7 (+24.5)	5439.0 (-0.4)	6545.2 (+19.8)	5719.1 (+4.7)
	End-century (2051-95)		8093.1 (+35.1)	5024.2 (-16.1)	4553.5 (-24.0)	1504.1 (-74.9)		6356.5 (+16.3)	3550.8 (-35.0)	3416.9 (-37.5)	1448.7 (-73.5)
24-June	Mid-century (2021-50)	5485.8	6458.6 (+17.7)	5700.9 (+3.9)	6364.4 (+16.0)	5717.4 (+4.2)	5496.4	6599.8 (+20.1)	6139.9 (+11.7)	6438.2 (+17.1)	6034.2 (+9.8)
	End-century (2051-95)		5757.5 (+5.0)	3951.8 (-28.0)	3670.1 (-33.1)	1756.5 (-68.0)		6449.4 (+17.3)	4182.0 (-23.9)	4078.8 (-25.8)	1862.2 (-66.1)

*% deviation from baseline value

Table 4.48: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Patiala, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	59	59 (0)*	58 (-1)	58 (-1)	57 (-2)	97	97 (0)	94 (-3)	96 (-1)	94 (-3)	3.25	3.58	3.61	3.56	3.54
	End-century (2051-95)		59 (0)	56 (-3)	56 (-3)	55 (-4)		96 (-1)	92 (-5)	92 (-5)	82 (-15)		3.62	3.39	3.40	2.08
06-June	Mid-century (2021-50)	60	58 (-2)	58 (-2)	57 (-3)	58 (-2)	98	96 (-2)	94 (-4)	95 (-3)	94 (-4)	3.23	3.59	3.57	3.53	3.63
	End-century (2051-95)		57 (-3)	57 (-3)	57 (-3)	56 (-4)		95 (-3)	92 (-5)	92 (-6)	73 (-25)		3.57	3.64	3.44	2.83
15-June	Mid-century (2021-50)	60	60 (0)	58 (-2)	59 (-1)	58 (-2)	99	98 (-1)	96 (-3)	97 (-2)	95 (-4)	3.15	4.06	3.96	4.00	4.10
	End-century (2051-95)		58 (-2)	57 (-3)	57 (-3)	56 (-4)		96 (-3)	93 (-6)	93 (-6)	86 (-13)		3.98	4.09	3.96	3.78
24-June	Mid-century (2021-50)	60	60 (0)	59 (-1)	60 (0)	60 (0)	101	99 (-2)	97 (-4)	98 (-3)	97 (-4)	3.03	3.29	3.12	3.18	3.25
	End-century (2051-95)		60 (0)	59 (-1)	59 (-1)	56 (-4)		98 (-3)	95 (-6)	95 (-6)	88 (-13)		3.18	3.27	3.27	3.18

*Deviation from baseline in DAS

Table 4.49: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Patiala, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	55	55 (0)*	55 (0)	55 (0)	55 (0)	95	95 (0)	94 (-1)	94 (-1)	94 (-1)	2.87	3.31	3.21	3.27	3.21
	End-century (2051-95)		55 (0)	55 (0)	55 (0)	52 (-3)		94 (-1)	92 (-3)	92 (-3)	82 (-13)		3.23	3.19	3.16	2.29
06-June	Mid-century (2021-50)	56	56 (0)	55 (-1)	56 (0)	53 (-3)	96	96 (0)	93 (-3)	94 (-2)	93 (-3)	2.70	3.00	3.03	2.98	3.06
	End-century (2051-95)		55 (-1)	55 (-1)	55 (-1)	52 (-4)		95 (-1)	90 (-6)	90 (-6)	73 (-23)		3.03	3.10	3.08	2.70
15-June	Mid-century (2021-50)	56	56 (0)	54 (-2)	56 (0)	56 (0)	97	96 (-1)	94 (-3)	96 (-1)	95 (-2)	2.61	3.57	3.63	3.59	3.63
	End-century (2051-95)		56 (0)	53 (-3)	56 (0)	52 (-4)		95 (-2)	92 (-5)	92 (-5)	84 (-13)		3.60	3.57	3.57	3.41
24-June	Mid-century (2021-50)	57	56 (-1)	56 (-1)	56 (-1)	55 (-2)	99	96 (-3)	95 (-4)	96 (-3)	95 (-4)	2.06	2.84	2.92	2.84	2.93
	End-century (2051-95)		55 (-2)	55 (-2)	55 (-2)	53 (-4)		96 (-3)	93 (-6)	93 (-6)	87 (-12)		2.90	2.71	2.74	2.83

*Deviation from baseline in DAS

Ensemble model

The model projected a large decline (Table 4.50) in yield of cultivars PMH1 and PMH2 in Ludhiana. The decline observed was by 0.9%- 46.6% during mid-century in PMH1 under all the scenarios and dates of sowing while the mid-century observed a decline by 11.7%-100% from the baseline range (5164.7 kg ha⁻¹ to 5561.2 kg ha⁻¹). RCP8.5 showed a 100% yield decline during the end-century and RCP4.5 and RCP6.0 observed an increase on 15th June (25.4% and 26.3%), respectively during mid-century and 19.3% and 0.3%, respectively during end-century. The maximum declination in yield was observed under RCP8.5 for both the centuries. PMH2 observed a decrease (Table 4.50) in yield under all the scenarios and dates of sowing ranging 12.9% to 62.1% and 1.1% to 93.4% during mid and end-century, respectively from the baseline range (4791.80 kg ha⁻¹ to 5409.6kg ha⁻¹). The RCP4.5 and RCP6.0 observed an increase by 1.9% and 8.8%, respectively on 15th June and by 8.7% and 7.5% on 24th June during the mid-century. The maximum yield decline was obtained during the end-century under RCP8.5.

The crop cultivar PMH1 in Ludhiana observed a shortened (Table 4.51) anthesis (Fig. 4.12) and maturity days (Fig. 4.13) during both the centuries and under the four RCPs. This decline in the anthesis and maturity was by 0-5 days and by 2-13 days, respectively during mid-century. The end-century observed the decline by 2-7 days for anthesis and by 5-29 days for maturity from the baseline range (60-61 DAS) and (99-101 DAS), respectively. The LAI (Fig. 4.14) ranged higher from the baseline. The anthesis (Fig. 4.15) and maturity (Fig. 4.16) duration shortened for PMH2 (Table 4.52) by 0-3 days during mid-century and by 2-5 days during the end-century from the baseline anthesis range (56-57 DAS). Some date of sowing during mid-century observed no change. The maturity days shortened by 1-14 days and 3-31 days during mid and end-century, respectively under all the four RCPs and dates of sowing. The anthesis and maturity days with maximum shortening occurred under RCP8.5 during end-century. The LAI (Fig. 4.17) for the 85 years period was found to be higher than the baseline.

The model projections for Amritsar depicted the yield of PMH1 (Table 4.53) to decline in the range 2.8% to 31.2% during the mid-century and 5.7% to 90.2% during the end-century from the baseline range (5507.1 kg ha⁻¹ to 6237.9 kg ha⁻¹). On 15th June an increase in yield was observed by 8.8%, 9.2%, 18.5% and 7% under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively and on 24th June under RCP4.5 (4.1%) and RCP6.0 (9.8%) during the mid-century. The maximum yield decline was observed under RCP8.5 during the end-century. Similarly, for PMH2 (Table 4.53) the yield decline ranged 1.1% to 35.6% and 1.1% to 83.5 % during mid and end-century from the baseline range (5374.6 kg ha⁻¹ to 6315.4 kg ha⁻¹). An increase in yield was obtained under RCP4.5 on 24th June (5%) and under

RCP6.0 on 15th June (3.1%) and 24th June (9.3%). The maximum decrement in yield among all the scenarios was found to be highest under RCP8.5 during the end-century.

The observed anthesis period (Fig. 4.18) of PMH1 cultivar (Table 4.54) in Amritsar shortened by 0-2 days and by 0-4 days during mid and end-century, respectively from the baseline (61-62 DAS). The maturity period (Fig. 4.19) shortened by 1-4 days and by 1-24 days during mid and end-century, respectively from the baseline (101 DAS). The LAI (Fig. 4.20) was observed to be higher than the baseline. For the cultivar PMH2 (Table 4.55) the shortening of anthesis (Fig. 4.21) was observed by 0-1 days and by 0-5 days during mid and end-century, respectively from the baseline (57-59 DAS). The maturity period (Fig. 4.22) shortened by 1-3 days and by 1-23 days during mid and end-century, respectively from the baseline (99-100 DAS). The LAI (Fig. 4.23) for the 85 years period was found higher from the baseline under all the four dates of sowing and RCPs except on 28th May. The maximum shortening of anthesis and maturity period was found under RCP8.5 during the end-century for both the cultivars.

The observed yield decline at Patiala for PMH1 (Table 4.56) ranged 1.7% to 8.7% and 5.0% to 90.8% from the baseline (5485.8 kg ha⁻¹ to 5990.0 kg ha⁻¹), respectively during mid and end-century under the four scenarios. The cultivar observed an increase by 37%, 35.1%, 35.7% and 29.8% on 15th June and by 18.4%, 11.0%, 18.8% and 10.4% on 24th June during the mid-century. The end-century observed an increase under RCP2.6, RCP4.5 and RCP6.0, respectively by 34.4%, 5.8% and 2.5% on 15th June and by 17.3% under RCP2.6 on 24th June. The maximum deviation in yield was obtained during the end-century under RCP8.5. PMH2 cultivar observed a deviation (Table 4.56) ranging 5.2% to 23.2% and 12.4% to 80.1% during mid and end-century, respectively from the baseline (5419.0 kg ha⁻¹ to 5506.4 kg ha⁻¹). The yield observed an increment by 32.7%, 17.7%, 24.4% and 21.6% on 15th June and by 20.4%, 16.7%, 22.0% and 13.2% on 24th June, respectively under RCP2.6, RCP4.5, RCP6.0 and RCP8.5 during mid-century. The end-century observed an increase by 26.1% and 14.8% under RCP2.6 and RCP4.5 on 15th June and by 18.4% under RCP2.6 on 24th June. The maximum decrement occurred under RCP8.5 during end-century.

The anthesis (Fig. 4.24) for PMH1 at Patiala observed (Table 4.57) shortening by 0-2 days and 0-4 days from the baseline (59-60 DAS) while the maturity (Fig. 4.25) observed the decrease by 0-3 days and 0-25 days from the baseline (97-101 DAS) during the mid and end-century, respectively. The shortening was highest for the end-century under RCP8.5. The LAI (Fig. 4.26) for the 85 year period was observed to be higher than the baseline. The PMH2 (Table 4.58) cultivar observed the shortening of anthesis (Fig. 4.27) by 0-2 days and 0-4 days and maturity (Fig. 4.28) by 0-10 days and 0-23 days during mid and end-century, respectively. The observed shortening of maturity days was highest for the end-century under RCP8.5. The LAI (Fig. 4.29) for the cultivar was higher from the baseline.

Table 4.50: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by Ensemble model during 21st century at Ludhiana, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5164.7	3790.9 (-26.6)*	4871.6 (-5.7)	4882.3 (-5.5)	2815.4 (-45.5)	4939.8	3418.5 (-30.8)	4186.1 (-15.3)	4303.2 (-12.9)	2730.9 (-44.7)
	End-century (2051-95)		3392.3 (-34.3)	4183.7 (-19.00)	4239.0 (-17.9)	444.3 (-91.4)		3150.6 (-36.2)	3436.2 (-30.4)	3406.9 (-31.0)	327.9 (-93.4)
06-June	Mid-century (2021-50)	5208.6	3145.4 (-39.6)	4739.9 (-9.00)	5164.5 (-0.9)	2881.1 (-44.7)	4791.8	2905.7 (-39.4)	3832.4 (-20.0)	4002.3 (-16.5)	1815.4 (-62.1)
	End-century (2051-95)		3149.5 (-39.5)	3577.9 (-31.3)	4597.8 (-11.7)	0 (-100)		2691.7 (-43.8)	2994.4 (-37.5)	3236.8 (-32.4)	314.5 (-93.4)
15-June	Mid-century (2021-50)	5561.2	4398.7 (-20.9)	6972.7 (25.4)	7022.9 (26.3)	3725.0 (-33.0)	5409.6	3292.8 (-39.1)	5512.9 (1.9)	5884.3 (8.8)	2846.2 (-47.4)
	End-century (2051-95)		4221.2 (-24.1)	6636.2 (19.3)	5578.6 (0.3)	572.4 (-89.7)		3184.7 (-41.1)	4318.9 (-20.1)	4080.8 (-24.6)	8.7 (-99.8)
24-June	Mid-century (2021-50)	5310.4	3047.7 (-42.6)	4382.3 (-17.5)	4608.8 (-13.2)	2837.7 (-46.6)	5293.4	4119.5 (-22.2)	5751.3 (8.7)	5688.2 (7.5)	3642.6 (-31.2)
	End-century (2051-95)		3287.5 (-38.1)	4147.5 (-21.9)	4552.6 (-14.3)	1250.4 (-76.4)		4290.9 (-18.9)	5237.3 (-1.1)	4891.5 (-7.6)	1091.0 (-79.4)

*% deviation from baseline value

Table 4.51: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by Ensemble model during 21st century at Ludhiana, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	62	57 (-5)*	58 (-4)	60 (-2)	57 (-5)	101	93 (-8)	95 (-6)	98 (-3)	88 (-13)	2.85	3.31	3.15	3.17	3.21
	End-century (2051-95)		57 (-5)	57 (-5)	57 (-5)	55 (-7)		93 (-8)	93 (-8)	93 (-8)	80 (-21)		2.98	3.36	3.22	0.76
06-June	Mid-century (2021-50)	61	60 (-1)	60 (-1)	60 (-1)	59 (-2)	100	96 (-4)	98 (-2)	98 (-2)	95 (-5)	2.78	3.43	3.26	3.28	3.45
	End-century (2051-95)		59 (-2)	59 (-2)	59 (-2)	58 (-3)		95 (-5)	95 (-5)	96 (-4)	71 (-29)		3.42	3.37	3.31	3.42
15-June	Mid-century (2021-50)	60	57 (-3)	59 (-1)	60 (0)	57 (-3)	99	94 (-5)	98 (-1)	98 (-1)	93 (-6)	2.94	4.00	3.78	3.70	3.96
	End-century (2051-95)		57 (-3)	57 (-3)	57 (-3)	56 (-4)		94 (-5)	94 (-5)	94 (-5)	80 (-19)		4.02	3.87	3.73	3.49
24-June	Mid-century (2021-50)	61	59 (-2)	59 (-2)	59 (-2)	58 (-3)	101	96 (-5)	98 (-3)	99 (-2)	95 (-6)	2.36	2.97	2.81	2.80	2.83
	End-century (2051-95)		59 (-2)	59 (-2)	59 (-2)	56 (-5)		96 (-5)	96 (-5)	96 (-5)	86 (-15)		3.01	2.67	2.65	3.03

*Deviation from baseline in DAS

Table 4.52: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by Ensemble model during 21st century at Ludhiana, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	56	56 (-1)*	56 (0)	56 (0)	54 (-3)	96	93 (-3)	94 (-2)	95 (-1)	87 (-9)	2.65	2.83	3.00	2.93	2.40
	End-century (2051-95)		55 (-1)	54 (-2)	54 (-2)	52 (-4)		93 (-3)	92 (-4)	92 (-4)	76 (-20)		2.75	3.06	2.89	0.53
06-June	Mid-century (2021-50)	57	56 (-1)	56 (-1)	57 (0)	55 (-2)	98	93 (-5)	95 (-3)	96 (-2)	84 (-14)	2.38	2.97	2.74	2.66	2.92
	End-century (2051-95)		55 (-2)	55 (-2)	55 (-2)	54 (-3)		93 (-5)	93 (-5)	93 (-5)	71 (-27)		2.99	2.82	2.75	1.83
15-June	Mid-century (2021-50)	56	55 (-1)	56 (0)	56 (0)	55 (-1)	97	94 (-3)	95 (-2)	96 (-1)	92 (-5)	2.62	3.37	3.15	3.06	3.37
	End-century (2051-95)		55 (-1)	55 (-1)	56 (0)	52 (-4)		93 (-4)	93 (-4)	94 (-3)	66 (-31)		3.39	3.27	3.16	2.96
24-June	Mid-century (2021-50)	57	55 (-2)	56 (-1)	56 (-1)	55 (-2)	99	94 (-5)	97 (-2)	98 (-1)	93 (-6)	1.96	2.54	2.42	2.38	2.50
	End-century (2051-95)		55 (-2)	55 (-2)	55 (-2)	52 (-5)		94 (-5)	94 (-5)	94 (-5)	85 (-14)		2.61	2.29	2.30	2.67

*Deviation from baseline in DAS

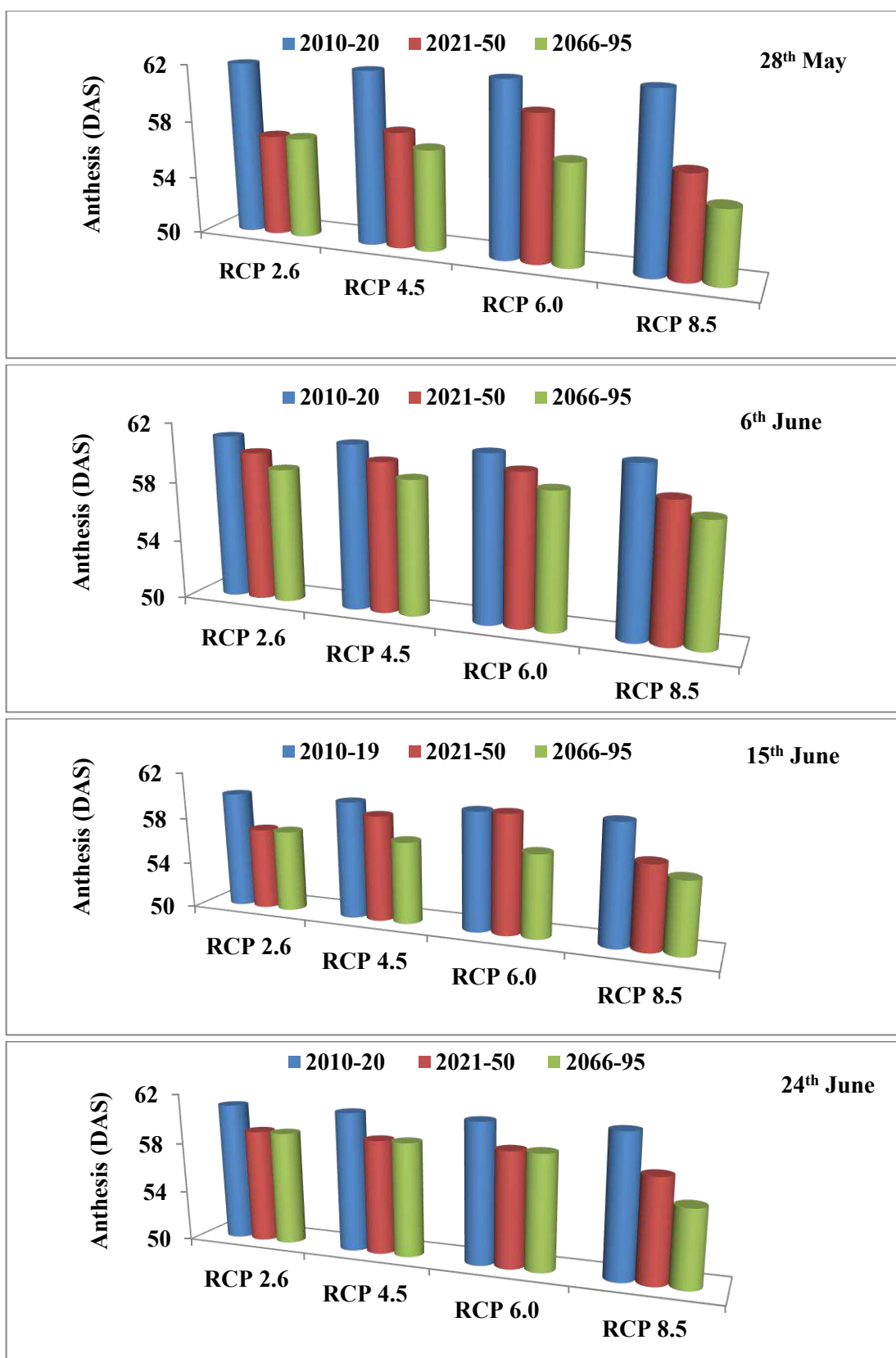


Fig. 4.12: Simulated changes in anthesis (DAS) of PMH1 by Ensemble model at agroclimatic zone III (Ludhiana)

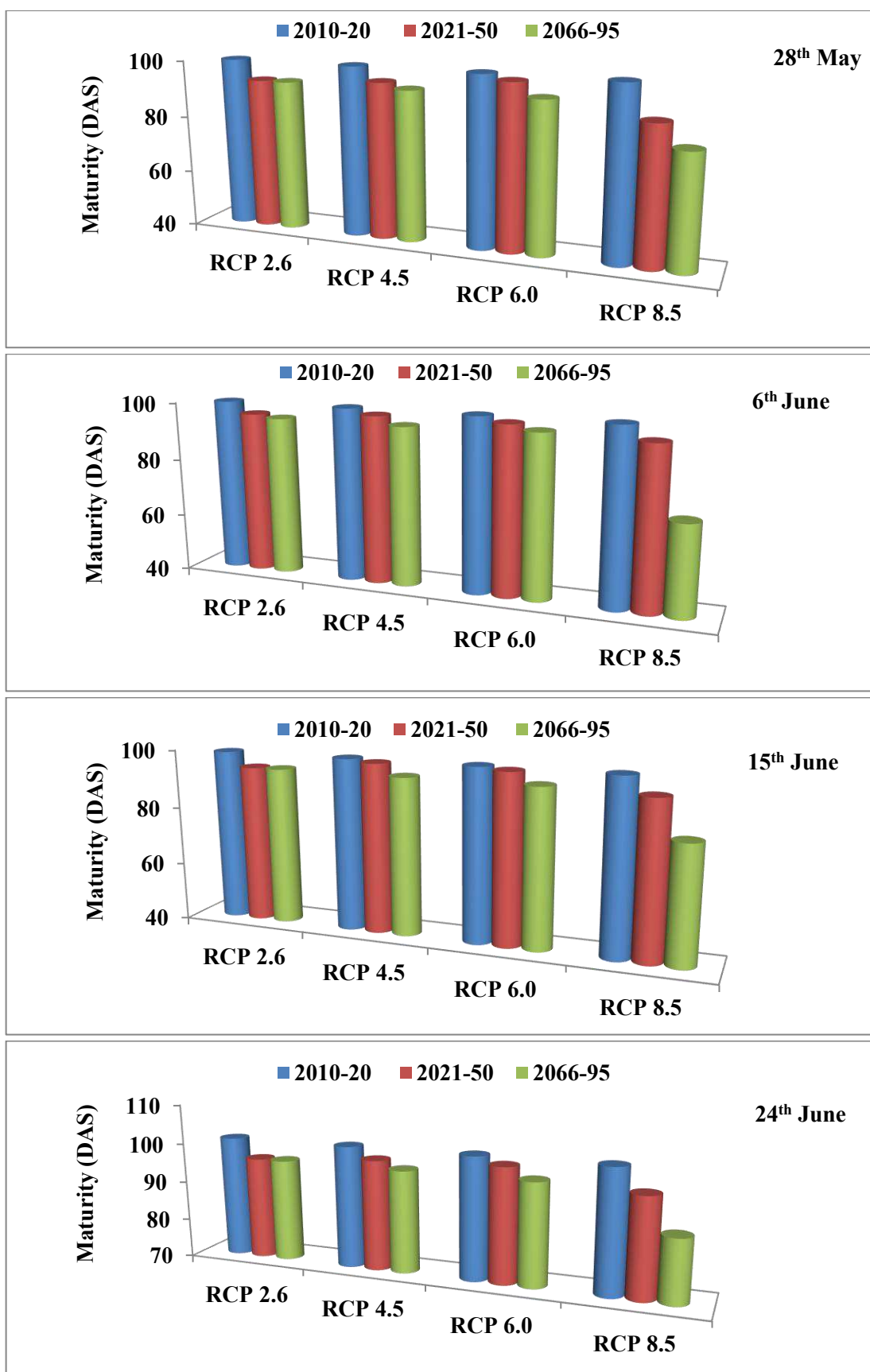


Fig. 4.13: Simulated changes in maturity (DAS) of PMH1 by Ensemble model at agroclimatic zone III (Ludhiana)

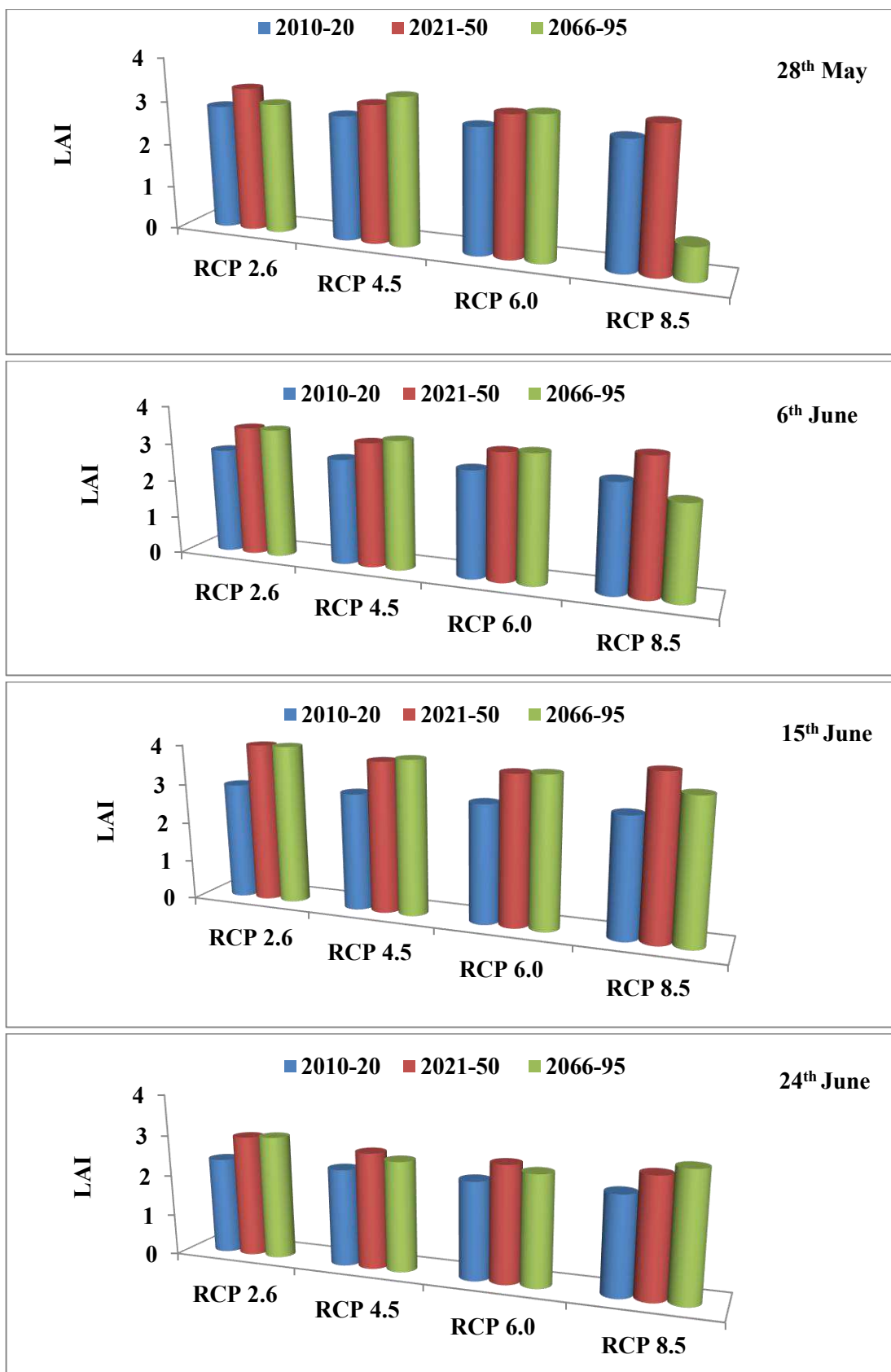


Fig. 4.14: Simulated changes in LAI of PMH1 by Ensemble model at agroclimatic zone III (Ludhiana)

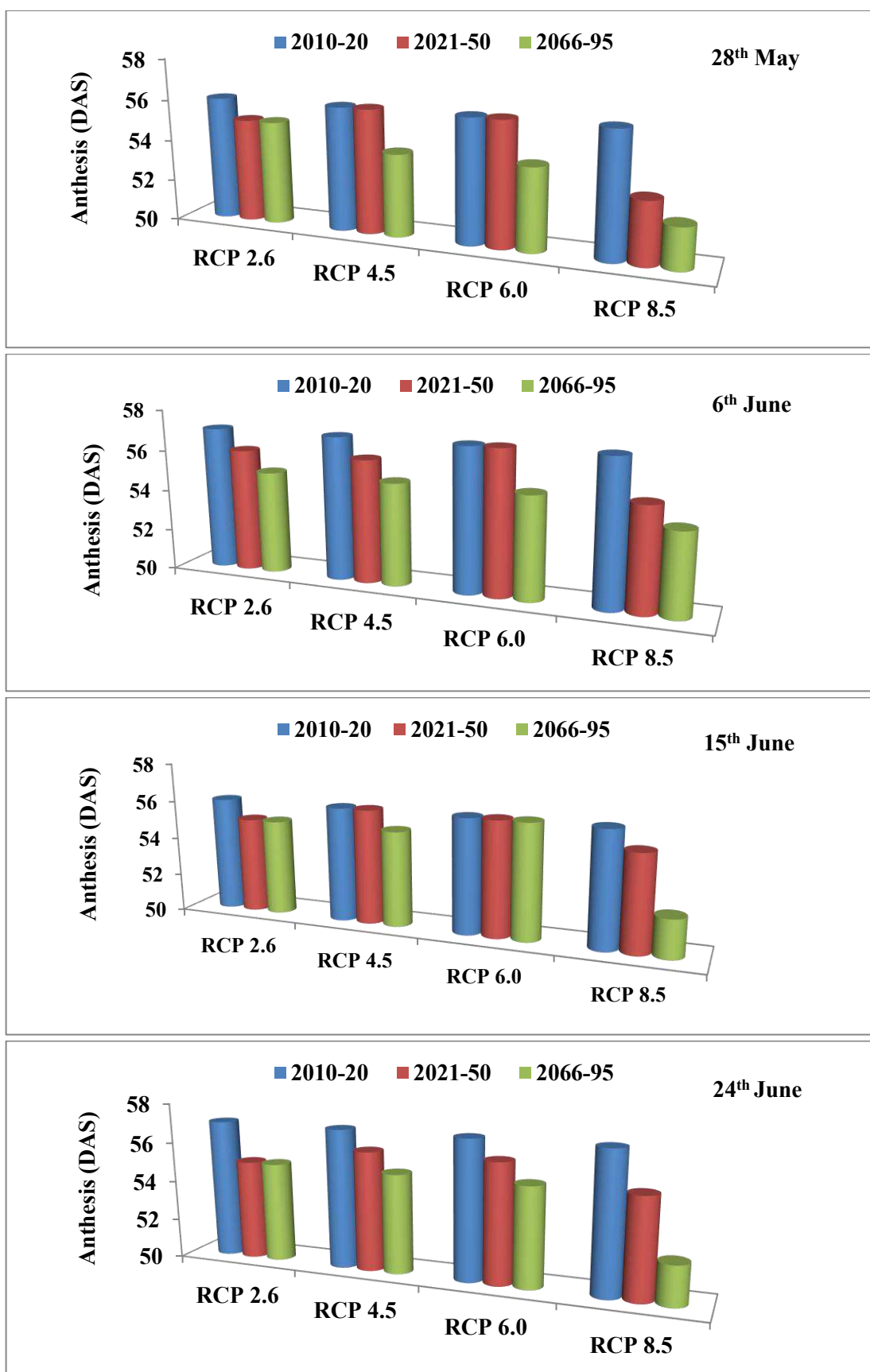


Fig. 4.15: Simulated changes in anthesis (DAS) of PMH2 by Ensemble model at agroclimatic zone III (Ludhiana)

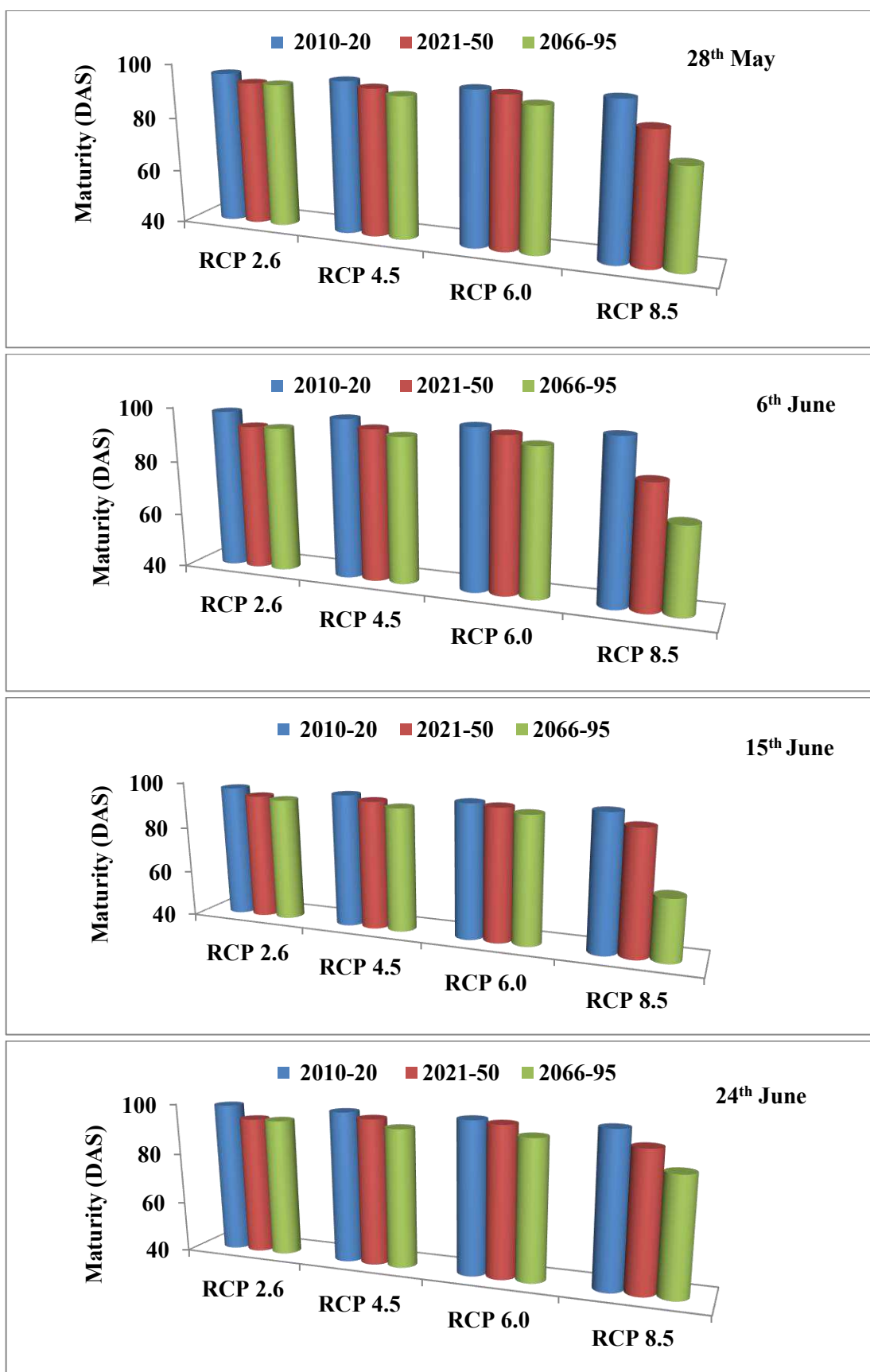


Fig. 4.16: Simulated changes in maturity (DAS) of PMH2 by Ensemble model at agroclimatic zone III (Ludhiana)

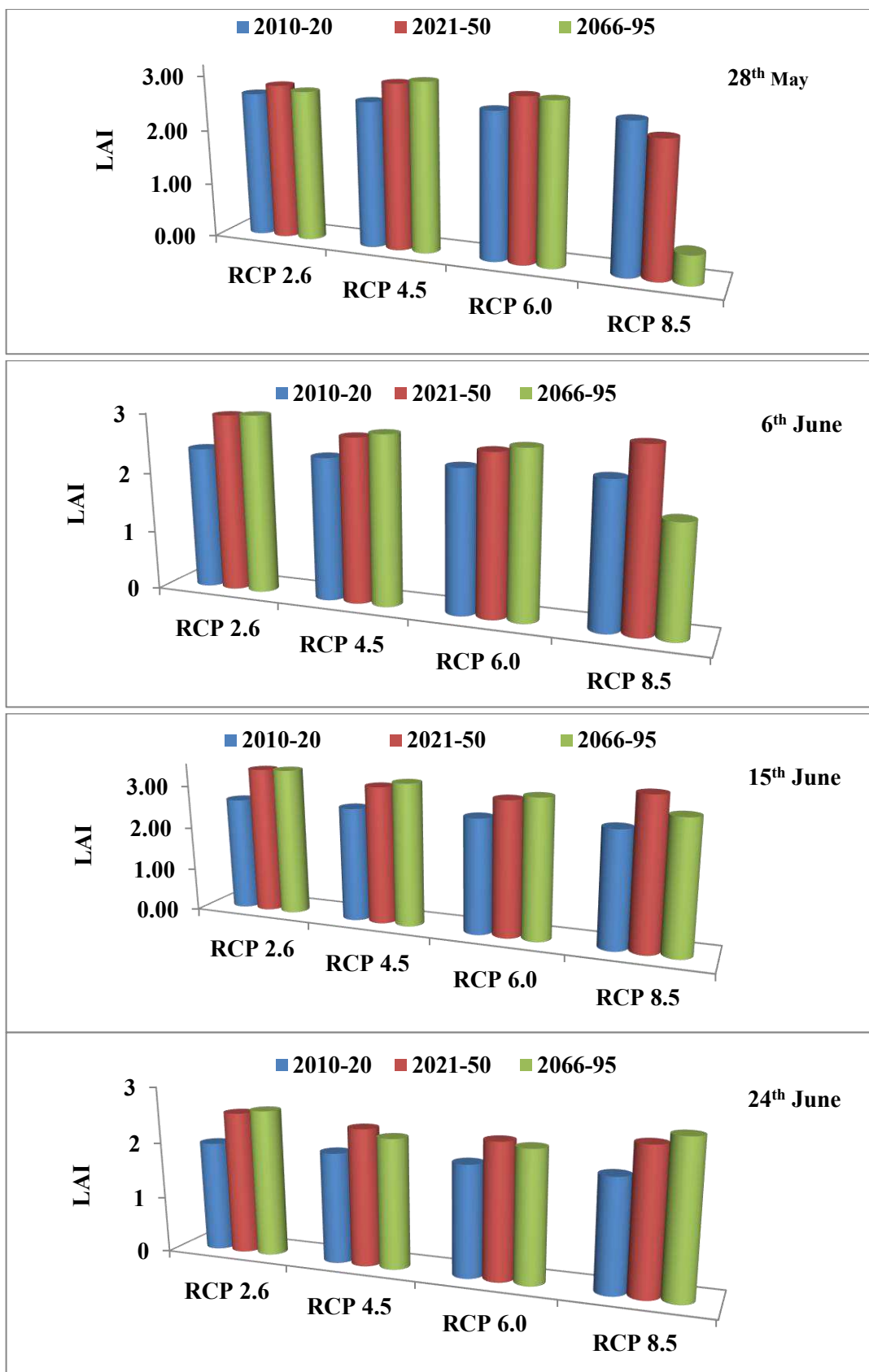


Fig. 4.17: Simulated changes in LAI of PMH2 by Ensemble model at agroclimatic zone III (Ludhiana)

Table 4.53: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by Ensemble model during 21st century at Amritsar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5980.6	4885.8 (-24.8)*	4510.1 (-30.6)	5174.0 (-20.4)	4469.4 (-31.2)	6315.4	4379.2 (-30.7)	4237.2 (-32.9)	4763.4 (-24.6)	4066.5 (-35.6)
	End-century (2051-95)		4691.8 (-27.8)	3799.8 (-41.6)	3590.6 (-44.8)	1763.3 (-72.9)		4308.8 (-31.8)	3384.2 (-46.4)	3202.3 (-49.3)	1758.3 (-72.2)
06-June	Mid-century (2021-50)	6091.7	5209.8 (-14.5)	5486.6 (-9.9)	5703.3 (-6.4)	4783.2 (-21.5)	5374.6	3747.3 (-30.3)	3517.7 (-34.6)	3829.3 (-28.8)	3516.0 (-34.6)
	End-century (2051-95)		5743.6 (-5.7)	4190.4 (-31.2)	3196.3 (-47.5)	593.6 (-90.2)		3570.0 (-33.6)	3155.1 (-41.3)	2874.8 (-46.5)	884.7 (-83.5)
15-June	Mid-century (2021-50)	6237.9	6787.3 (+8.8)	6813.4 (+9.2)	7394.4 (+18.5)	6672.0 (+7.0)	5626.3	5585.6 (-0.7)	5134.8 (-8.7)	5801.7 (+3.1)	5137.4 (-8.7)
	End-century (2051-95)		6726.6 (+7.8)	5394.6 (-13.5)	5461.4 (-12.4)	2895.4 (-53.6)		5388.1 (-4.2)	3886.7 (-30.9)	3558.2 (-36.8)	2061.2 (-63.4)
24-June	Mid-century (2021-50)	5507.1	5351.7 (-2.8)	5731.1 (+4.1)	6044.3 (+9.8)	5110.2 (-7.2)	5662.4	5598.8 (-1.1)	5783.6 (+5.0)	6017.6 (+9.3)	5732.5 (+4.1)
	End-century (2051-95)		4333.0 (-21.3)	3717.5 (-32.5)	4261.3 (-22.6)	2524.1 (-54.2)		5448.7 (-1.1)	4781.2 (-13.2)	4845.1 (-12.0)	2779.4 (-49.5)

*% deviation from baseline value

Table 4.54: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by Ensemble model during 21st century at Amritsar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
			Anthesis					Maturity					LAI			
28-May	Mid-century (2021-50)	62	62 (0)*	62 (0)	62 (0)	62 (0)	101	100 (-1)	99 (-2)	99 (-2)	99 (-2)	3.25	3.23	3.35	3.51	3.36
	End-century (2051-95)		62 (0)	59 (-3)	60 (-2)	58 (-4)		100 (-1)	95 (-6)	95 (-6)	84 (-17)		3.36	3.46	3.55	3.26
06-June	Mid-century (2021-50)	62	61 (-1)	60 (-2)	60 (-2)	60 (-2)	101	99 (-2)	97 (-4)	98 (-3)	97 (-4)	3.21	3.28	3.39	3.39	3.26
	End-century (2051-95)		62 (0)	59 (-3)	59 (-3)	58 (-4)		98 (-3)	95 (-6)	95 (-6)	77 (-24)		3.28	3.50	3.33	3.46
15-June	Mid-century (2021-50)	62	61 (-1)	61 (-1)	61 (-1)	61 (-1)	101	100 (-1)	100 (-1)	100 (-1)	100 (-1)	3.31	3.40	3.63	3.76	3.59
	End-century (2051-95)		62 (0)	59 (-3)	60 (-2)	58 (-4)		100 (-1)	96 (-5)	96 (-5)	93 (-8)		3.50	3.76	3.76	3.93
24-June	Mid-century (2021-50)	61	61 (0)	60 (-1)	60 (-1)	60 (-1)	101	101 (0)	99 (-2)	100 (-1)	99 (-2)	2.57	2.67	2.83	32.94	2.69
	End-century (2051-95)		60 (-1)	58 (-3)	58 (-3)	57 (-4)		100 (-1)	96 (-5)	95 (-6)	92 (-9)		2.48	2.56	2.72	2.76

*Deviation from baseline in DAS

Table 4.55: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by Ensemble model during 21st century at Amritsar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
			Anthesis					Maturity					LAI			
28-May	Mid-century (2021-50)	58	58 (0)*	58 (0)	58 (0)	58 (0)	99	97 (-2)	97 (-2)	97 (-2)	96 (-3)	3.27	3.06	3.10	3.20	3.04
	End-century (2051-95)		58 (0)	57 (-1)	57 (-1)	55 (-3)		97 (-2)	95 (-4)	94 (-5)	84 (-15)		3.19	3.22	3.26	2.95
06-June	Mid-century (2021-50)	59	58 (-1)	58 (-1)	58 (-1)	58 (-1)	99	98 (-1)	97 (-2)	97 (-2)	97 (-2)	2.74	2.75	2.84	2.84	2.75
	End-century (2051-95)		58 (-1)	55 (-4)	55 (-4)	54 (-5)		98 (-1)	93 (-6)	93 (-6)	76 (-23)		2.81	2.94	2.86	2.96
15-June	Mid-century (2021-50)	59	58 (-1)	58 (-1)	58 (-1)	58 (-1)	100	98 (-2)	97 (-3)	98 (-2)	97 (-3)	2.88	2.89	3.08	3.18	3.07
	End-century (2051-95)		58 (-1)	57 (-2)	57 (-2)	55 (-4)		98 (-2)	96 (-4)	95 (-5)	91 (-9)		3.01	3.33	3.18	3.35
24-June	Mid-century (2021-50)	57	57 (0)	57 (0)	57 (0)	57 (0)	99	98 (-1)	97 (-2)	98 (-1)	97 (-2)	2.21	2.26	2.44	2.52	2.34
	End-century (2051-95)		57 (0)	55 (-2)	55 (-2)	54 (-3)		98 (-1)	93 (-6)	93 (-6)	91 (-8)		2.13	2.27	2.35	2.53

*Deviation from baseline in DAS

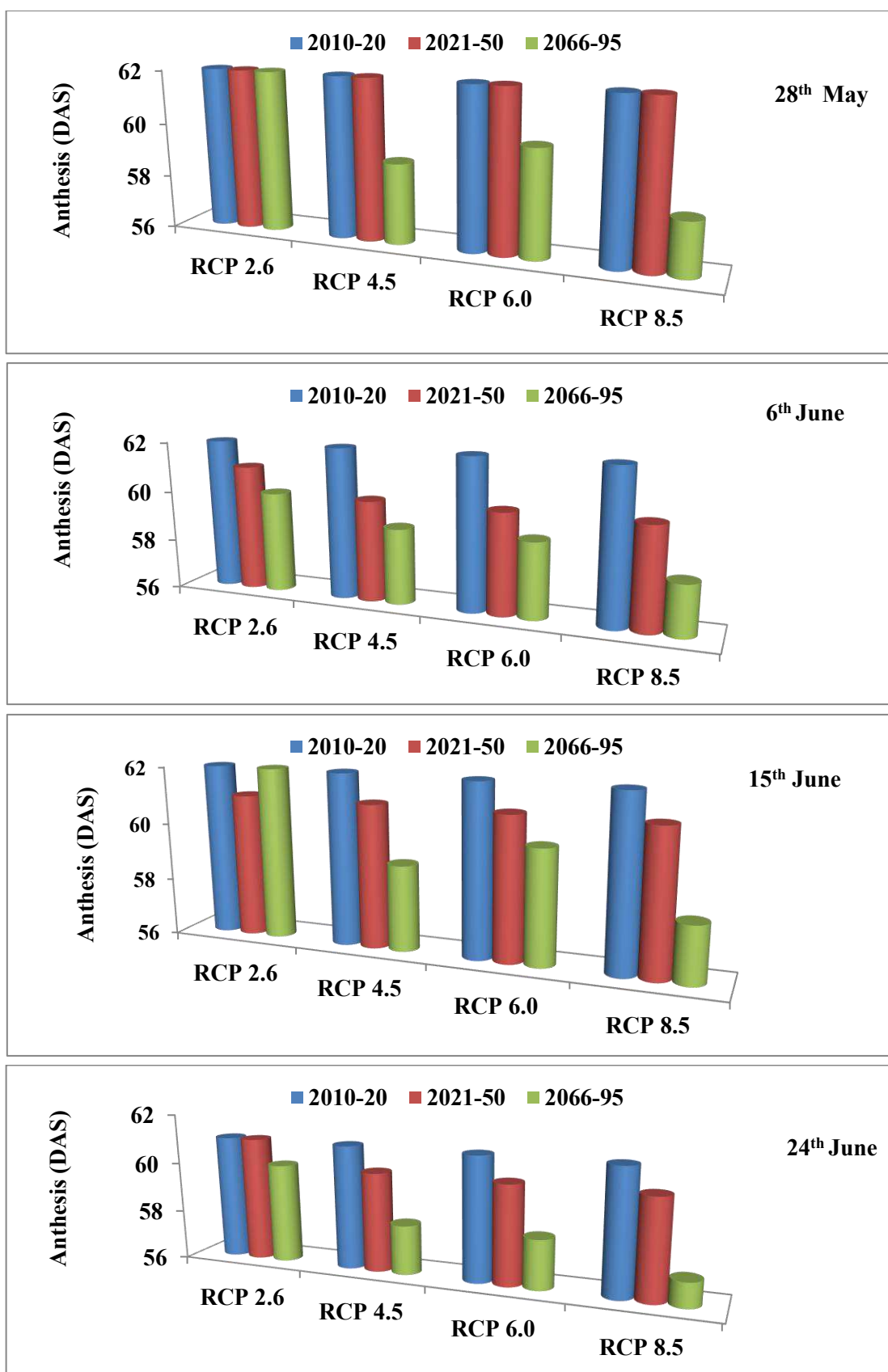


Fig. 4.18: Simulated changes in Anthesis (DAS) of PMH1 by Ensemble model at agroclimatic zone III (Amritsar)

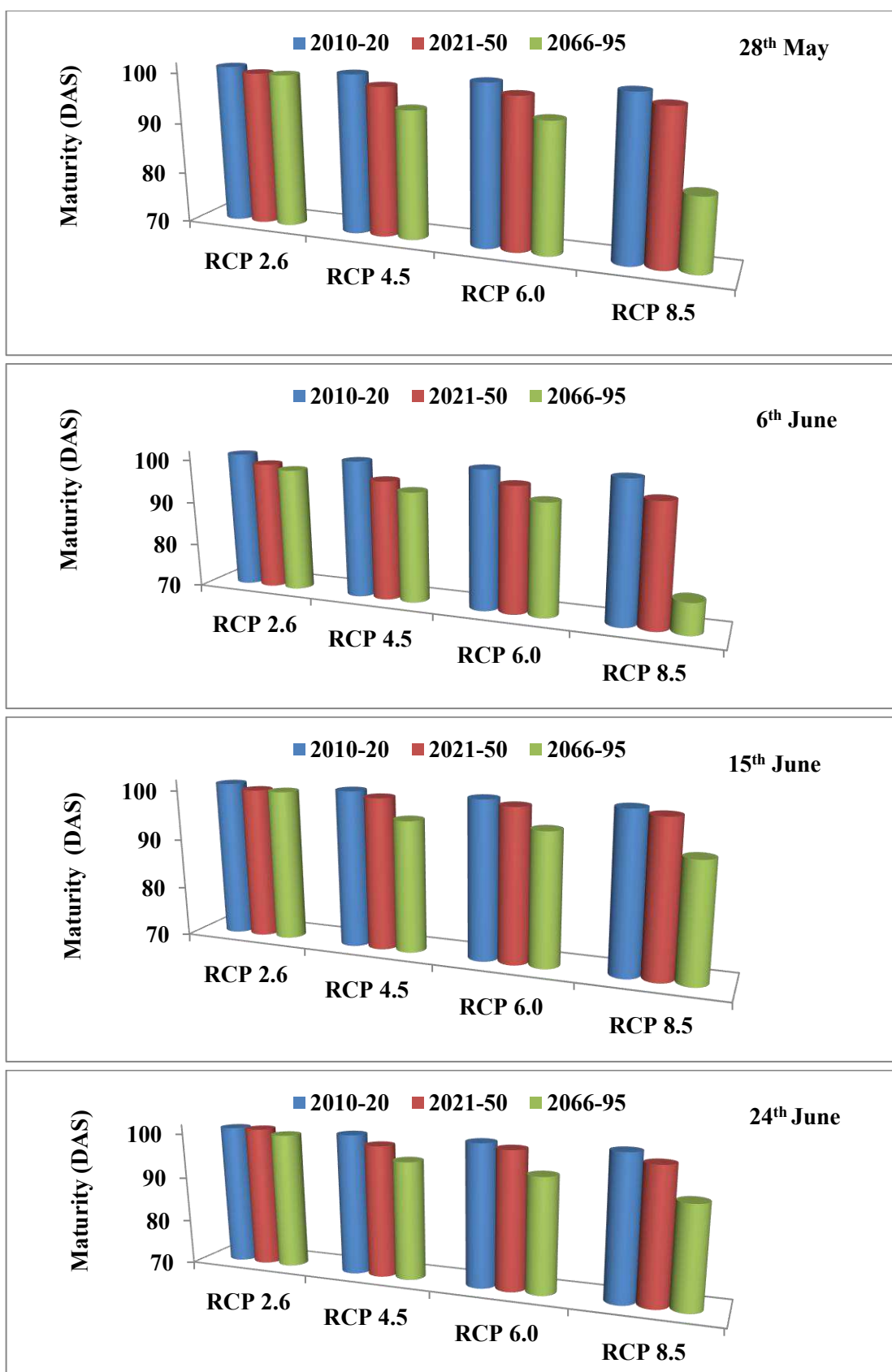


Fig. 4.19: Simulated changes in maturity (DAS) of PMH1 by Ensemble model at agroclimatic zone III (Amritsar)

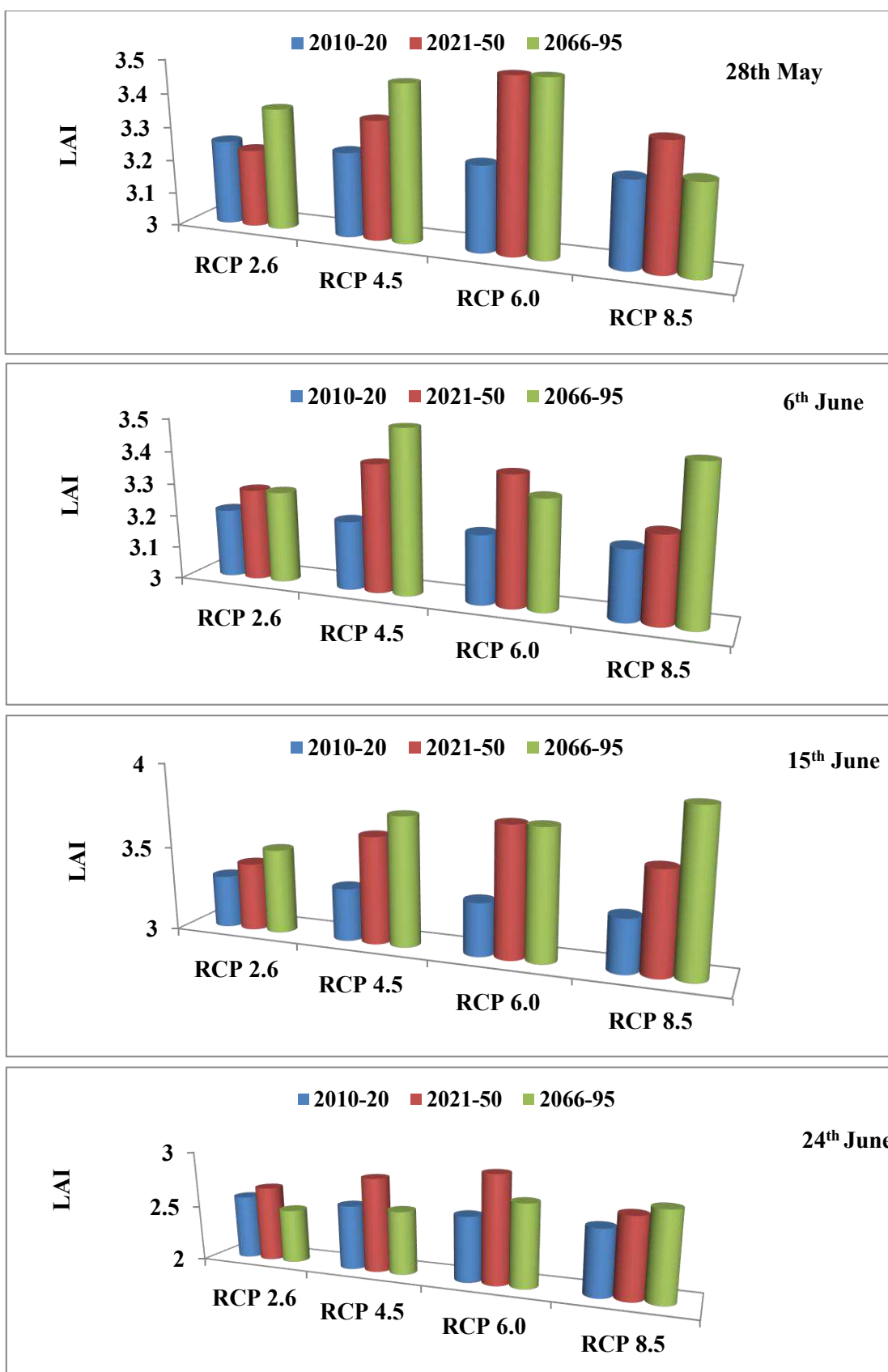


Fig. 4.20: Simulated changes in LAI of PMH1 by Ensemble model at agroclimatic zone III (Amritsar)

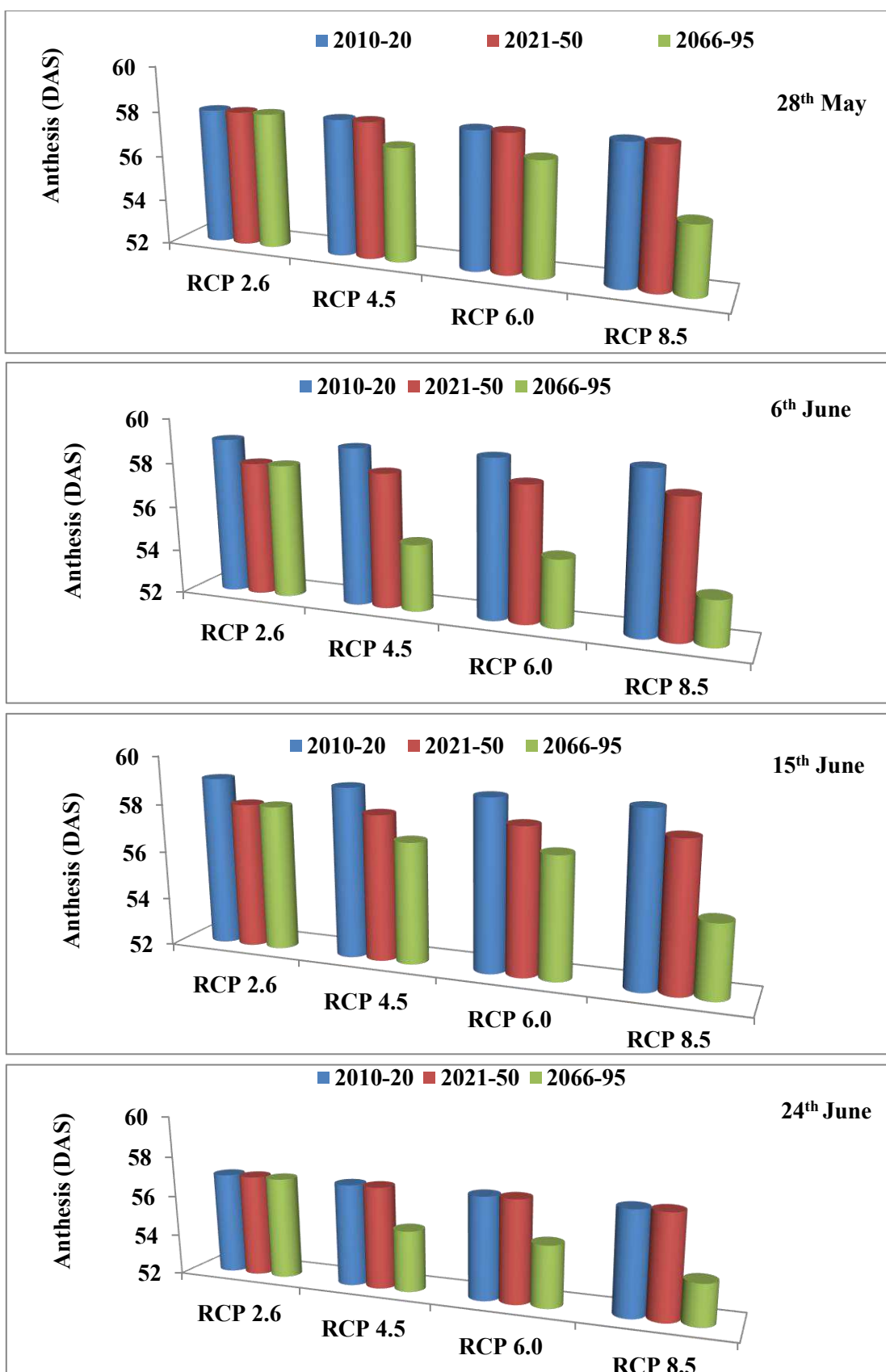


Fig. 4.21: Simulated changes in anthesis (DAS) of PMH2 by Ensemble model at agroclimatic zone III (Amritsar)

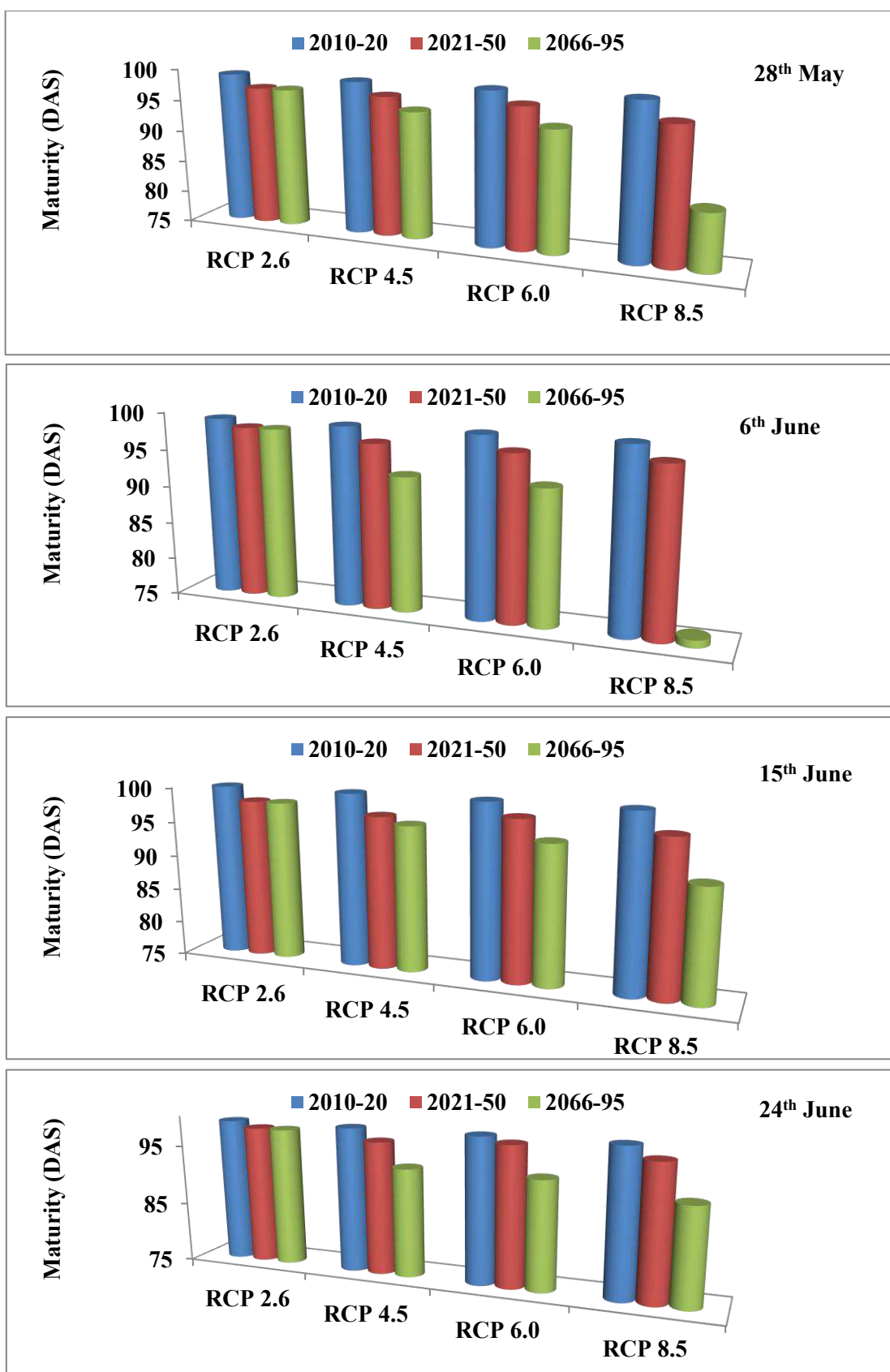


Fig. 4.22: Simulated changes in maturity (DAS) of PMH2 by Ensemble model at agroclimatic zone III (Amritsar)

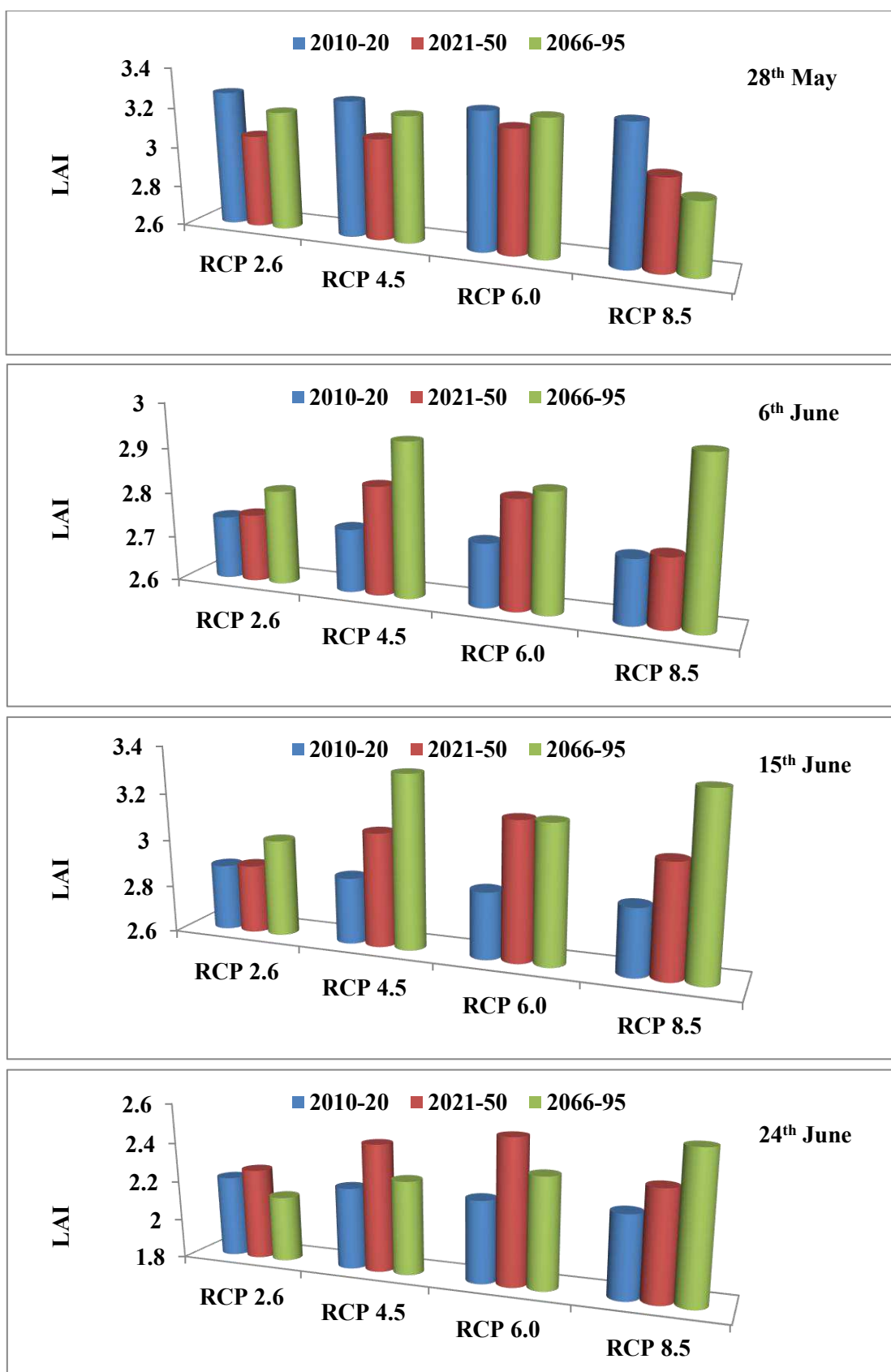


Fig. 4.23: Simulated changes in LAI of PMH2 by Ensemble model at agroclimatic zone III (Amritsar)

Table 4.56: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by Ensemble model during 21st century at Patiala, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	5881.6	5983.4 (+0.8)*	5672.4 (-4.4)	5854.9 (-1.4)	5418.5 (-8.7)	5506.4	5163.9 (-6.2)	4968.5 (-9.8)	5220.4 (-5.2)	4576.3 (-16.9)
	End-century (2051-95)		5639.9 (-5.0)	5182.8 (-12.7)	4754.3 (-19.9)	1814.9 (-69.4)		4919.1 (-10.7)	4368.7 (-20.7)	3988.0 (-27.6)	1908.5 (-65.3)
06-June	Mid-century (2021-50)	5936.4	6097.6 (+2.7)	6268.8 (+5.6)	6413.3 (+8.0)	5835.8 (-1.7)	5419.0	4422.2 (-18.4)	4451.3 (-17.9)	4631.7 (-14.5)	4160.7 (-23.2)
	End-century (2051-95)		6193.4 (+4.3)	5150.5 (-13.2)	4296.7 (-27.6)	548.3 (-90.8)		4160.4 (-23.2)	3833.3 (-29.3)	3670.6 (-32.3)	1079.8 (-80.1)
15-June	Mid-century (2021-50)	5990.0	8209.7 (+37.0)	8091.9 (+35.1)	8129.9 (+35.7)	7777.7 (+29.8)	5464.1	7252.1 (+32.7)	6429.6 (+17.7)	6799.5 (+24.4)	6642.7 (+21.6)
	End-century (2051-95)		8048.6 (+34.4)	6335.0 (+5.8)	6142.0 (+2.5)	3127.0 (-47.8)		6891.6 (+26.1)	6273.0 (+14.8)	4320.2 (-20.9)	2445.3 (-55.2)
24-June	Mid-century (2021-50)	5485.8	6493.3 (+18.4)	6091.3 (+11.0)	6518.5 (+18.8)	6054.5 (+10.4)	5496.4	6616.4 (+20.4)	6414.9 (+16.7)	6707.8 (+22.0)	6221.1 (+13.2)
	End-century (2051-95)		6436.3 (+17.3)	4674.2 (-14.8)	4376.0 (-20.2)	2850.8 (-48.0)		6509.5 (+18.4)	4787.5 (-12.9)	4813.8 (-12.4)	3043.1 (-44.6)

*% deviation from baseline value

Table 4.57: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by Ensemble model during 21st century at Patiala, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	59	59 (0)*	58 (-1)	59 (0)	58 (-1)	97	97 (0)	95 (-2)	97 (0)	95 (-2)	3.25	3.73	3.75	3.74	3.67
	End-century (2051-95)		59 (0)	57 (-2)	57 (-2)	56 (-3)		97 (0)	93 (-4)	93 (-4)	81 (-16)		3.75	3.67	3.67	2.88
06-June	Mid-century (2021-50)	60	58 (-2)	58 (-2)	58 (-2)	58 (-2)	98	96 (-2)	95 (-3)	96 (-2)	95 (-3)	3.23	3.63	3.66	3.61	3.63
	End-century (2051-95)		58 (-2)	57 (-3)	57 (-3)	56 (-4)		96 (-2)	94 (-4)	93 (-5)	73 (-25)		3.57	3.68	3.62	3.45
15-June	Mid-century (2021-50)	60	60 (0)	59 (-1)	59 (-1)	58 (-2)	99	99 (0)	97 (-2)	98 (-1)	96 (-3)	3.15	4.23	4.26	4.22	4.24
	End-century (2051-95)		60 (0)	57 (-3)	57 (-3)	56 (-4)		98 (-1)	94 (-5)	94 (-5)	91 (-8)		4.20	4.16	4.06	3.96
24-June	Mid-century (2021-50)	60	60 (0)	60 (0)	60 (0)	60 (0)	101	99 (-2)	98 (-3)	99 (-2)	98 (-3)	3.03	3.08	3.14	3.18	3.07
	End-century (2051-95)		60 (0)	59 (-1)	59 (-1)	56 (-4)		99 (-2)	96 (-5)	96 (-5)	91 (-10)		3.03	2.79	2.81	3.17

*Deviation from baseline in DAS

Table 4.58: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by Ensemble model during 21st century at Patiala, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
			Anthesis					Maturity					LAI			
28-May	Mid-century (2021-50)	55	55 (0)*	55 (0)	55 (0)	55 (0)	95	95 (0)	94 (-1)	85 (-10)	94 (-1)	2.87	3.23	3.23	3.19	3.19
	End-century (2051-95)		55 (0)	55 (0)	54 (-1)	52 (-3)		95 (0)	93 (-2)	92 (-3)	81 (-14)		3.25	3.25	3.21	2.38
06-June	Mid-century (2021-50)	56	56 (0)	54 (-2)	55 (-1)	54 (-2)	96	96 (0)	94 (-2)	95 (-1)	93 (-3)	2.70	2.98	3.03	2.99	2.99
	End-century (2051-95)		56 (0)	53 (-3)	53 (-3)	52 (-4)		95 (-1)	91 (-5)	91 (-5)	73 (-23)		2.97	3.14	3.10	2.95
15-June	Mid-century (2021-50)	56	56 (0)	56 (0)	56 (0)	56 (0)	97	96 (-1)	96 (-1)	96 (-1)	95 (-2)	2.61	3.57	3.63	3.54	3.61
	End-century (2051-95)		56 (0)	56 (0)	56 (0)	52 (-4)		96 (-1)	94 (-3)	94 (-3)	88 (-9)		3.52	3.61	3.49	3.52
24-June	Mid-century (2021-50)	57	56 (-1)	55 (-2)	56 (-1)	55 (-2)	99	97 (-2)	96 (-3)	96 (-3)	96 (-3)	2.06	2.79	2.84	2.85	2.79
	End-century (2051-95)		55 (-2)	55 (-2)	55 (-2)	53 (-4)		96 (-3)	94 (-5)	94 (-5)	90 (-9)		2.75	2.52	2.55	2.88

*Deviation from baseline in DAS

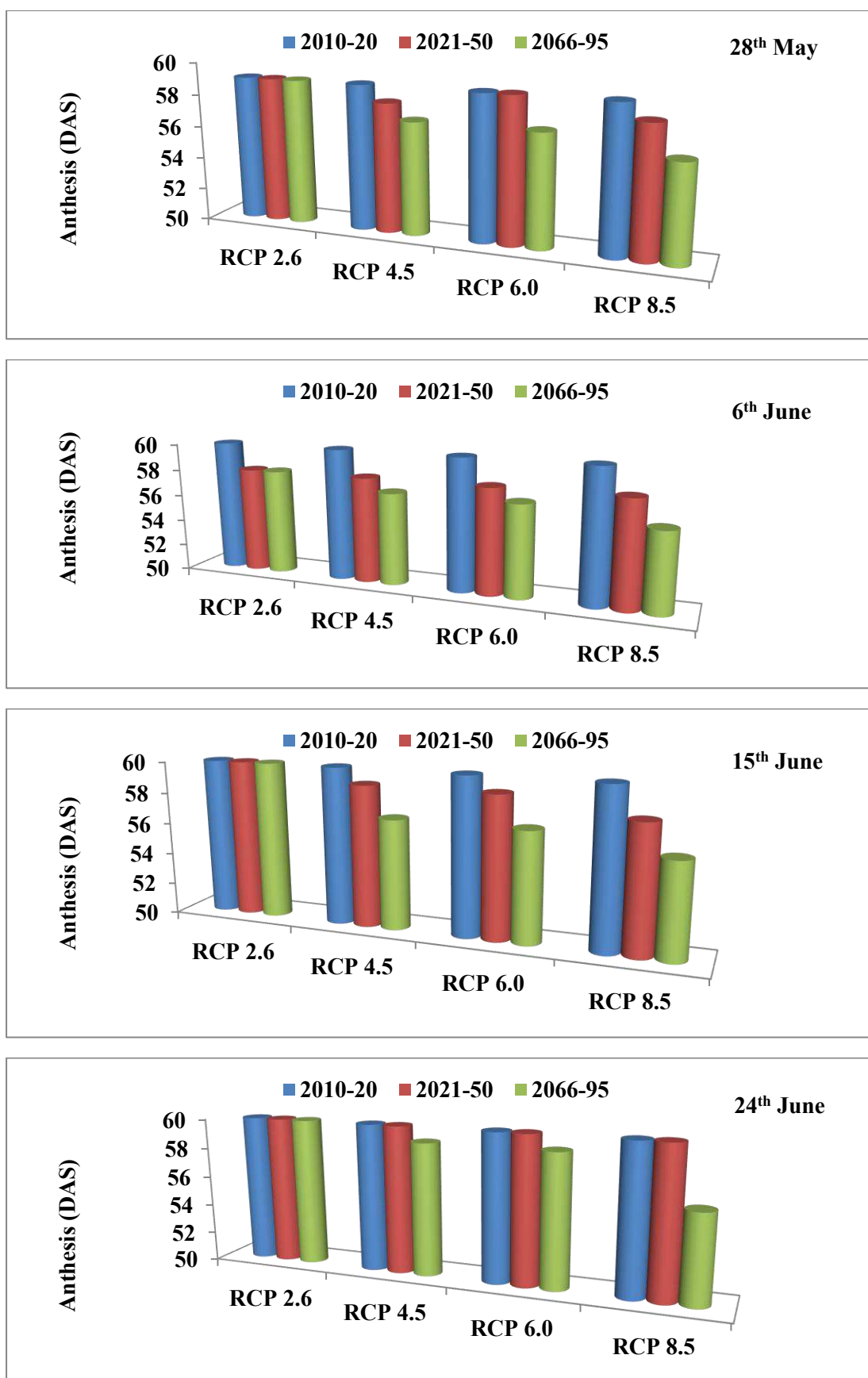


Fig. 4.24: Simulated changes in anthesis (DAS) of PMH1 by Ensemble model at agroclimatic zone III (Patiala)

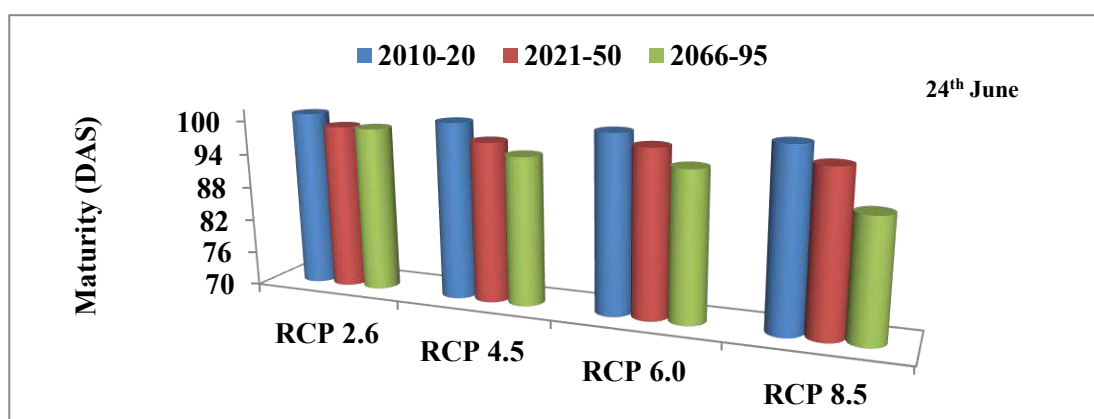
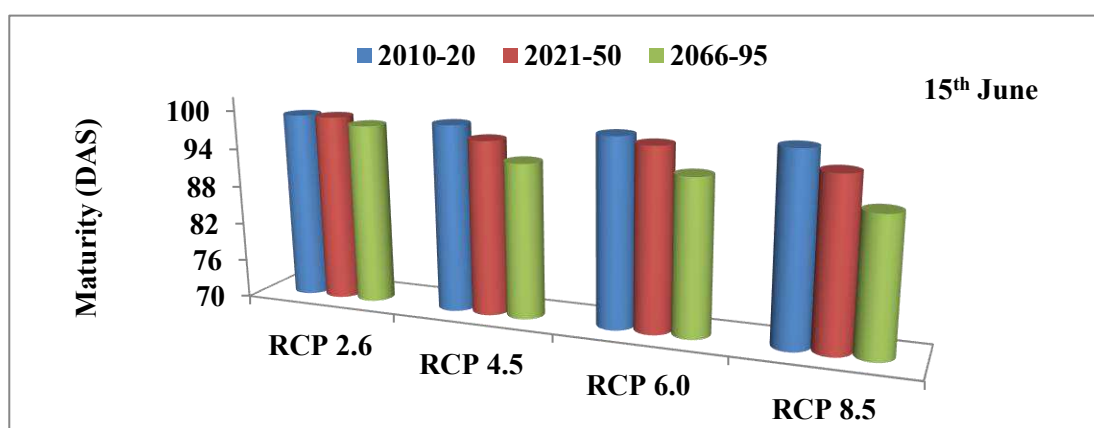
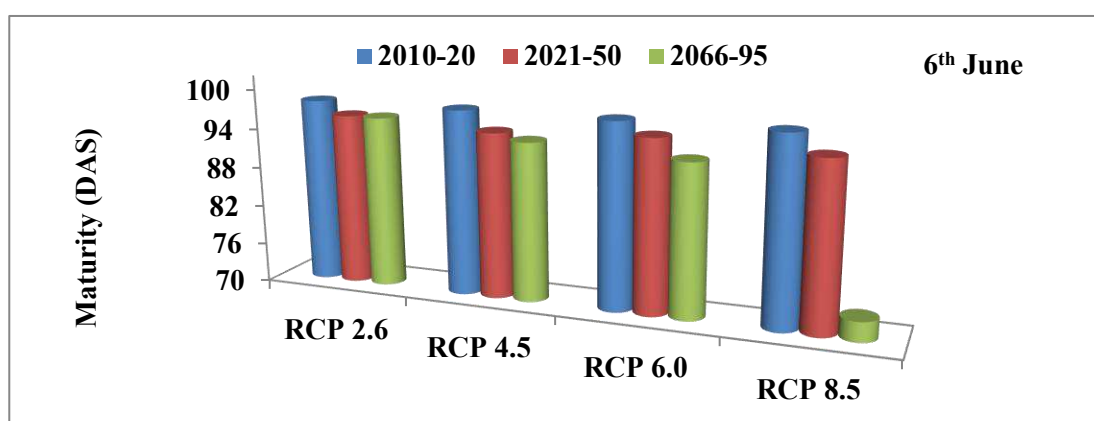
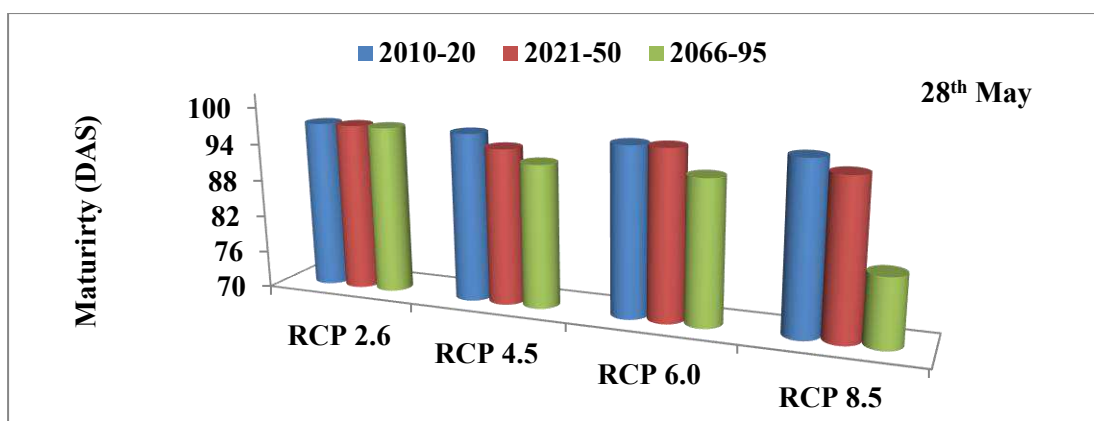


Fig. 4.25: Simulated changes in maturity (DAS) of PMH1 by Ensemble model at agroclimatic zone III (Patiala)

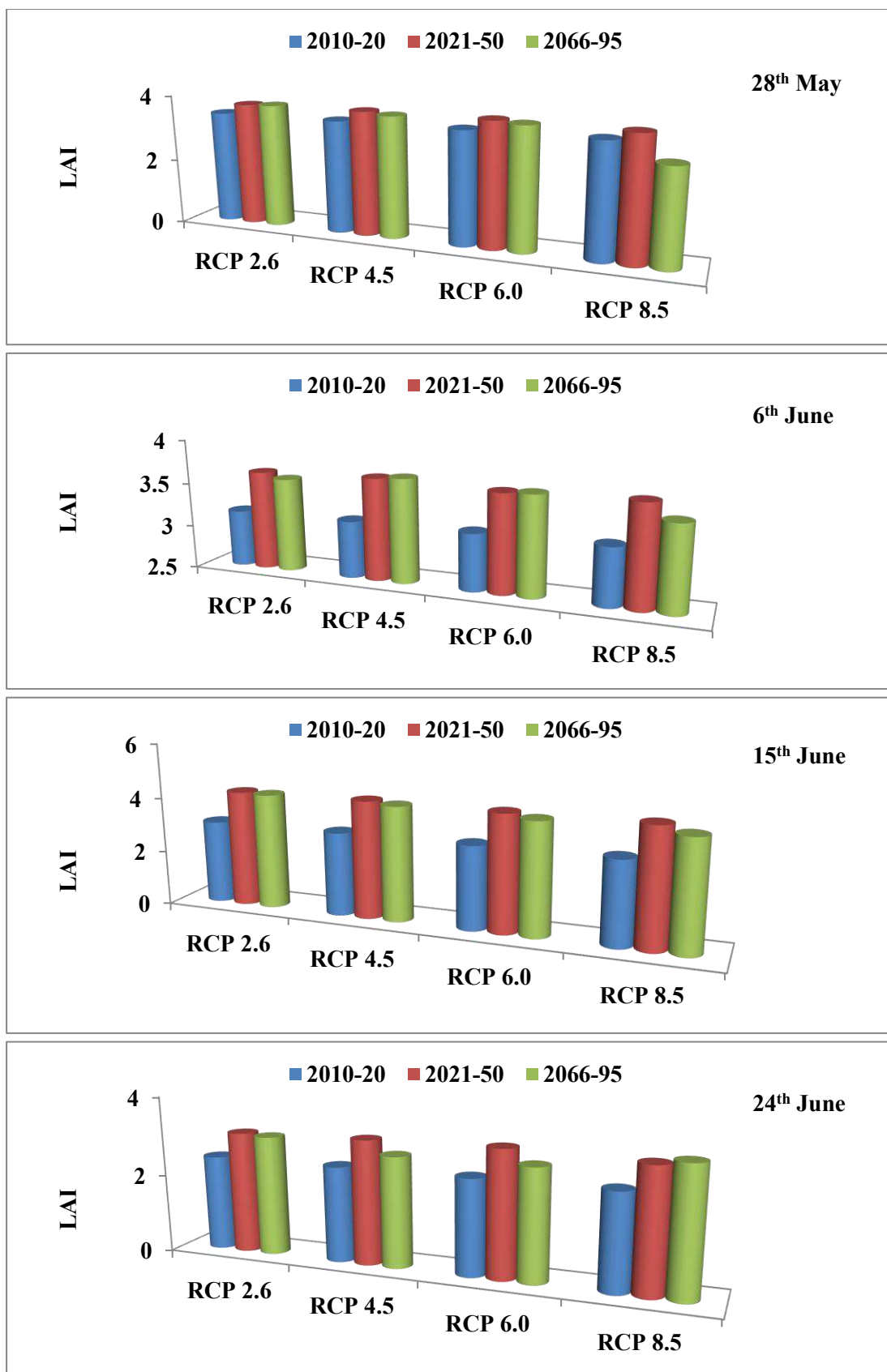


Fig. 4.26: Simulated changes in LAI of PMH1 by Ensemble model at agroclimatic zone III (Patiala)

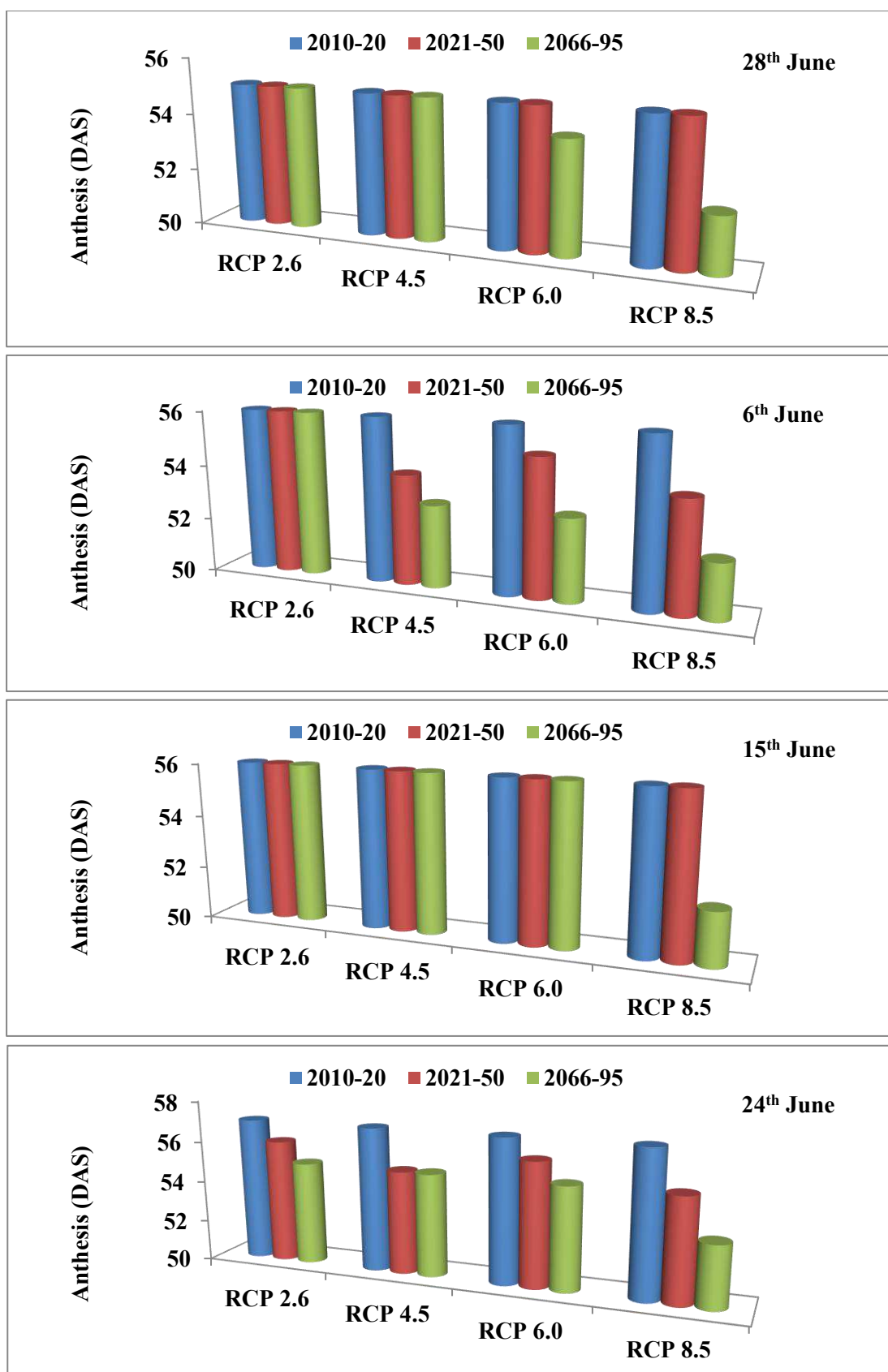


Fig. 4.27: Simulated changes in anthesis (DAS) of PMH2 by Ensemble model at agroclimatic zone III (Patiala)

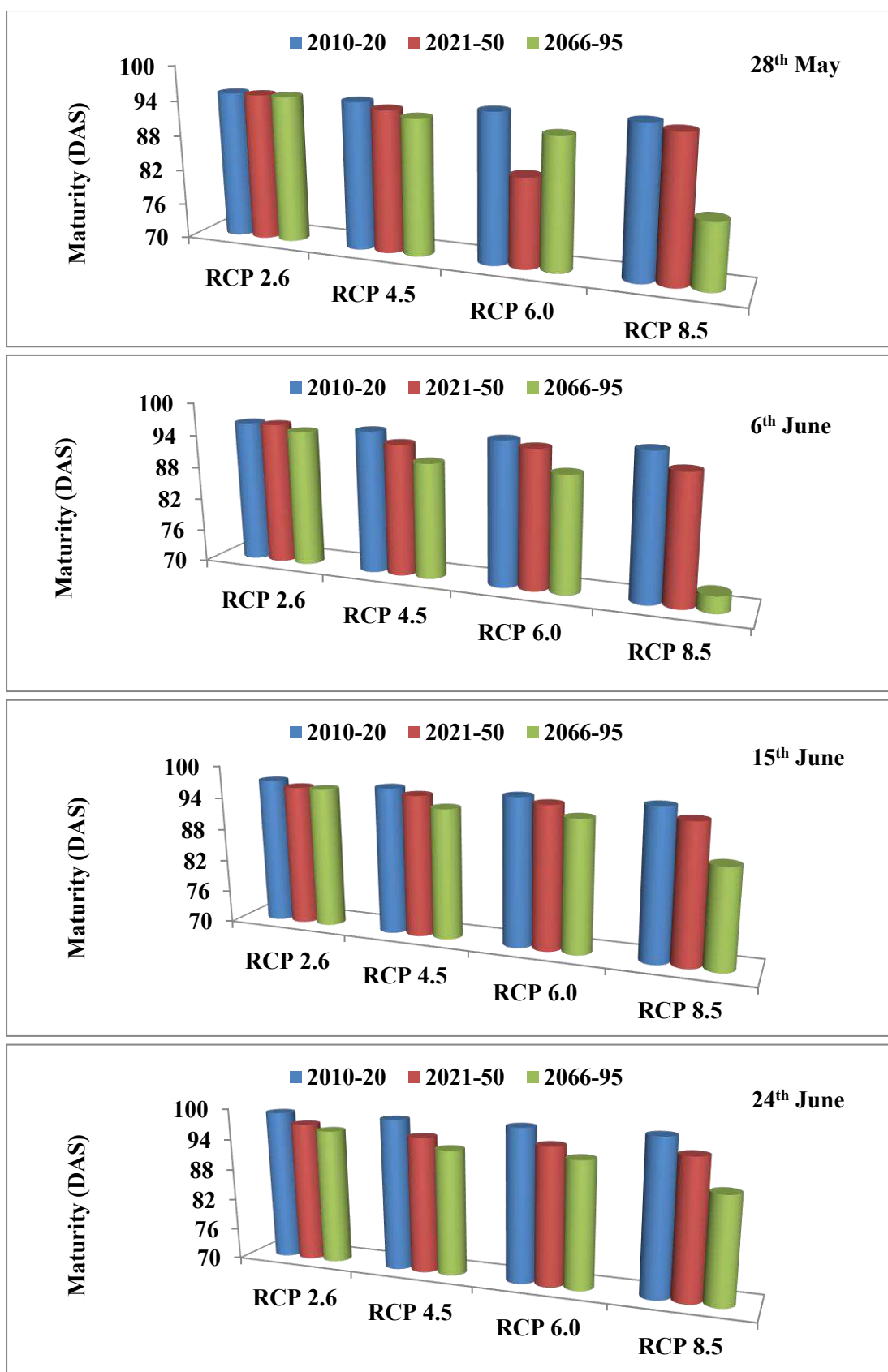


Fig. 4.28: Simulated changes in maturity (DAS) of PMH2 by Ensemble model at agroclimatic zone III (Patiala)

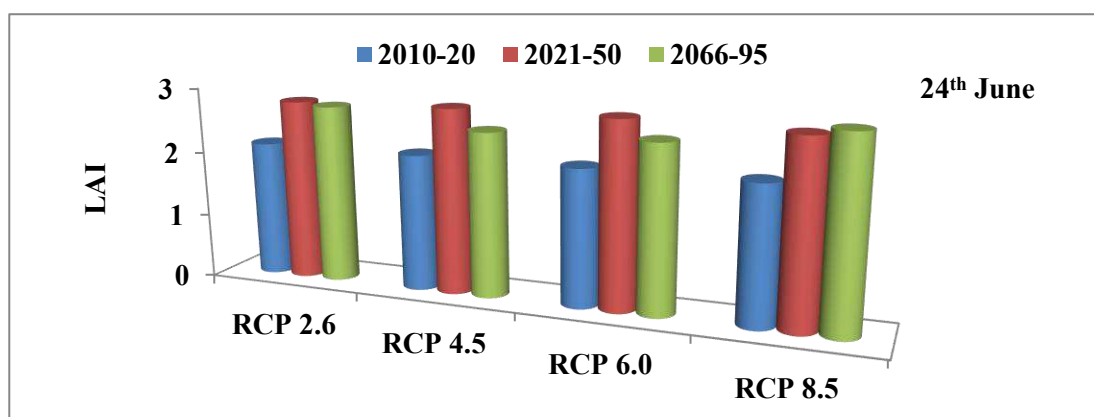
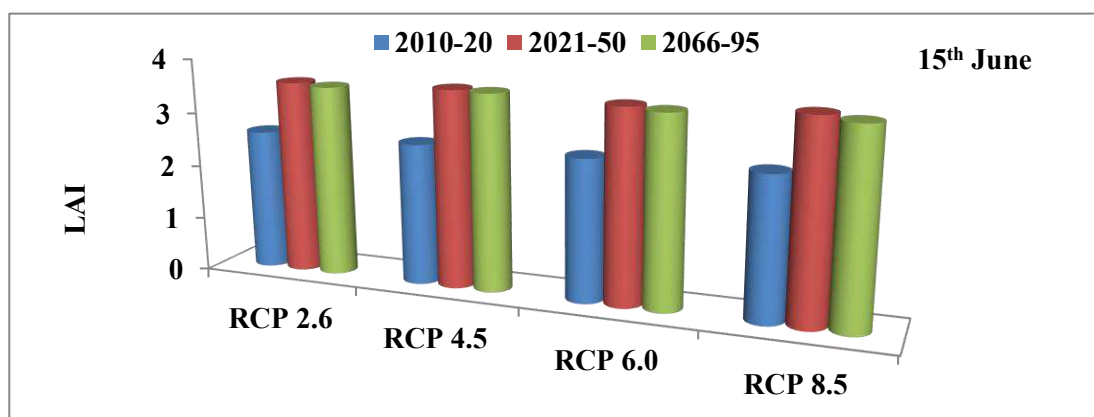
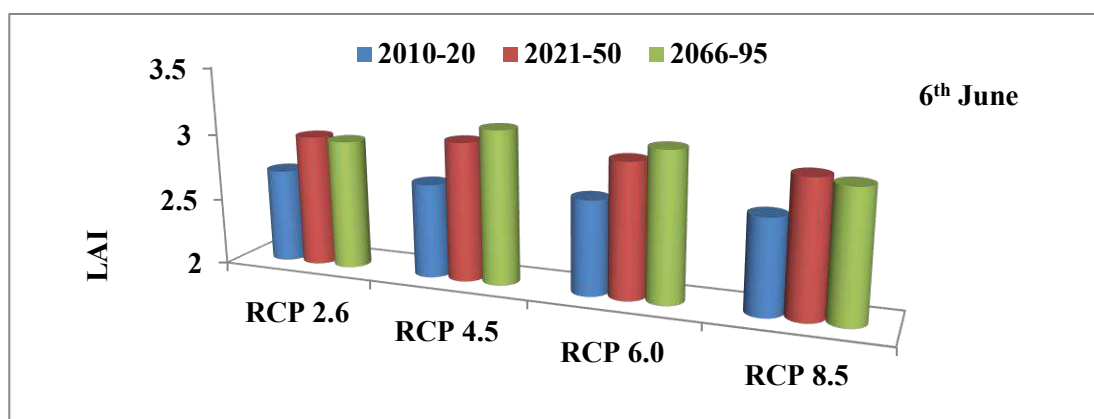
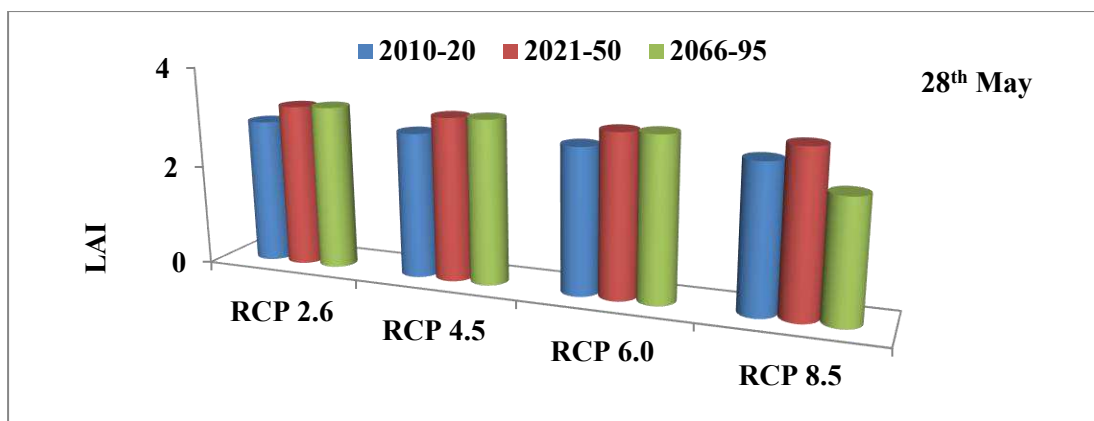


Fig. 4.29: Simulated changes in LAI of PMH2 by Ensemble model at agroclimatic zone III (Patiala)

Agroclimatic zone IV (Bathinda)

CSIRO Mk-36-0 model

In Bathinda, the yield decline as observed of PMH1 (Table 4.59) cultivar ranged 9.7% to 44.4% during the mid-century while 34.6% to 99.9% during the end-century from the baseline range (3183.1kg ha⁻¹ to 3528.7kg ha⁻¹). A higher decrease was observed under RCP4.5 and RCP8.5 with a complete failure of crop on 15th June during end-century under RCP4.5. The yield obtained during the end-century ranged <2500 kg ha⁻¹. The large decline in yield depicts the requirement of better management practices for good maize production under future conditions. For PMH2 (Table 4.59) the yield decrement was observed ranging 6.1% to 84.6% during the mid-century and 11.3% to 99.9% during the end-century from the baseline range (2921.3 kg ha⁻¹ to 3196.3 kg ha⁻¹). The major decline in yield was observed under RCP4.5 and RCP8.5. Under RCP4.5 complete crop failure was observed on 15th June and under RCP8.5 on 28th May under RCP8.5. The yield for the end-century ranged <3000 kg ha⁻¹ under the four RCPs and dates of sowing.

The anthesis period for PMH1 cultivar in Bathinda was projected (Table 4.60) to shorten by 1-3 days during the mid-century and by 2-5 days during the end-century from the baseline (59-60 DAS) while the maturity period was projected to shorten by 4-25 days and 8-30 days during the mid and end-century, respectively from the baseline (97-100 DAS). The maximum shortening was observed during the mid-century under RCP4.5 and under RCP8.5 during the end-century. The LAI was found to be higher than the baseline except under RCP4.5 and RCP8.5 where LAI was lower for 28th May and 6th June. For PMH2 (Table 4.61) the shortening of anthesis and maturity was observed by 0-3 days from the baseline (55-56 DAS) and 2-23 days from the baseline (95-98 DAS), respectively during mid-century. The end-century indicated a decline in anthesis and maturity by 1-5 days and 5-30 days, respectively. The LAI obtained for the 85 year period was higher than the baseline except on 28th May where it was lower for both the centuries. The highest shortening of days was observed under RCP4.5 and RCP8.5.

Table4.59: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Bathinda, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	3528.7	2472.3 (-29.9)*	1167.9 (-66.9)	2789.97 (-20.9)	2228.00 (-36.9)	3081.3	2040.1 (-33.8)	1116.2 (-63.8)	2303.6 (-25.2)	1880.8 (-39.0)
	End-century (2051-95)		1807.7 (-48.8)	471.9 (-86.6)	1059.1 (-70.0)	348.8 (-90.1)		1554.7 (-49.5)	44.8 (-98.6)	858.8 (-72.1)	3.4 (-99.9)
06-June	Mid-century (2021-50)	3304.8	2268.4 (-31.4)	301.9 (-90.9)	2432.7 (-26.4)	1837.3 (-44.4)	2921.3	1861.3 (-36.3)	449.9 (-84.6)	2050.9 (-29.8)	1535.6 (-47.4)
	End-century (2051-95)		1700.9 (-48.5)	217.7 (-93.4)	394.0 (-88.1)	222.7 (-93.3)		1409.8 (-51.7)	250.2 (-91.4)	457.2 (-84.3)	196.5 (-93.3)
15-June	Mid-century (2021-50)	3392.4	2849.2 (-16.0)	1326.4 (-60.9)	3064.2 (-9.7)	2501.0 (-26.3)	3196.3	2274.3 (-28.9)	1374.4 (-57.0)	2490.5 (-22.1)	2033.2 (-36.4)
	End-century (2051-95)		2219.8 (-34.6)	2.6 (-99.9)	1436.8 (-57.7)	143.3 (-95.8)		1809.8 (-43.4)	2.9 (-99.9)	1504.6 (-52.9)	136.9 (-95.7)
24-June	Mid-century (2021-50)	3183.1	1862.1 (-41.5)	1042.3 (-67.2)	2049.7 (-35.6)	1788.8 (-43.8)	3343.2	2968.5 (-11.2)	1660.9 (-50.3)	3137.5 (-6.1)	2754.3 (-17.6)
	End-century (2051-95)		1803.1 (-43.3)	537.5 (-83.1)	1138.8 (-64.2)	458.4 (-85.6)		2964.2 (-11.3)	613.8 (-81.6)	1921.9 (-42.5)	610.8 (-81.7)

*% deviation from baseline value

Table 4.60: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Bathinda, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	59	56 (-3)	56 (-3)	57 (-2)	56 (-3)	97	92 (-5)	82 (-15)	93 (-4)	90 (-7)	1.82	1.89	1.79	1.91	1.94
	End-century (2051-95)		56 (-3)	55 (-4)	55 (-4)	55 (-4)		89 (-8)	82 (-15)	83 (-14)	77 (-20)		1.97	1.01	1.89	0.95
06-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	57 (-3)	98	93 (-5)	73 (-25)	94 (-4)	89 (-9)	1.85	1.97	2.01	1.97	1.98
	End-century (2051-95)		56 (-4)	56 (-4)	56 (-4)	55 (-5)		88 (-10)	73 (-25)	74 (-24)	73 (-25)		2.01	1.61	1.98	1.49
15-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	57 (-3)	99	94 (-5)	92 (-7)	94 (-5)	93 (-6)	1.81	2.20	2.31	2.15	2.22
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	55 (-5)		92 (-7)	69 (-30)	90 (-9)	71 (-28)		2.27	2.32	2.27	2.26
24-June	Mid-century (2021-50)	60	59 (-1)	57 (-3)	59 (-1)	58 (-2)	100	96 (-4)	94 (-6)	97 (-3)	95 (-5)	1.38	1.56	1.58	1.54	1.55
	End-century (2051-95)		58 (-2)	56 (-4)	56 (-4)	55 (-5)		95 (-5)	90 (-10)	91 (-9)	85 (-15)		1.61	1.64	1.58	1.57

*Deviation from baseline in DAS

Table 4.61: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Bhatinda, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	55	54 (-1)*	53 (-2)	55 (0)	54 (-1)	95	92 (-3)	82 (-13)	92 (-3)	90 (-5)	1.70	1.67 (-1.76)	1.53 (-10)	1.69 (-0.59)	1.69 (14.94)
	End-century (2051-95)		54 (-1)	52 (-3)	52 (-3)	51 (-4)		89 (-6)	66 (-29)	78 (-17)	65 (-30)		1.73 (1.76)	0.86 (-49.41)	1.56 (-8.23)	0.85 (-50)
06-June	Mid-century (2021-50)	56	53 (-3)	53 (-3)	53 (-3)	53 (-3)	96	91 (-5)	73 (-23)	91 (-5)	87 (-9)	1.53	1.60 (4.58)	1.65 (7.84)	1.61 (5.23)	1.61 (5.23)
	End-century (2051-95)		53 (-3)	52 (-4)	52 (-4)	51 (-5)		87 (-9)	74 (-23)	74 (-22)	70 (-26)		1.62 (5.88)	1.29 (-15.69)	1.61 (5.23)	1.23 (-19.61)
15-June	Mid-century (2021-50)	55	54 (-1)	53 (-2)	55 (0)	54 (-1)	96	92 (-4)	90 (-6)	94 (-2)	91 (-5)	1.55	1.89 (21.93)	1.96 (26.45)	1.87 (20.64)	1.91 (23.22)
	End-century (2051-95)		53 (-2)	52 (-3)	52 (-3)	51 (-4)		90 (-6)	66 (-30)	88 (-8)	68 (-28)		1.92 (23.87)	1.95 (25.81)	1.92 (23.87)	1.92 (23.87)
24-June	Mid-century (2021-50)	56	55 (-1)	55 (-1)	55 (-1)	55 (-1)	98	94 (-4)	92 (-6)	95 (-3)	93 (-5)	1.19	1.51 (26.89)	1.55 (30.25)	1.50 (26.05)	1.52 (27.73)
	End-century (2051-95)		55 (-1)	52 (-4)	54 (-2)	51 (-5)		93 (-5)	88 (-10)	91 (-7)	81 (-17)		1.58 (32.77)	1.66 (39.50)	1.59 (33.61)	1.58 (32.77)

*Deviation from baseline in DAS

FIO-ESM model

In Bathinda, the yield decline as observed of PMH1 (Table 4.62) cultivar ranged 6.7% to 40.9% during the mid-century while 10.3% to 79.4% during the end-century from the baseline range (3183.1kg ha⁻¹ to 3528.7kg ha⁻¹). A higher decrease was observed under RCP8.5. The yield increment was observed on 15th June during mid-century by (17.6%, 26.8%, 24.4% and 23.9%) under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively while increment by (23.9% and 4.2%), respectively under RCP2.6 and RCP4.5. The yield obtained during the end-century under RCP8.5 ranged <1191.8 kg ha⁻¹. For PMH2 (Table 4.62) the yield decrement was observed ranging 7.2% to 21.6% during the mid-century and 14.2% to 87.5% during the end-century from the baseline range (2921.3 kg ha⁻¹ to 3196.3 kg ha⁻¹). The major decline in yield was observed under RCP6.0 and RCP8.5. The yield for the end-century ranged <3267 kg ha⁻¹ under the four RCPs and dates of sowing.

The anthesis period for PMH1 cultivar in Bathinda was projected (Table 4.63) to shorten by 1-3 days during the mid-century and by 0-5 days during the end-century from the baseline (59-60 DAS) while the maturity period was projected to shorten by 2-4 days and 1-26 days during the mid and end-century, respectively from the baseline (97-100 DAS). The maximum shortening was observed under RCP8.5 during the end-century. The LAI was found to be higher than the baseline except on 28th May and 6th June. For PMH2 (Table 4.64) the shortening of anthesis and maturity was observed by 0-3 days from the baseline (55-56 DAS) and 2-4 days from the baseline (95-98 DAS), respectively during mid-century. The end-century indicated a decline in anthesis and maturity by 0-4 days and 2-24 days, respectively. The LAI obtained for the 85 year period was higher than the baseline. The highest shortening of days was observed under RCP8.5 during the end-century.

Table 4.62: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by FIO-ESM model during 21st century at Bathinda, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	3528.7	3101.2 (-12.1)*	3154.8 (-10.6)	3173.0 (-6.7)	3291.5 (-6.7)	3081.3	2470.1 (-19.8)	2544.6 (-17.4)	2587.3 (-16.0)	2662.7 (-13.6)
	End-century (2051-95)		3048.9 (-13.6)	2593.1 (-26.5)	2032.9 (-42.4)	725.5 (-79.4)		2266.9 (-26.4)	2042.1 (-33.7)	1644.0 (-46.6)	417.4 (-86.4)
06-June	Mid-century (2021-50)	3304.8	2882.4 (-12.8)	2778.9 (-12.5)	2892.9 (-12.5)	2836.8 (-14.2)	2921.3	2422.0 (-17.1)	2371.7 (-18.8)	2291.3 (-21.6)	2373.3 (-18.8)
	End-century (2051-95)		2963.2 (-10.3)	2586.8 (-21.7)	1657.4 (-49.8)	266.6 (-91.9)		2395.7 (-18.0)	2058.5 (-29.5)	1404.7 (-51.9)	365.9 (-87.5)
15-June	Mid-century (2021-50)	3392.4	3990.7 (17.6)	4300.7 (26.8)	4221.5 (24.4)	4204.6 (23.9)	3196.3	3326.3 (+4.1)	3253.6 (+1.8)	3156.6 (-1.2)	3267.9 (+2.2)
	End-century (2051-95)		4203.9 (23.9)	3533.8 (4.2)	2779.0 (-18.1)	1066.7 (-68.6)		3440.3 (+7.6)	2743.5 (-14.2)	2070.9 (-35.2)	1152.1 (-63.9)
24-June	Mid-century (2021-50)	3183.1	1929.5 (-39.4)	2041.2 (-35.9)	1857.0 (-41.7)	1880.5 (-40.9)	3343.2	3017.8 (-9.7)	2937.4 (-12.1)	3000.7 (-10.2)	3100.9 (-7.2)
	End-century (2051-95)		2106.3 (-33.8)	1701.7 (-58.3)	1327.2 (-58.3)	1191.8 (-62.6)		3484.7 (+4.2)	2819.0 (-15.7)	2220.9 (-33.6)	1615.4 (-51.7)

*% deviation from baseline value

Table 4.63: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by FIO-ESM model during 21st century at Bathinda, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	59	58 (-1)*	57 (-2)	57 (-2)	57 (-2)	97	95 (-2)	93 (-4)	94 (-3)	93 (-4)	1.82	1.76	1.81	1.82	1.84
	End-century (2051-95)		59 (0)	57 (-2)	56 (-3)	55 (-4)		96 (-1)	93 (-4)	90 (-7)	81 (-16)		1.71	1.78	1.84	1.54
06-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	57 (-3)	98	94 (-4)	94 (-4)	94 (-4)	94 (-4)	1.85	1.66	1.64	1.68	1.69
	End-century (2051-95)		57 (-3)	57 (-3)	57 (-3)	55 (-5)		94 (-4)	93 (-5)	89 (-9)	72 (-26)		1.60	1.66	1.71	1.63
15-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	57 (-3)	99	95 (-4)	95 (-4)	95 (-4)	95 (-4)	1.81	1.99	1.91	1.89	1.88
	End-century (2051-95)		59 (-1)	57 (-3)	57 (-3)	56 (-4)		98 (-1)	94 (-5)	93 (-6)	83 (-16)		1.95	1.93	1.90	1.91
24-June	Mid-century (2021-50)	60	59 (-1)	59 (-1)	59 (-1)	59 (-1)	100	98 (-2)	98 (-2)	98 (-2)	98 (-2)	1.38	1.45	1.47	1.42	1.44
	End-century (2051-95)		59 (-1)	59 (-1)	58 (-2)	56 (-4)		98 (-2)	97 (-3)	96 (-4)	92 (-9)		1.47	1.46	1.49	1.57

*Deviation from baseline in DAS

Table 4.64: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by FIO-ESM model during 21st century at Bathinda, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	55	55 (0)*	55 (0)	55 (0)	55 (0)	95	93 (-2)	93 (-2)	93 (-2)	93 (-2)	1.70	1.76	1.81	1.82	1.84
	End-century (2051-95)		55 (0)	55 (0)	55 (0)	52 (-3)		93 (-2)	92 (-3)	90 (-5)	73 (-22)		1.71	1.78	1.84	1.54
06-June	Mid-century (2021-50)	56	55 (-1)	53 (-3)	53 (-3)	53 (-3)	96	94 (-2)	92 (-4)	92 (-4)	92 (-4)	1.53	1.66	1.64	1.68	1.69
	End-century (2051-95)		58 (-2)	58 (-2)	56 (-4)	52 (-4)		94 (-2)	91 (-5)	87 (-9)	72 (-24)		1.60	1.66	1.71	1.63
15-June	Mid-century (2021-50)	55	55 (0)	55 (0)	55 (0)	55 (0)	96	95 (-1)	95 (-1)	95 (-1)	95 (-1)	1.55	1.99	1.91	1.89	1.88
	End-century (2051-95)		55 (0)	55 (0)	55 (0)	52 (-3)		95 (-1)	94 (-2)	93 (-3)	80 (-16)		1.95	1.93	1.90	3.58
24-June	Mid-century (2021-50)	56	55 (0)	55 (0)	55 (0)	55 (0)	98	95 (-3)	95 (-3)	96 (-2)	96 (-2)	1.19	1.45	1.47	1.42	1.44
	End-century (2051-95)		55 (0)	55 (0)	55 (0)	53 (-3)		96 (-2)	94 (-4)	93 (-5)	90 (-8)		1.47	1.46	1.49	1.57

*Deviation from baseline in DAS

IPSL-CM5A-MR model

The yield decline as observed at Bathinda for PMH1 (Table 4.65) cultivar ranged 8.6% to 48.5% during the mid-century while 11.1% to 87.8% during the end-century from the baseline range (3183.1kg ha⁻¹ to 3528.7kg ha⁻¹). A higher decrease was observed under RCP8.5 during the end-century. No yield increment was projected under the scenarios and four sowing dates. The yield obtained during the end-century under RCP8.5 ranged <1000 kg ha⁻¹. For PMH2 (Table 4.65) the yield decrement was observed ranging 5.5% to 41.9% during the mid-century and 21.1% to 92.5% during the end-century from the baseline range (2921.3 kg ha⁻¹ to 3196.3 kg ha⁻¹). The major decline in yield was observed under RCP8.5 where the yield during end-century ranged <1008 kg ha⁻¹ under the four RCPs and dates of sowing.

The anthesis period was projected to shorten for PMH1 cultivar in Bathinda (Table 4.66) by 2-5 days during the mid-century and by 1-4 days during the end-century from the baseline (59-60 DAS) while the maturity period was projected to shorten by 2-6 days and 4-24 days during the mid and end-century, respectively from the baseline (97-100 DAS). The maximum shortening was observed under RCP8.5 during the end-century. The LAI was found to be higher than the baseline except on 28th May. For PMH2 (Table 4.67) the shortening of anthesis and maturity was observed by 0-3 days from the baseline (55-56 DAS) and 2-6 days from the baseline (95-98 DAS), respectively during mid-century. The end-century indicated a decline in anthesis and maturity by 0-4 days and 3-24 days, respectively. The LAI obtained for the 85 year period was higher than the baseline. The highest shortening of days was observed under RCP8.5 during the end-century.

Table 4.65: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Bathinda, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	3528.7	3226.1 (-8.6)*	2417.5 (-31.5)	2958.8 (-16.1)	2425.5 (-31.3)	3081.3	2497.8 (-18.9)	1989.4 (-35.4)	2376.9 (-22.9)	2016.0 (-34.6)
	End-century (2051-95)		2558.0 (-27.5)	2049.6 (-41.9)	1923.0 (-45.5)	917.5 (-74.0)		2022.5 (-34.4)	1793.0 (-41.8)	1639.5 (-46.8)	230.3 (-92.5)
06-June	Mid-century (2021-50)	3304.8	2621.2 (-38.0)	2048.3 (-38.0)	2465.2 (-25.40)	2198.1 (-33.5)	2921.3	2255.8 (-22.8)	1697.9 (-41.9)	2135.6 (-26.9)	1766.7 (-39.5)
	End-century (2051-95)		2332.6 (-29.4)	1976.0 (-40.2)	1642.5 (-50.3)	404.8 (-87.8)		2002.6 (-31.4)	1612.7 (-44.8)	1330.6 (-54.4)	510.4 (-82.5)
15-June	Mid-century (2021-50)	3392.4	4253.0 (-22.8)	2619.5 (-22.8)	3327.2 (-1.9)	2680.1 (-21.0)	3196.3	3020.5 (-5.5)	2513.6 (-21.4)	2692.8 (-15.7)	2038.5 (-36.2)
	End-century (2051-95)		3014.8 (-11.1)	1891.9 (-44.2)	1953.2 (-42.4)	888.6 (-73.8)		2521.8 (-21.1)	2109.4 (-34.0)	1640.2 (-48.7)	1008.4 (-68.4)
24-June	Mid-century (2021-50)	3183.1	1860.0 (-41.6)	1639.3 (-48.5)	1826.6 (-42.6)	1906.6 (-40.1)	3343.2	2638.2 (-21.1)	2604.2 (-22.1)	2822.7 (-15.6)	2675.3 (-20.0)
	End-century (2051-95)		1664.0 (-47.7)	1473.0 (-53.7)	1381.5 (-56.6)	588.7 (-81.5)		2595.5 (-22.4)	2226.3 (-33.4)	2287.0 (-31.6)	980.3 (-70.7)

*% deviation from baseline value

Table 4.66: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Bathinda, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	59	58 (-1)	56 (-3)	57 (-2)	56 (-3)	97	94 (-3)	92 (-5)	93 (-4)	92 (-5)	1.82	1.52	1.50	1.54	1.55
	End-century (2051-95)		57 (-2)	55 (-4)	56 (-3)	55 (-4)		92 (-5)	90 (-7)	88 (-9)	83 (-14)		1.97	1.98	1.95	1.10
06-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	57 (-3)	98	94 (-4)	93 (-5)	94 (-4)	93 (-5)	1.85	1.26	2.19	2.20	2.55
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	56 (-4)		93 (-5)	91 (-7)	86 (-12)	74 (-24)		1.97	1.98	1.90	1.61
15-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	57 (-3)	99	95 (-4)	93 (-6)	94 (-5)	93 (-6)	1.81	1.99	1.91	1.97	1.99
	End-century (2051-95)		57 (-3)	57 (-3)	57 (-3)	56 (-4)		94 (-5)	92 (-7)	92 (-7)	90 (-9)		2.25	2.27	2.27	2.35
24-June	Mid-century (2021-50)	60	59 (-1)	59 (-1)	59 (-1)	59 (-1)	100	98 (-2)	96 (-4)	97 (-3)	96 (-4)	1.38	1.89	1.90	1.90	1.98
	End-century (2051-95)		59 (-1)	57 (-3)	57 (-3)	56 (-4)		96 (-4)	92 (-8)	92 (-8)	90 (-10)		1.56	1.60	1.60	1.66

*Deviation from baseline in DAS

Table 4.67: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Bathinda, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
			Anthesis					Maturity					LAI			
28-May	Mid-century (2021-50)	55	54 (-1)*	54 (-1)	55 (-2)	54 (-1)	95	93 (-2)	92 (-3)	93 (-2)	91 (-4)	1.70	1.73	1.68	1.70	1.73
	End-century (2051-95)		55 (0)	53 (-2)	53 (-2)	52 (-3)		92 (-3)	89 (-6)	88 (-7)	71 (-24)		1.71	1.66	1.67	0.95
06-June	Mid-century (2021-50)	56	53 (-3)	53 (-3)	53 (-3)	53 (-3)	96	92 (-4)	91 (-5)	91 (-5)	90 (-6)	1.53	1.62	1.55	1.61	1.61
	End-century (2051-95)		53 (-3)	52 (-4)	52 (-4)	52 (-4)		91 (-5)	89 (-7)	84 (-12)	74 (-22)		1.61	1.60	1.61	1.32
15-June	Mid-century (2021-50)	55	56 (1)	54 (-1)	55 (0)	54 (-1)	96	95 (-1)	92 (-4)	94 (-2)	92 (-4)	1.55	1.96	1.89	1.91	1.94
	End-century (2051-95)		55 (0)	53 (-2)	52 (-3)	52 (-3)		93 (-3)	90 (-6)	90 (-6)	88 (-8)		1.94	1.92	1.92	1.97
24-June	Mid-century (2021-50)	56	56 (0)	55 (-1)	55 (-1)	55 (-1)	98	95 (-3)	93 (-5)	95 (-3)	93 (-5)	1.19	1.48	1.49	1.48	1.54
	End-century (2051-95)		55 (-1)	55 (-1)	55 (-1)	53 (-3)		94 (-4)	92 (-6)	92 (-6)	89 (-9)		1.60	1.55	1.59	1.62

*Deviation from baseline in DAS

Ensemble model

Bathinda observed a yield decline for PMH1 (Table 4.68) cultivar ranging 2.5% to 42.9% during the mid-century while 9.7% to 91.9% during the end-century from the baseline range (3183.1kg ha⁻¹ to 3528.7kg ha⁻¹). A higher decrease was observed under RCP8.5 during the end-century. No significant yield increment was projected under the scenarios and four sowing dates. The yield obtained during the end-century under RCP8.5 ranged <850 kg ha⁻¹. For PMH2 (Table 4.68) the yield decrement was observed ranging 2.2% to 32.9% during the mid-century and 2.2% to 87.2% during the end-century from the baseline range (2921.3 kg ha⁻¹ to 3196.3 kg ha⁻¹). The major decline in yield was observed under RCP8.5 where the yield during end-century ranged <1050 kg ha⁻¹ under the four RCPs and dates of sowing.

The anthesis (Fig 4.30) period was projected to shorten for PMH1 cultivar in Bathinda (Table 4.69) by 1-3 days during the mid-century and by 1-5 days during the end-century from the baseline (59-60 DAS) while the maturity period (Fig. 4.31) was projected to shorten by 2-5 days and 3-26 days during the mid and end-century, respectively from the baseline (97-100 DAS). The maximum shortening was observed under RCP8.5 during the end-century. The LAI (Fig. 4.32) was found to be higher than the baseline except. For PMH2 (Table 4.70) the shortening of anthesis (Fig 4.33) and maturity (Fig. 4.34) was observed by 0-3 days from the baseline (55-56 DAS) and 2-5 days from the baseline (95-98 DAS), respectively during mid-century. The end-century indicated a decline in anthesis and maturity by 0-4 days and 3-24 days, respectively. The LAI (Fig. 4.35) obtained for the 85 year period was higher than the baseline. The highest shortening of days was observed under RCP8.5 during the end-century.

Table 4.68: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by Ensemble model during 21st century at Bathinda, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	3528.7	2880.0 (-18.38)*	2786.40 (-21.04)	2934.03 (-16.85)	2564.67 (-27.32)	3081.3	2322.13 (-24.64)	2213.23 (-28.17)	2346.37 (-23.85)	2069.00 (-32.85)
	End-century (2051-95)		2718.37 (-22.96)	2166.87 (-38.59)	1893.50 (-46.34)	776.90 (-77.98)		2203.70 (-28.48)	1817.40 (-41.02)	1612.30 (-47.67)	596.63 (-80.64)
06-June	Mid-century (2021-50)	3304.8	2493.63 (-24.54)	2397.60 (-27.45)	2557.53 (-22.61)	2312.77 (-30.02)	2921.3	2071.37 (-29.09)	2071.67 (-29.08)	2107.23 (-27.87)	1961.77 (-32.84)
	End-century (2051-95)		2343.10 (-29.10)	1778.47 (-46.19)	1559.50 (-52.81)	266.03 (-91.95)		1930.40 (-33.92)	1507.57 (-48.39)	1362.47 (-53.36)	373.60 (-87.21)
15-June	Mid-century (2021-50)	3392.4	3521.20 (3.80)	3307.00 (-2.52)	3673.33 (8.28)	3231.00 (-4.76)	3196.3	2984.87 (-6.61)	2734.53 (-14.45)	3125.87 (-2.20)	2665.17 (-16.62)
	End-century (2051-95)		3272.77 (-16.01)	2892.2 (-60.90)	2327.40 (-9.67)	795.03 (-26.28)		2763.9 (-13.5)	2764.7 (-2.2)	2487.80 (-53.76)	915.53 (-71.36)
24-June	Mid-century (2021-50)	3183.1	1815.87 (-42.95)	1832.50 (-42.43)	1976.73 (-37.90)	1921.03 (-39.65)	3343.2	2795.20 (-16.39)	2641.87 (-20.98)	2868.33 (-14.20)	2650.73 (-20.71)
	End-century (2051-95)		1866.40 (-41.36)	1415.57 (-55.53)	1666.80 (-47.63)	849.37 (-73.32)		2732.83 (-18.26)	1905.10 (-43.01)	2135.43 (-36.12)	1042.63 (-68.81)

*% deviation from baseline value

Table 4.69: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by Ensemble model during 21st century at Bathinda, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	59	57 (-2)*	57 (-2)	58 (-1)	57 (-2)	97	93 (-4)	93 (-4)	94 (-3)	92 (-5)	1.82	1.85 (1.65)	1.92 (5.49)	1.82 (0)	1.91 (4.94)
	End-century (2051-95)		57 (-2)	56 (-3)	56 (-3)	55 (-4)		93 (-4)	91 (-6)	89 (-8)	81 (-16)		1.93 (6.04)	2.00 (9.89)	1.93 (6.04)	1.32 (-27.47)
06-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	57 (-3)	98	94 (-4)	93 (-5)	94 (-4)	93 (-5)	1.85	1.96 (5.94)	3.52 (26.57)	3.53 (26.97)	3.65 (31.20)
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	55 (-5)		94 (-4)	92 (-6)	88 (-10)	72 (-26)		2.02 (9.19)	2.02 (9.19)	2.04 (10.27)	1.88 (1.62)
15-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	57 (-3)	99	95 (-4)	94 (-5)	95 (-4)	94 (-5)	1.81	2.20 (21.55)	2.32 (28.18)	2.19 (21.00)	2.31 (27.62)
	End-century (2051-95)		57 (-3)	57 (-3)	57 (-3)	56 (-4)		94 (-5)	92 (-7)	92 (-7)	84 (-15)		2.27 (25.41)	2.32 (28.18)	2.28 (25.97)	2.32 (28.18)
24-June	Mid-century (2021-50)	60	59 (-1)	59 (-1)	59 (-1)	59 (-1)	100	97 (-3)	97 (-3)	98 (-2)	97 (-3)	1.38	1.52 (10.14)	1.61 (16.67)	1.55 (12.32)	1.60 (15.94)
	End-century (2051-95)		59 (-1)	57 (-3)	57 (-3)	56 (-4)		97 (-3)	93 (-7)	94 (-6)	90 (-10)		1.57 (13.77)	1.54 (11.59)	1.57 (13.77)	1.57 (13.77)

*Deviation from baseline in DAS

Table 4.70: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by Ensemble model during 21st century at Bathinda, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	55	55 (0)*	55 (0)	55 (0)	55 (0)	95	93 (-2)	93 (-2)	93 (-2)	92 (-3)	1.70	1.67 (-1.76)	1.75 (2.94)	1.66 (-2.35)	1.73 (1.76)
	End-century (2051-95)		55 (0)	53 (-2)	53 (-2)	52 (-3)		93 (-2)	90 (-5)	89 (-6)	75 (-20)		1.77 (4.12)	1.74 (2.35)	1.70 (0)	1.12 (-34.12)
06-June	Mid-century (2021-50)	56	53 (-3)	53 (-3)	53 (-3)	53 (-3)	96	92 (-4)	91 (-5)	92 (-4)	91 (-5)	1.53	1.61 (5.23)	1.67 (9.15)	1.59 (3.92)	1.65 (7.84)
	End-century (2051-95)		53 (-3)	53 (-3)	53 (-3)	52 (-4)		91 (-5)	90 (-6)	86 (-10)	72 (-24)		1.66 (8.50)	1.66 (8.50)	1.65 (7.84)	1.53 (0)
15-June	Mid-century (2021-50)	55	56 (-1)	55 (0)	56 (-1)	55 (0)	96	95 (-1)	94 (-2)	95 (-1)	94 (-2)	1.55	1.91 (23.22)	2.00 (29.03)	1.92 (23.87)	1.99 (28.39)
	End-century (2051-95)		55 (0)	53 (-2)	54 (-1)	52 (-3)		94 (-2)	90 (-6)	91 (-5)	82 (-14)		1.98 (27.74)	1.90 (22.58)	1.96 (26.45)	1.95 (25.81)
24-June	Mid-century (2021-50)	56	55 (0)	55 (0)	55 (0)	55 (0)	98	95 (-3)	94 (-4)	95 (-3)	94 (-4)	1.19	1.44 (21.01)	1.52 (27.73)	1.44 (21.01)	1.53 (28.57)
	End-century (2051-95)		55 (0)	55 (0)	55 (0)	53 (-3)		95 (-3)	93 (-5)	93 (-5)	89 (-9)		1.50 (26.05)	1.53 (28.57)	1.54 (29.41)	1.59 (33.61)

*Deviation from baseline in DAS

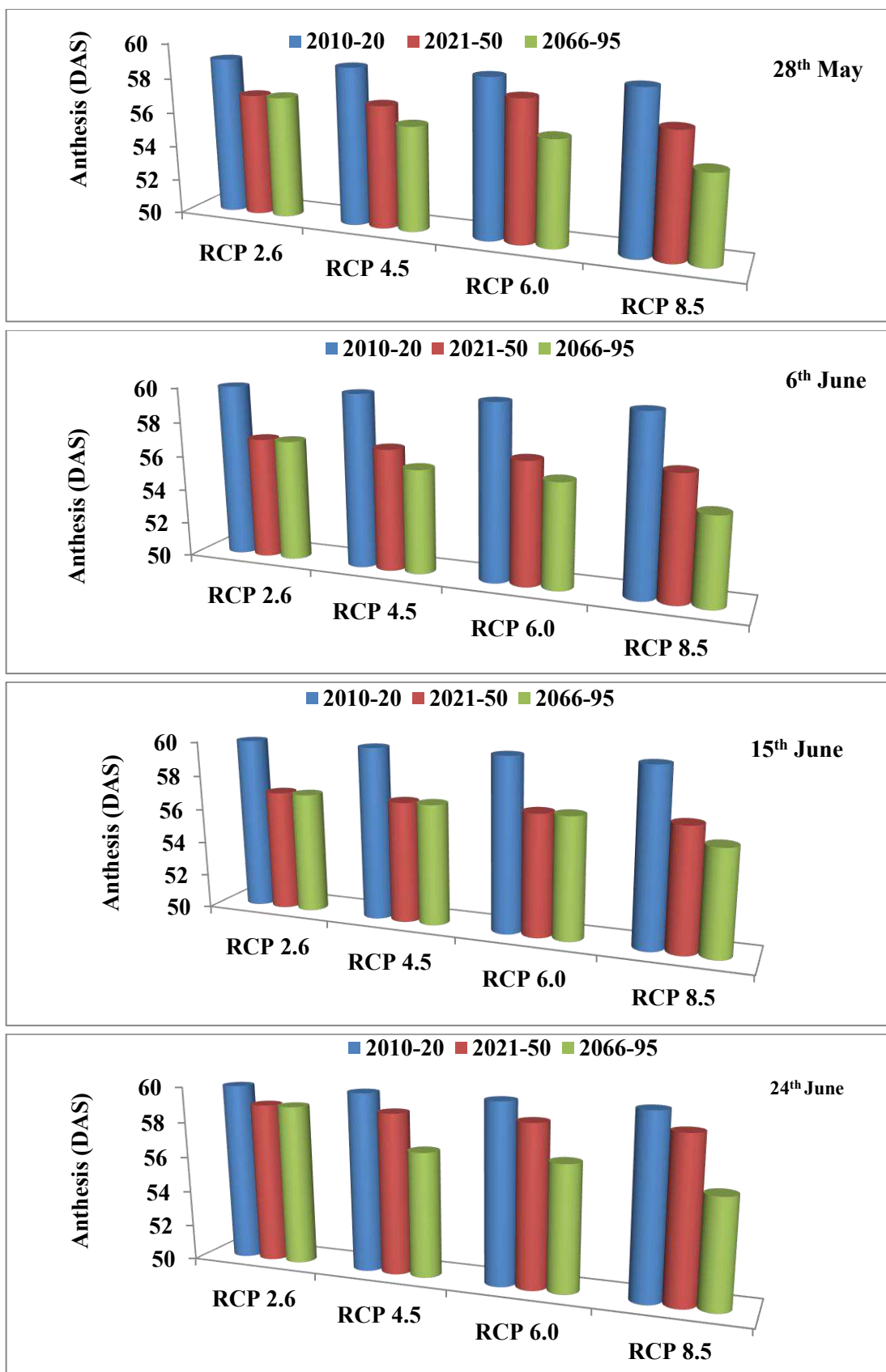


Fig. 4.30: Simulated changes in anthesis (DAS) of PMH1 by Ensemble model at agroclimatic zone IV (Bathinda)

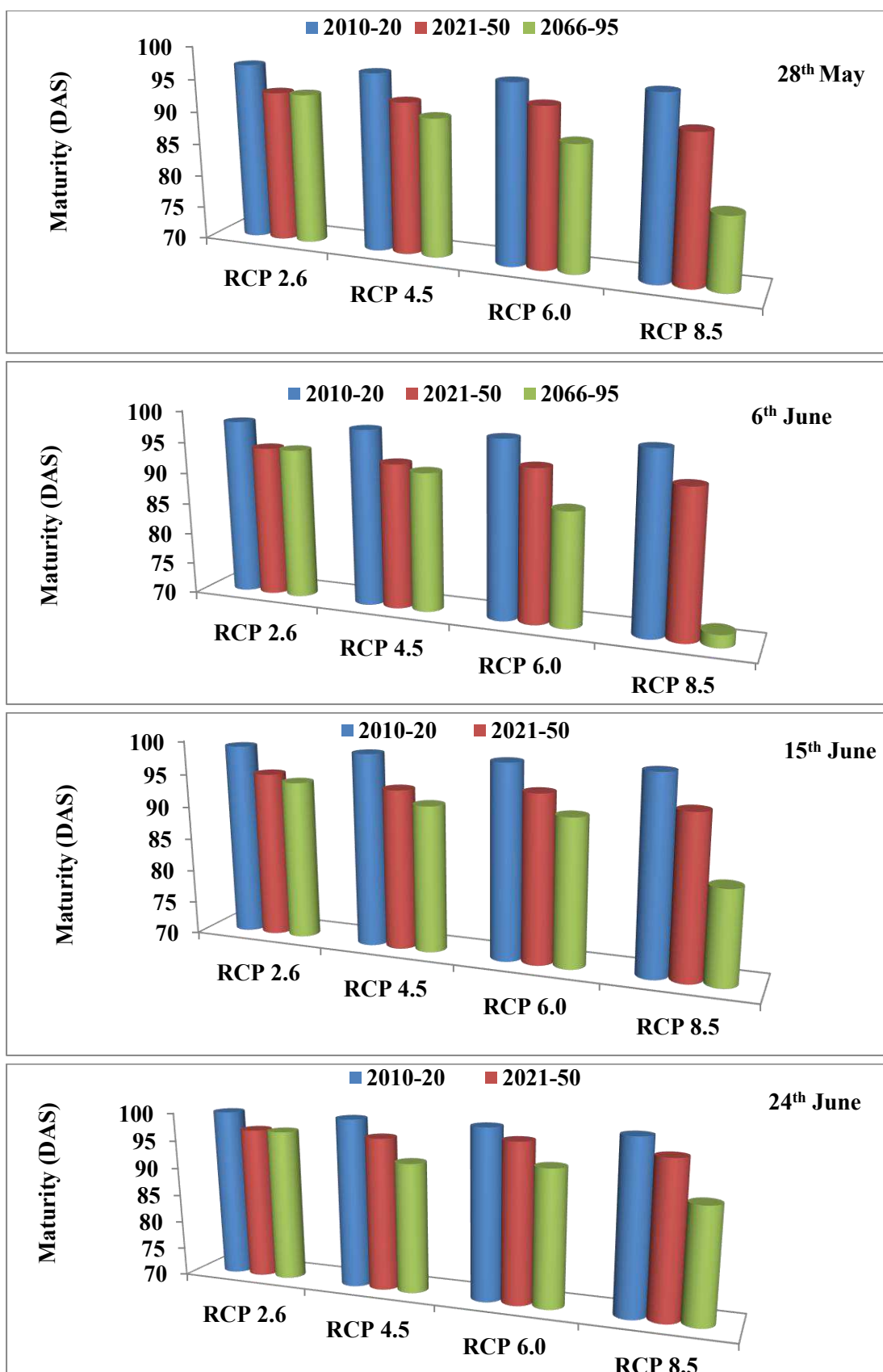


Fig. 4.31: Simulated changes in maturity (DAS) of PMH1 by Ensemble model at agroclimatic zone IV (Bathinda)

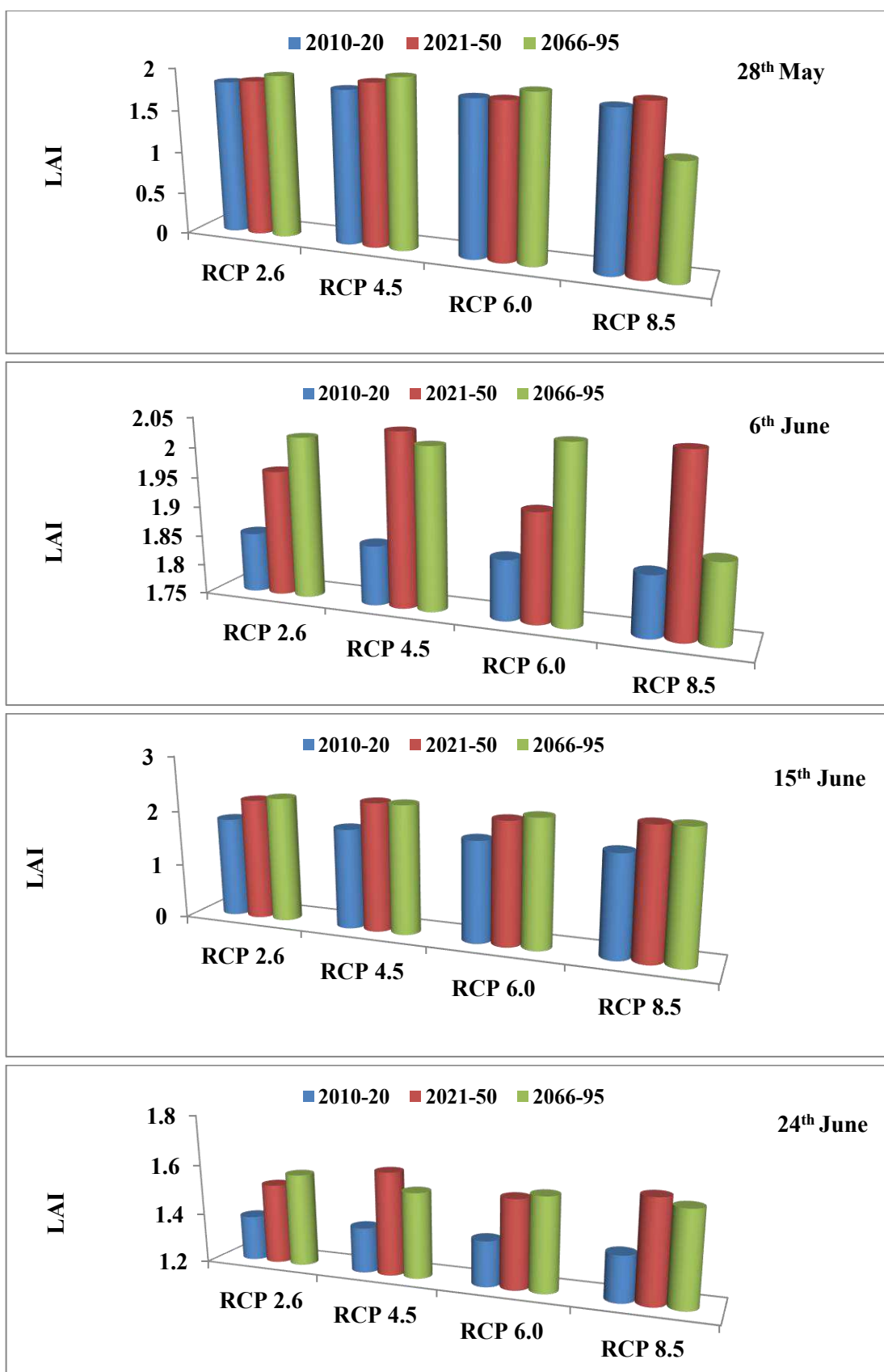


Fig. 4.32: Simulated changes in LAI of PMH1 by Ensemble model at agroclimatic zone IV (Bathinda)

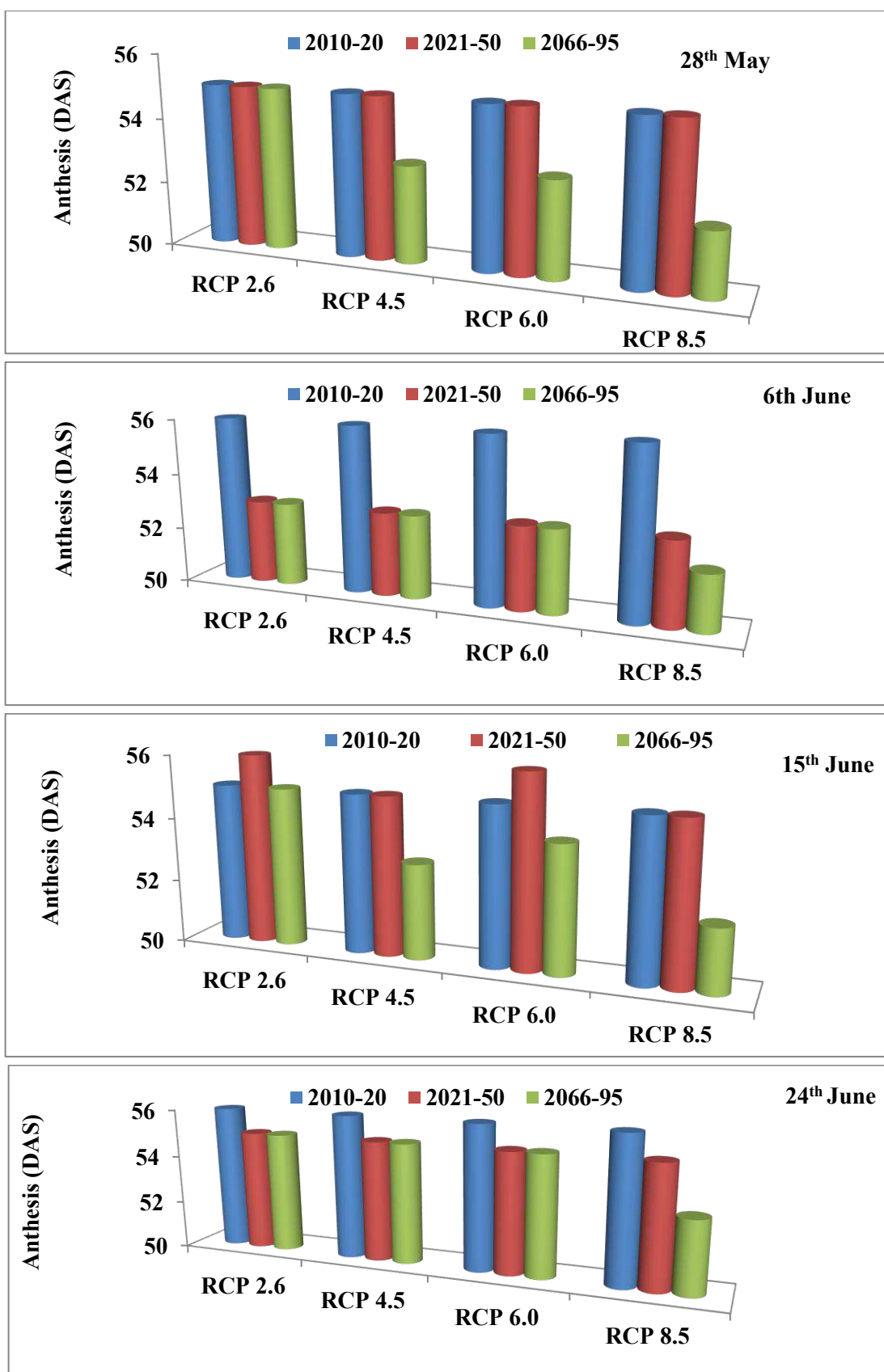


Fig. 4.33: Simulated changes in anthesis (DAS) of PMH2 by Ensemble model at agroclimatic zone IV (Bathinda)

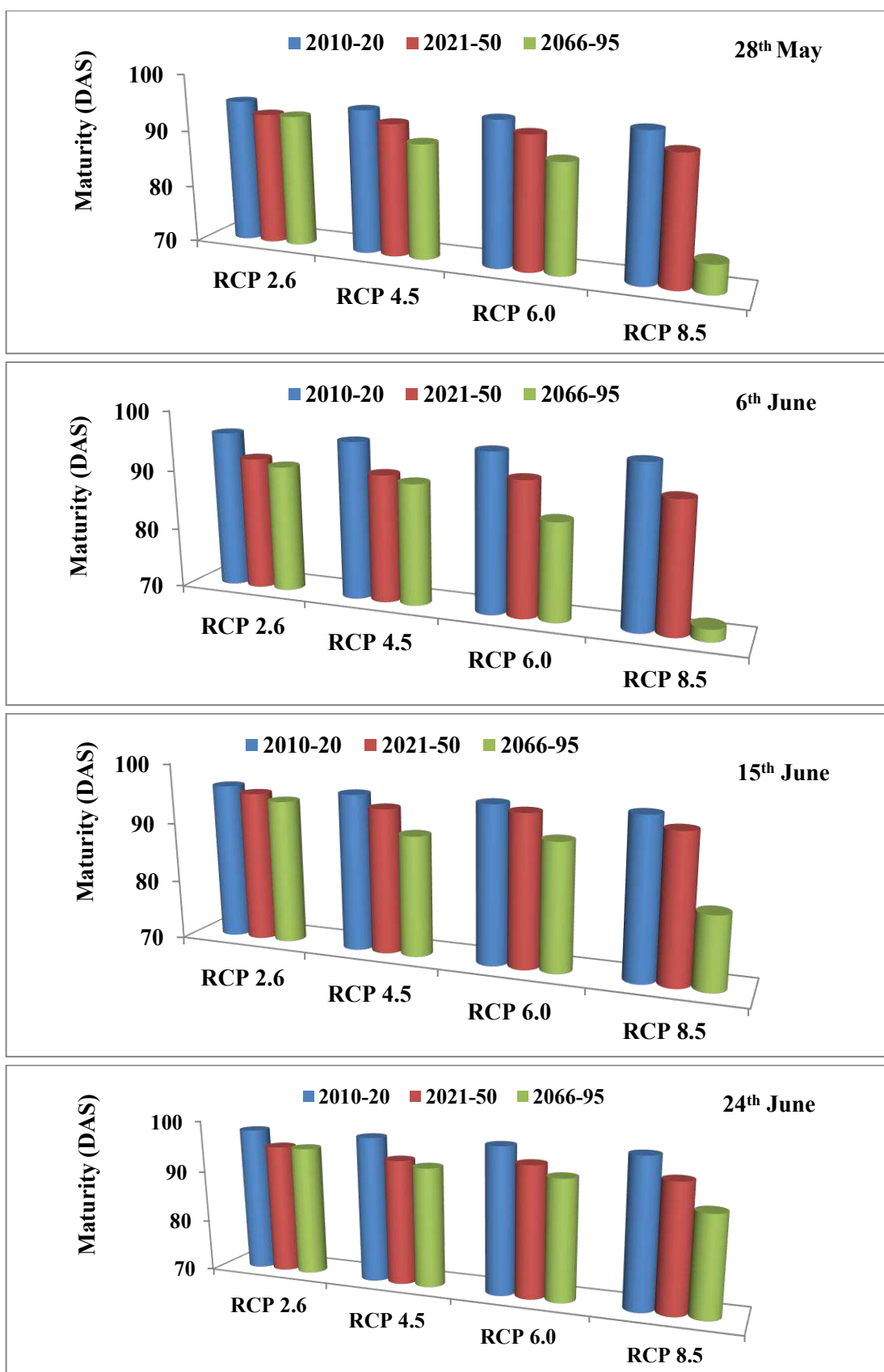


Fig. 4.34: Simulated changes in maturity (DAS) of PMH2 by Ensemble model at agroclimatic zone IV (Bathinda)

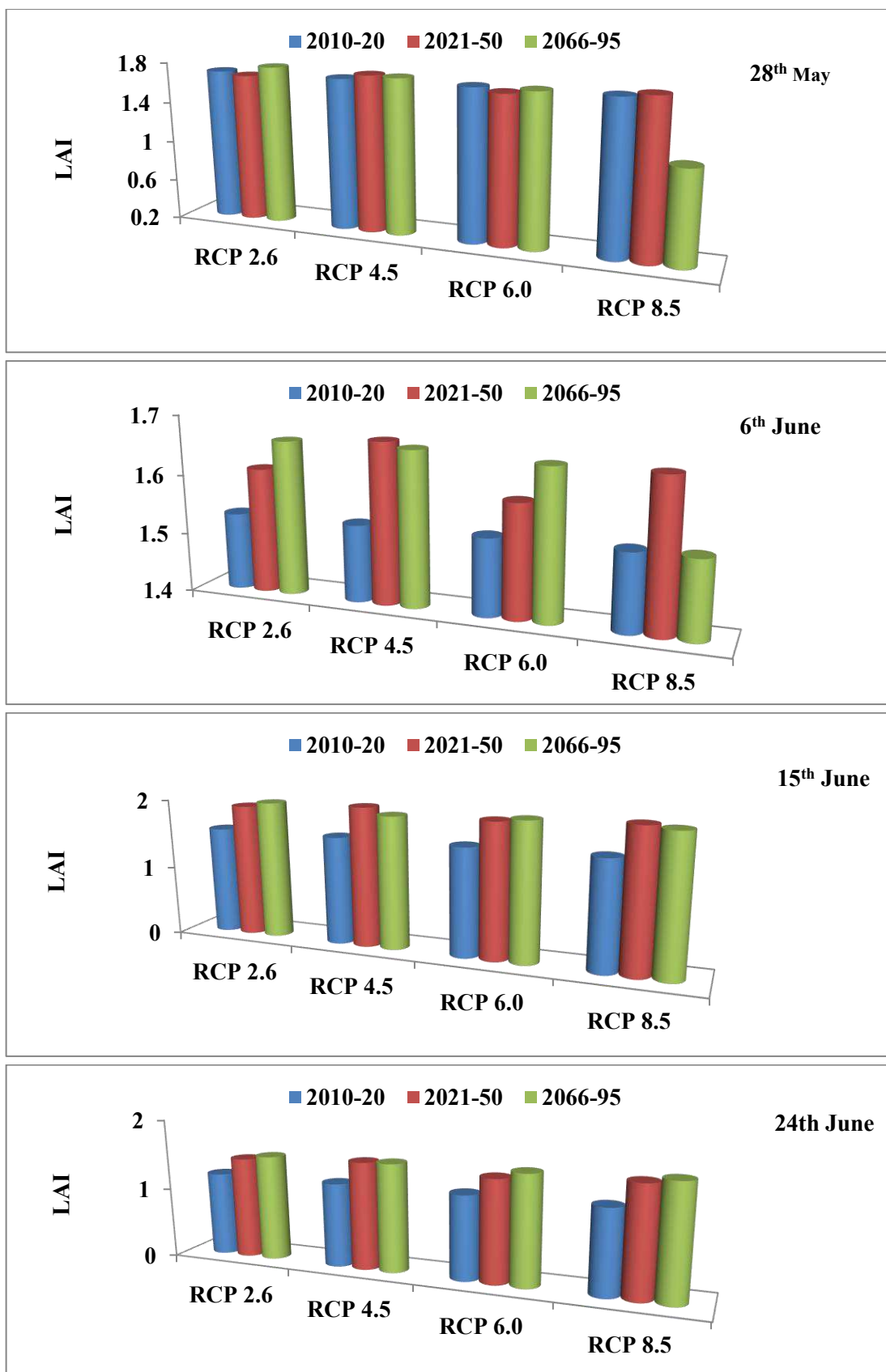


Fig. 4.35: Simulated changes in LAI of PMH2 by Ensemble model at agroclimatic zone IV (Bathinda)

Agroclimatic zone V (Abohar and Faridkot)

CSIRO Mk-36-0 model

At Abohar, PMH1 (Table 4.71) observed a yield decline ranging 19.1% to 58.0% during the mid-century while 46.1% to 98.9% during the end-century from the baseline range (3218.3 kg ha⁻¹ to 3831.6 kg ha⁻¹). A higher decrease was observed under RCP4.5, RCP6.0 and RCP8.5 during the end-century. The yield obtained during the end-century ranged <1457 kg ha⁻¹ and <387.7 kg ha⁻¹ under RCP4.5 and RCP8.5, respectively. For PMH2 (Table 4.71) the yield decrement ranged between 1.2% to 60.7% during the mid-century and 0.4% to 99.7% during the end-century from the baseline range (3113.5 kg ha⁻¹ to 3522.3 kg ha⁻¹). The major decline in yield was observed under RCP8.5 during the end-century. Also 24th June observed a yield increment under RCP2.6 (6.1%) and RCP6.0 (10.6%). The yield for the end-century ranged <394.5 kg ha⁻¹ under the four RCPs and dates of sowing.

The PMH1 cultivar (Table 4.72) at Abohar showed shortening by 3-4 days during the mid-century and by 3-6 days during the end-century from the baseline (60-61 DAS) while the maturity period was projected to shorten by 4-13 days and 6-25 days during the mid and end-century, respectively from the baseline (99-101 DAS). The maximum shortening was observed under RCP8.5 during the end-century. The LAI was found to be higher than the baseline for most of the scenarios and dates of sowing. The PMH2 cultivar (Table 4.73) showed shortening of anthesis and maturity was by 2-3 days from the baseline (56-57 DAS) and 4-13 days from the baseline (96-99 DAS), respectively during mid-century. The end-century indicated a shortening of anthesis and maturity by 2-6 days and 6-31 days, respectively. The LAI obtained for the 85 year period was higher than the baseline except on 28th May and 6th June where it was lower for both the centuries. The highest shortening of days was observed under RCP8.5 during the end-century.

Faridkot observed a yield decline in PMH1 (Table 4.74) cultivar ranging 4.5% to 19.2% during the mid-century while 16.3% to 93.3% during the end-century from the baseline range (5690.0 kg ha⁻¹ to 6581.2 kg ha⁻¹). A higher decrease was observed under RCP4.5, RCP6.0 and RCP8.5 during the end-century. The yield obtained during the end-century ranged <1331 kg ha⁻¹ under RCP8.5. A significant yield increase was observed by 3.9%, 1.0% and 9.8%, respectively under RCP2.6, RCP4.5 and RCP6.0 on 14th June during mid-century. For PMH2 (Table 4.74) the yield decrement was observed ranging 2.7% to 23.7% during the mid-century and 12.7% to 92.1% during the end-century from the baseline range (5614.2 kg ha⁻¹ to 6411.1 kg ha⁻¹). The major decline in yield was observed under RCP4.5, RCP6.0 and RCP8.5 during the end-century. The yield for the end-century ranged <1365 kg ha⁻¹ under the four RCPs and dates of sowing.

Table 4.71: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Abohar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	3743.8	2257.2 (-39.7)*	2205.4 (-41.1)	2505.4 (-33.1)	1941.3 (-48.1)	3480.6	1854.6 (-46.7)	1827.0 (-47.5)	2026.4 (-41.8)	1624.1 (-53.3)
	End-century (2051-95)		1306.6 (-65.1)	938.8 (-74.9)	970.8 (-74.1)	157.3 (-95.8)		1128.5 (-67.6)	395.0 (-88.7)	672.5 (-80.7)	19.5 (-99.4)
06-June	Mid-century (2021-50)	3831.6	2233.4 (-41.7)	2014.2 (-47.4)	2402.1 (-37.3)	1608.5 (-58.0)	3522.3	1816.9 (-48.4)	1690.7 (-52.0)	1960.8 (-44.3)	1384.1 (-60.7)
	End-century (2051-95)		514.9 (-86.6)	466.1 (-87.8)	435.3 (-88.6)	172.6 (-95.5)		636.8 (-81.9)	550.3 (-84.4)	563.1 (-84.0)	95.1 (-97.3)
15-June	Mid-century (2021-50)	3543.2	2553.6 (-27.9)	2317.8 (-34.6)	2867.6 (-19.1)	2174.8 (-38.6)	3374.7	2786.3 (-17.4)	2202.7 (-34.7)	2889.5 (-14.4)	2345.2 (-30.5)
	End-century (2051-95)		1907.7 (-46.1)	1457.3 (-58.9)	1520.4 (-57.1)	39.6 (-98.9)		2400.3 (-28.9)	173.8 (-94.9)	76.7 (-97.7)	10.1 (-99.7)
24-June	Mid-century (2021-50)	3218.3	1615.0 (-49.8)	1397.9 (-56.6)	1710.3 (-46.9)	1560.1 (-51.5)	3113.5	3304.5 (+6.1)	3076.6 (-1.2)	3443.0 (+10.6)	3001.0 (-3.6)
	End-century (2051-95)		1395.0 (-56.7)	1221.4 (-62.0)	1267.9 (-60.6)	387.7 (-88.0)		3099.3 (-0.4)	1672.6 (-46.3)	1668.5 (-46.4)	394.5 (-87.3)

*% deviation from baseline value

Table 4.72: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Abohar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
			Anthesis					Maturity					LAI			
28-May	Mid-century (2021-50)	60	56 (-4)*	56 (-4)	57 (-3)	56 (-4)	99	92 (-7)	90 (-9)	93 (-6)	89 (-10)	1.85	1.90	1.90	1.86	1.91
	End-century (2051-95)		56 (-4)	55 (-5)	55 (-5)	54 (-6)		84 (-15)	84 (-15)	84 (-15)	77 (-22)		1.90	1.89	1.87	1.29
06-June	Mid-century (2021-50)	60	56 (-4)	56 (-4)	57 (-3)	56 (-4)	99	92 (-7)	89 (-10)	93 (-6)	86 (-13)	1.99	1.95	1.95	1.92	1.94
	End-century (2051-95)		56 (-4)	55 (-5)	55 (-5)	55 (-5)		77 (-22)	75 (-24)	77 (-22)	74 (-25)		1.94	2.00	1.99	1.64
15-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	57 (-3)	100	93 (-7)	93 (-7)	94 (-6)	92 (-8)	1.86	2.20	2.20	2.17	2.21
	End-century (2051-95)		56 (-4)	56 (-4)	56 (-4)	55 (-5)		92 (-8)	90 (-10)	90 (-10)	76 (-24)		2.22	2.29	2.22	2.25
24-June	Mid-century (2021-50)	61	58 (-3)	58 (-3)	59 (-2)	58 (-3)	101	96 (-5)	96 (-5)	97 (-4)	95 (-6)	1.42	1.57	1.57	1.55	1.58
	End-century (2051-95)		58 (-3)	56 (-4)	56 (-4)	55 (-6)		95 (-6)	91 (-10)	92 (-9)	85 (-16)		1.59	1.64	1.61	1.68

*Deviation from baseline in DAS

Table 4.73: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Abohar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	56	54 (-2)*	54 (-2)	54 (-2)	54 (-2)	96	91 (-5)	92 (-4)	92 (-4)	88 (-8)	1.77	1.68	1.66	1.64	1.67
	End-century (2051-95)		54 (-2)	51 (-5)	52 (-4)	51 (-5)		83 (-13)	68 (-28)	77 (-19)	65 (-31)		1.67	1.67	1.66	1.18
06-June	Mid-century (2021-50)	56	53 (-3)	53 (-3)	53 (-3)	53 (-3)	97	90 (-7)	88 (-9)	91 (-6)	84 (-13)	1.64	1.56	1.57	1.54	1.56
	End-century (2051-95)		52 (-4)	52 (-4)	52 (-4)	51 (-5)		74 (-23)	75 (-22)	75 (-22)	68 (-29)		1.55	1.60	1.61	1.39
15-June	Mid-century (2021-50)	57	54 (-3)	54 (-3)	55 (-2)	54 (-3)	98	92 (-6)	94 (-4)	93 (-5)	91 (-7)	1.60	1.88	1.87	1.86	1.88
	End-century (2051-95)		52 (-5)	52 (-5)	52 (-5)	51 (-6)		89 (-9)	89 (-9)	67 (-31)	65 (-33)		1.87	1.95	1.89	1.91
24-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	55 (-2)	55 (-2)	99	94 (-5)	94 (-5)	94 (-5)	93 (-6)	1.26	1.50	1.51	1.48	1.53
	End-century (2051-95)		54 (-3)	53 (-4)	53 (-4)	51 (-6)		93 (-6)	89 (-10)	90 (-9)	77 (-22)		1.55	1.65	1.59	1.57

*Deviation from baseline in DAS

Table 4.74: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Faridkot, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1				PMH 2					
28-May	Mid-century (2021-50)	6501.0	5894.3 (-9.3)*	5721.1 (-12.0)	6206.0 (-4.5)	5273.2 (-18.9)	6411.1	5372.0 (-16.2)	5296.8 (-17.4)	5846.3 (-8.8)	4890.6 (-23.7)
	End-century (2051-95)		4403.1 (-32.3)	2194.8 (-66.2)	2473.9 (-62.0)	733.3 (-88.7)		4191.2 (-34.6)	2105.5 (-67.2)	2379.2 (-62.9)	534.6 (-91.7)
06-June	Mid-century (2021-50)	6331.6	6035.9 (-4.7)	5808.3 (-8.3)	6386.8 (+0.9)	5531.0 (-12.6)	6290.7	5999.9 (-4.6)	5900.8 (-6.2)	6425.5 (+2.1)	5546.0 (-11.8)
	End-century (2051-95)		5299.9 (-16.3)	928.0 (-85.3)	1443.3 (-77.2)	410.7 (-93.5)		5069.9 (-19.4)	1391.3 (-77.9)	1823.3 (-71.0)	495.2 (-92.1)
15-June	Mid-century (2021-50)	6581.2	6836.3 (+3.9)	6645.9 (+1.0)	7223.4 (+9.8)	6130.8 (-6.8)	6337.1	5948.1 (-6.1)	5826.9 (-8.0)	6417.3 (+1.3)	5463.2 (-13.8)
	End-century (2051-95)		5337.3 (-18.9)	2856.4 (-56.6)	3009.9 (-54.3)	629.4 (-90.4)		5216.7 (-17.7)	2682.1 (-57.7)	3003.5 (-52.6)	515.5 (-91.9)
24-June	Mid-century (2021-50)	5690.0	4597.1 (-19.2)	4914.8 (-13.6)	4663.3 (-18.0)	4615.5 (-18.9)	5614.2	4852.0 (-13.5)	5460.2 (-2.7)	4898.2 (-12.8)	5238.6 (-6.7)
	End-century (2051-95)		4271.5 (-24.9)	3069.9 (-46.0)	3107.6 (-45.4)	1331.8 (-76.6)		4900.2 (-12.7)	3912.4 (-30.3)	4037.5 (-28.1)	1365.5 (-75.7)

*% deviation from baseline value

Table 4.75: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Faridkot, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	60	59 (-1)*	58 (-2)	59 (-1)	58 (-2)	98	95 (-3)	95 (-3)	96 (-4)	94 (-4)	3.54	2.88	2.85	2.88	2.79
	End-century (2051-95)		59 (-1)	56 (-4)	55 (-4)	55 (-5)		94 (-4)	83 (-15)	84 (-14)	80 (-18)		2.83	2.49	2.51	1.97
06-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	58 (-2)	57 (-3)	98	94 (-4)	94 (-4)	95 (-3)	93 (-5)	3.34	3.80	3.76	3.80	3.74
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	55 (-5)		93 (-5)	74 (-24)	77 (-21)	73 (-25)		3.67	3.53	3.58	2.90
15-June	Mid-century (2021-50)	60	58 (-2)	58 (-2)	59 (-1)	58 (-2)	99	96 (-3)	95 (-4)	97 (-2)	94 (-5)	3.37	3.95	3.99	3.94	3.97
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	55 (-5)		93 (-6)	91 (-8)	91 (-8)	77 (-22)		3.93	3.93	3.92	3.89
24-June	Mid-century (2021-50)	60	59 (-1)	59 (-1)	60 (0)	59 (-1)	100	97 (-3)	97 (-3)	98 (-2)	96 (-4)	2.51	3.01	3.04	3.01	3.02
	End-century (2051-95)		58 (-2)	57 (-3)	57 (-3)	55 (-5)		96 (-4)	93 (-7)	93 (-7)	87 (-13)		3.03	3.00	2.99	2.79

*Deviation from baseline in DAS

Table 4.76: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Faridkot, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	56	55 (-1)*	55 (-1)	55 (-1)	55 (-1)	96	93 (-3)	93 (-3)	94 (-2)	92 (-4)	3.29	2.45	2.53	2.53	2.48
	End-century (2051-95)		54 (-2)	54 (-2)	54 (-2)	51 (-5)		92 (-4)	83 (-13)	84 (-12)	72 (-24)		2.58	2.40	2.38	1.62
06-June	Mid-century (2021-50)	56	54 (-2)	54 (-2)	56 (0)	54 (-2)	96	93 (-3)	92 (-4)	94 (-2)	92 (-4)	3.01	3.26	3.21	3.27	3.20
	End-century (2051-95)		53 (-3)	52 (-4)	52 (-4)	51 (-5)		91 (-5)	74 (-22)	77 (-19)	71 (-25)		3.14	2.98	3.01	2.51
15-June	Mid-century (2021-50)	56	55 (-1)	55 (-1)	56 (0)	55 (-1)	97	94 (-3)	94 (-3)	95 (-2)	93 (-4)	2.90	3.41	3.43	3.38	3.42
	End-century (2051-95)		55 (-1)	52 (-4)	53 (-3)	51 (-5)		93 (-4)	87 (-10)	89 (-8)	72 (-25)		3.41	3.40	3.40	3.39
24-June	Mid-century (2021-50)	56	56 (0)	56 (0)	56 (0)	55 (-1)	98	95 (-3)	95 (-3)	97 (-1)	94 (-4)	2.37	2.71	2.80	2.78	2.67
	End-century (2051-95)		55 (-1)	54 (-2)	54 (-2)	52 (-4)		94 (-4)	91 (-7)	91 (-7)	85 (-13)		2.71	2.80	2.78	2.67

*Deviation from baseline in DAS

PMH1 cultivar (Table 4.75) in Faridkot showed shortening by 0-3 days during the mid-century and by 1-5 days during the end-century from the baseline (60 DAS) while the maturity period was projected to shorten by 2-5 days and 4-25 days during the mid and end-century, respectively from the baseline (98-100 DAS). The maximum shortening was observed under RCP8.5 during the end-century. The LAI was found to be higher than the baseline except on 28th May. The PMH2 cultivar (Table 4.76) showed shortening of anthesis and maturity was by 0-2 days from the baseline (56 DAS) and 1-4 days from the baseline (96-98 DAS), respectively during mid-century. The end-century indicated a shortening of anthesis and maturity by 1-5 days and 4-25 days, respectively. The LAI obtained for the 85 year period was higher than the baseline except on 28th May where it was lower for both the centuries. The highest shortening of days was observed under RCP8.5 during the end-century.

FIO-ESM model

The PMH1 (Table 4.77) cultivar at Abohar observed a decrease in yield ranging 20.4% to 48.1% during the mid-century while 25.9% to 92.3% during the end-century from the baseline range (3218.3 kg ha⁻¹ to 3831.6 kg ha⁻¹). 15th June observed a significant yield increment under RCP2.6 (20.8%), RCP4.5 (15.7%), RCP6.0 (16.5%) and RCP8.5 (20.6%). A higher decrease was observed under RCP8.5 during the end-century. The yield under RCP8.5 ranged <1229.4 kg ha⁻¹. The PMH2 (Table 4.77) cultivar observed the yield decrement ranging 3.1% to 36.1% during the mid-century and 8.7% to 96.4% during the end-century from the baseline range (3113.5 kg ha⁻¹ to 3522.3 kg ha⁻¹). The cultivar also observed an increment on 15th June under RCP2.6 (0.5%), RCP4.5 (0.9%) and RCP8.5 (1.9%) and on 24th June (22.1%, 11.9%, 12.0% and 9.4%) under the four scenarios, respectively during the mid-century. The major decline in yield was observed under RCP8.5 during the end-century ranging <1572.4.

At Abohar the PMH1 cultivar (Table 4.78) showed shortening by 1-3 days during the mid-century and by 1-6 days during the end-century from the baseline (60-61 DAS) while the maturity period was projected to shorten by 3-6 days and 3-26 days during the mid and end-century, respectively from the baseline (99-101 DAS). The maximum shortening was observed under RCP8.5 during the end-century under all the scenarios and dates of sowing. The LAI was found to be higher than the baseline. The anthesis and maturity for PMH2 cultivar (Table 4.79) showed shortening by 1-3 days from the baseline (56-57 DAS) and 3-5 days from the baseline (96-99 DAS), respectively during the mid-century. The end-century indicated a shortening of anthesis and maturity by 1-4 days and 3-28 days, respectively. The LAI obtained for the 85

year period was higher than the baseline except on 5th June where it was lower for both the centuries. The highest shortening of days was observed under RCP8.5 during the end-century.

The decrease in yield for PMH1 at Faridkot was ranged (Table 4.80) 4.4% to 16.2% during the mid-century while 3.5% to 81.3% during the end-century from the baseline range (5690.0 kg ha⁻¹ to 6581.2 kg ha⁻¹). An increment in yield was observed on 28th May by 4.1%, 1.0% and 3.2%, respectively under RCP4.5, RCP6.0 and RCP8.5. Significant yield increase was also found during mid-century on 6th June (8.7%, 11.1%, 10.4% and 12.0%) and 15th June (10.6%, 6.5%, 4.7% and 13.3%) under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively while a yield increase by (8.5% and 1.3%) and (10% and 8.3%) on respective dates under RCP2.6 and RCP4.5, respectively during end-century. A higher decrease was observed under RCP8.5 during the end-century. The PMH2 (Table 4.80) cultivar observed the yield decrement ranging 11.3% to 15.3% during the mid-century and 13.7% to 73.7% during the end-century from the baseline range (5614.2 kg ha⁻¹ to 6411.1 kg ha⁻¹). The major decline in yield was observed under RCP8.5 during the end-century.

Similar results as CSIRO-Mk-3-6-0 were obtained where PMH1 cultivar (Table 4.81) in Faridkot showed shortening by 0-3 days during the mid-century and by 1-4 days during the end-century from the baseline (60 DAS) while the maturity period was projected to shorten by 0-4 days and 1-23 days during the mid and end-century, respectively from the baseline (98-100 DAS). The maximum shortening was observed under RCP8.5 during the end-century. The LAI was found to be higher than the baseline except on 28th May. The PMH2 cultivar (Table 4.82) showed shortening of anthesis and maturity was by 0-1 days from the baseline (56 DAS) and 0-2 days from the baseline (96-98 DAS), respectively during mid-century. The end-century indicated a shortening of anthesis and maturity by 1-4 days and 1-21 days, respectively. The LAI obtained for the 85 year period was higher than the baseline except on 28th May where it was lower for both the centuries. The highest shortening of days was observed under RCP8.5 during the end-century.

Table 4.77: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by FIO-ESM model during 21st century at Abohar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1				PMH 2					
28-May	Mid-century (2021-50)	3743.8	2977.9 (-20.4)*	2856.1 (-23.7)	2753.2 (-26.4)	1941.3 (-48.1)	3480.6	2967.0 (-26.9)	2722.6 (-32.9)	2721.1 (-32.9)	2799.0 (-31.0)
	End-century (2051-95)		2617.4 (-30.1)	2308.5 (-38.3)	1557.3 (-58.4)	490.5 (-86.9)		2473.3 (-39.0)	2233.7 (-44.9)	1565.9 (-61.4)	145.2 (-96.4)
06-June	Mid-century (2021-50)	3831.6	2911.9 (-24.0)	2977.2 (-22.3)	2789.0 (-27.2)	2736.5 (-28.6)	3522.3	2471.2 (-29.8)	2549.5 (-27.6)	2248.9 (-36.1)	2251.0 (-36.1)
	End-century (2051-95)		2839.8 (-25.9)	2512.6 (-34.4)	1353.9 (-64.7)	294.1 (-92.3)		2380.9 (-32.4)	2053.2 (-41.7)	1157.7 (-67.1)	275.1 (-92.2)
15-June	Mid-century (2021-50)	3543.2	4280.1 (+20.8)	4100.8 (+15.7)	4128.5 (+16.5)	4273.2 (+20.6)	3374.7	3390.5 (+0.5)	3404.2 (+0.9)	3269.6 (-3.1)	3440.3 (+1.9)
	End-century (2051-95)		2561.1 (-27.7)	2301.4 (-35.0)	1448.5 (-59.1)	712.8 (-79.9)		3049.2 (-9.6)	2590.3 (-23.2)	2648.7 (-21.5)	912.8 (-73.0)
24-June	Mid-century (2021-50)	3218.3	2321.1 (-27.9)	2164.6 (-32.7)	2071.8 (-35.6)	2167.8 (-32.6)	3113.5	3802.4 (+22.1)	3483.3 (+11.9)	3488.3 (+12.0)	3405.5 (+9.4)
	End-century (2051-95)		1888.9 (-41.3)	1729.7 (-46.2)	1599.3 (-50.3)	1229.4 (-61.8)		2805.5 (-9.9)	2843.4 (-8.7)	2692.1 (-13.5)	1572.4 (-49.5)

*% deviation from baseline value

Table 4.78: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by FIO-ESM model during 21st century at Abohar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	60	59 (-1)*	58 (-2)	58 (-2)	57 (-3)	99	95 (-4)	95 (-4)	94 (-5)	93 (-6)	1.85	1.90	1.86	1.91	1.93
	End-century (2051-95)		59 (-1)	57 (-3)	56 (-4)	55 (-5)		95 (-4)	93 (-6)	87 (-12)	80 (-19)		1.86	1.87	1.94	1.97
06-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	57 (-3)	99	94 (-5)	93 (-6)	93 (-6)	93 (-6)	1.99	2.00	1.91	1.97	1.96
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	55 (-5)		94 (-5)	93 (-6)	83 (-16)	73 (-26)		1.92	1.96	2.01	1.98
15-June	Mid-century (2021-50)	60	59 (-1)	57 (-3)	57 (-3)	57 (-3)	100	97 (-3)	95 (-5)	95 (-5)	95 (-5)	1.86	2.19	2.21	2.13	2.15
	End-century (2051-95)		58 (-2)	56 (-4)	56 (-4)	55 (-5)		97 (-3)	93 (-7)	92 (-8)	83 (-17)		2.14	2.18	2.20	2.30
24-June	Mid-century (2021-50)	61	59 (-2)	59 (-2)	58 (-3)	59 (-2)	101	98 (-3)	98 (-3)	98 (-3)	98 (-3)	1.42	1.62	1.65	1.56	1.57
	End-century (2051-95)		58 (-3)	58 (-3)	58 (-3)	55 (-6)		98 (-3)	97 (-4)	95 (-6)	91 (-10)		1.60	1.60	1.63	1.69

*Deviation from baseline in DAS

Table 4.79: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by FIO-ESM model during 21st century at Abohar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	56	55 (-1)*	55 (-1)	55 (-1)	54 (-2)	96	93 (-3)	92 (-4)	92 (-4)	92 (-4)	1.77	1.91	1.89	1.93	1.95
	End-century (2051-95)		55 (-1)	54 (-2)	54 (-2)	52 (-4)		93 (-3)	92 (-4)	87 (-9)	68 (-28)		1.86	1.88	1.95	1.85
06-June	Mid-century (2021-50)	56	55 (-1)	54 (-2)	54 (-2)	53 (-3)	97	94 (-3)	93 (-4)	93 (-4)	92 (-5)	1.64	1.61	1.56	1.60	1.61
	End-century (2051-95)		55 (-1)	54 (-2)	52 (-4)	52 (-4)		94 (-3)	91 (-6)	82 (-15)	73 (-24)		1.55	1.58	1.63	1.65
15-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	55 (-2)	55 (-2)	98	95 (-3)	94 (-4)	94 (-4)	94 (-4)	1.60	1.88	1.88	1.85	1.86
	End-century (2051-95)		55 (-2)	55 (-2)	54 (-3)	51 (-6)		94 (-4)	93 (-5)	91 (-7)	80 (-18)		1.82	1.87	1.89	1.96
24-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	55 (-2)	55 (-2)	99	95 (-4)	95 (-4)	95 (-4)	95 (-4)	1.26	1.44	1.48	1.42	1.44
	End-century (2051-95)		55 (-2)	54 (-3)	54 (-3)	53 (-4)		96 (-3)	94 (-5)	93 (-6)	90 (-9)		1.40	1.46	1.48	1.60

*Deviation from baseline in DAS

Table 4.80: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by FIO-ESM model during 21st century at Faridkot, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	6501.0	6217.1 (-4.4)*	6770.0 (+4.1)	6564.1 (+1.0)	6710.0 (+3.2)	6411.1	5486.5 (-14.4)	6782.3 (+5.8)	6725.3 (+4.9)	6740.3 (+5.1)
	End-century (2051-95)		6274.9 (-3.48)	6246.5 (-21.0)	5132.7 (-21.0)	1780.1 (-72.6)		5184.9 (-19.1)	5533.7 (-13.7)	4652.0 (-27.4)	1683.6 (-73.7)
06-June	Mid-century (2021-50)	6331.6	6883.7 (+8.7)	7034.1 (+11.1)	6989.1 (+10.4)	7094.4 (+12.0)	6290.7	6773.2 (+7.7)	7030.4 (+11.8)	6888.7 (+9.5)	7104.5 (+12.9)
	End-century (2051-95)		6873.4 (+8.6)	6415.6 (+1.3)	5264.3 (-16.9)	1182.4 (-81.3)		6623.8 (+5.3)	6297.6 (+0.1)	5111.3 (-18.8)	1422.8 (-77.4)
15-June	Mid-century (2021-50)	6581.2	7280.2 (+10.6)	7006.4 (+6.5)	6888.9 (+4.7)	7458.3 (+13.3)	6337.1	6624.6 (+4.5)	7011.2 (+10.6)	6907.5 (+9.0)	7343.3 (+15.9)
	End-century (2051-95)		7236.4 (+9.9)	7109.9 (+8.0)	5899.0 (-10.4)	2633.4 (-60.0)		6773.2 (+6.9)	6385.3 (+0.8)	5023.4 (-20.7)	2588.4 (-59.1)
24-June	Mid-century (2021-50)	5690.0	4280.4 (-24.8)	4311.7 (-24.2)	4283.6 (-24.7)	4768.6 (-16.2)	5614.2	4757.2 (-15.3)	4755.7 (-15.3)	4754.0 (-15.3)	4981.7 (-11.3)
	End-century (2051-95)		4360.8 (-23.4)	4203.7 (-26.1)	3591.8 (-36.9)	2436.6 (-51.2)		4615.0 (-17.8)	4501.9 (-19.8)	4322.6 (-23.0)	2565.7 (-54.3)

*% deviation from baseline value

Table 4.81: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by FIO-ESM model during 21st century at Faridkot, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	60	58 (-2)*	59 (-1)	60 (0)	59 (-1)	98	95 (-3)	95 (-3)	97 (-1)	97 (-1)	3.54	2.83	3.23	3.15	3.16
	End-century (2051-95)		59 (-1)	59 (-1)	59 (-1)	56 (-4)		96 (-2)	94 (-4)	94 (-4)	83 (-15)		2.90	3.09	3.05	2.60
06-June	Mid-century (2021-50)	60	57 (-3)	58 (-2)	58 (-2)	58 (-2)	98	94 (-4)	98 (0)	95 (-3)	95 (-3)	3.34	3.81	3.77	3.77	3.73
	End-century (2051-95)		57 (-3)	57 (-3)	57 (-3)	56 (-4)		94 (-4)	97 (-1)	93 (-5)	75 (-23)		3.75	3.75	3.75	3.60
15-June	Mid-century (2021-50)	60	57 (-3)	59 (-1)	59 (-1)	59 (-1)	99	95 (-4)	98 (0)	98 (-1)	98 (-1)	3.37	4.05	4.08	4.05	4.07
	End-century (2051-95)		59 (-1)	59 (-1)	58 (-2)	56 (-4)		98 (-1)	97 (-1)	95 (-4)	91 (-8)		4.09	4.07	4.07	4.08
24-June	Mid-century (2021-50)	60	59 (-1)	60 (0)	60 (0)	59 (-1)	100	98 (-2)	99 (-1)	100 (0)	99 (-1)	2.51	3.10	3.04	3.01	2.97
	End-century (2051-95)		59 (-1)	58 (-2)	58 (-2)	57 (-3)		98 (-2)	97 (-3)	96 (-4)	92 (-8)		3.13	3.03	3.01	3.07

*Deviation from baseline in DAS

Table 4.82: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by FIO-ESM model during 21st century at Faridkot, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	56	55 (-1)*	55 (-1)	56 (0)	55 (-1)	96	93 (-3)	94 (-2)	94 (-2)	94 (-2)	3.29	2.45	2.83	2.77	2.80
	End-century (2051-95)		55 (-1)	55 (-1)	55 (-1)	53 (-3)		93 (-3)	93 (-3)	92 (-4)	83 (-13)		2.49	2.75	2.67	2.46
06-June	Mid-century (2021-50)	56	55 (-1)	56 (0)	56 (0)	55 (-1)	96	94 (-2)	95 (-1)	95 (-1)	95 (-1)	3.01	3.34	3.33	3.34	3.32
	End-century (2051-95)		55 (-1)	55 (-1)	55 (-1)	52 (-4)		94 (-2)	94 (-2)	93 (-3)	75 (-21)		3.30	3.28	3.30	3.10
15-June	Mid-century (2021-50)	56	55 (-1)	55 (-1)	56 (0)	55 (-1)	97	95 (-2)	96 (-1)	96 (-1)	96 (-1)	2.90	3.50	3.44	3.42	3.42
	End-century (2051-95)		55 (-1)	55 (-1)	55 (-1)	53 (-3)		95 (-2)	95 (-2)	93 (-4)	90 (-7)		3.43	3.44	3.42	3.48
24-June	Mid-century (2021-50)	56	55 (-1)	57 (1)	57 (1)	56 (0)	98	95 (-3)	99 (1)	99 (1)	98 (0)	2.37	2.76	2.72	2.70	2.69
	End-century (2051-95)		55 (-1)	75 (1)	55 (-1)	54 (-2)		96 (-2)	97 (-1)	94 (-4)	91 (-7)		2.79	2.72	2.73	2.87

*Deviation from baseline in DAS

IPSL-CM5A-MR model

The PMH1 (Table 4.83) cultivar at Abohar observed a decrement in yield ranging 0.64% to 51.4% during the mid-century while 11.6% to 88.5% during the end-century from the baseline (3218.3 kg ha⁻¹ to 3831.6 kg ha⁻¹). A small increment in yield was observed on 15th June by 4.8% under RCP2.6 during the mid-century. A higher decrease was observed under RCP8.5 during the end-century where yield ranged <990.4 kg ha⁻¹. The PMH2 (Table 4.83) cultivar observed the yield decrement ranging 4.8% to 52.4% during the mid-century and 8.2% to 91.3% during the end-century from the baseline (3113.5 kg ha⁻¹ to 3522.3 kg ha⁻¹). The major decline in yield was observed under RCP8.5 during the end-century while a small increment was observed on 24th June (9.5%) under RCP2.6.

Abohar observed similar results for anthesis and maturity shortening for both the cultivars. The PMH1 cultivar (Table 4.84) showed shortening by 2-4 days during the mid-century and by 3-5 days during the end-century from the baseline (60-61 DAS) while the maturity period was projected to shorten by 4-8 days and 5-25 days during the mid and end-century, respectively from the baseline (99-101 DAS). The maximum shortening was observed under RCP8.5 during the end-century. The LAI was found to be higher than the baseline. The PMH2 (Table 4.85) cultivar showed shortening of anthesis and maturity by 2-4 days from the baseline (56-57 DAS) and 4-7 days from the baseline (96-99 DAS), respectively during mid-century. The end-century indicated a shortening of anthesis and maturity by 2-5 days and 5-25 days, respectively. The LAI obtained for the 85 year period was higher than the baseline except on 6th June where it was lower for both the centuries.

The yield decline for PMH1 at Faridkot ranged (Table 4.86) 3.4% to 26.8% during the mid-century while 1.6% to 86.4% during the end-century from the baseline (5690.0 kg ha⁻¹ to 6581.2 kg ha⁻¹). An increment in yield was observed on 6th June by 11.3% and 3.9%, respectively under RCP2.6 and RCP6.0. Significant yield increase was also found during mid-century on 15th June (10.0%, 1.0%, 8.7% and 2.4%) under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively and a yield increase by 9.5% during end-century under RCP2.6. A higher decrease was observed under RCP8.5 during the end-century where yield ranged <1858 kg ha⁻¹. The PMH2 (Table 4.86) cultivar observed the yield decrement ranging 0.6% to 19.1% during the mid-century and 0.8% to 80.2% during the end-century from the baseline (5614.2 kg ha⁻¹ to 6411.1 kg ha⁻¹). The major decline in yield was observed under RCP8.5 during the end-century.

Similar results as previous models were obtained where PMH1 cultivar (Table 4.87) in Faridkot showed shortening by 0-3 days during the mid-century and by 1-5 days during the end-century from the baseline (60 DAS) while the maturity period was projected to shorten by 1-4 days and 2-24 days during the mid and end-century, respectively from the baseline (98-100 DAS).

Table 4.83: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Abohar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	3743.8	3141.6 (-16.1)*	2186.7 (-41.6)	2694.6 (-28.0)	2205.6 (-41.1)	3480.6	2965.4 (-26.9)	2205.3 (-45.6)	2674.8 (-34.0)	2192.2 (-46.0)
	End-century (2051-95)		2358.6 (-37.0)	1649.8 (-55.9)	1518.3 (-59.4)	908.8 (-75.7)		2292.2 (-43.5)	1682.2 (-58.5)	1634.1 (-59.7)	352.3 (-91.3)
06-June	Mid-century (2021-50)	3831.6	2933.8 (-23.4)	2148.4 (-43.9)	2568.6 (-33.0)	2289.9 (-40.2)	3522.3	2363.9 (-32.9)	1676.3 (-52.4)	2140.5 (-39.2)	1704.8 (-51.6)
	End-century (2051-95)		2429.2 (-36.6)	1801.3 (-53.0)	1443.6 (-62.3)	439.2 (-88.5)		1835.7 (-47.9)	1561.6 (-55.7)	1251.9 (-64.4)	460.2 (-86.9)
15-June	Mid-century (2021-50)	3543.2	3715.0 (+4.8)	2412.0 (-31.9)	3521.2 (-0.6)	2431.0 (-31.4)	3374.7	3043.6 (-9.8)	3090.2 (-8.4)	2941.0 (-12.9)	2286.9 (-32.2)
	End-century (2051-95)		3133.4 (-11.6)	2233.8 (-37.0)	1833.3 (-48.2)	990.4 (-72.0)		3096.2 (-8.2)	2214.6 (-34.4)	2328.0 (-31.0)	1132.0 (-66.4)
24-June	Mid-century (2021-50)	3218.3	1890.4 (-41.2)	1605.8 (-50.1)	2007.3 (-37.6)	1564.0 (-51.4)	3113.5	2965.4 (-4.8)	2919.3 (-6.2)	3444.3 (+10.6)	2917.6 (-6.3)
	End-century (2051-95)		2003.9 (-37.7)	1221.4 (-62.0)	1203.9 (-62.6)	627.8 (-80.5)		3408.3 (+9.5)	2083.9 (-33.1)	2432.8 (-21.9)	1134.7 (-63.5)

*% deviation from baseline value

Table 4.84: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Abohar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
			Anthesis					Maturity					LAI			
28-May	Mid-century (2021-50)	60	58 (-2)*	57 (-3)	56 (-4)	56 (-4)	99	95 (-4)	92 (-7)	92 (-7)	91 (-8)	1.85	1.88	1.86	1.89	1.88
	End-century (2051-95)		58 (-2)	55 (-5)	55 (-5)	55 (-5)		94 (-5)	90 (-9)	87 (-12)	83 (-16)		1.87	1.83	1.99	1.74
06-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	56 (-4)	99	94 (-5)	92 (-7)	93 (-6)	92 (-7)	1.99	1.95	1.93	1.93	1.90
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	56 (-4)		92 (-7)	91 (-8)	84 (-15)	74 (-25)		1.90	2.00	1.92	1.87
15-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	56 (-4)	100	95 (-5)	93 (-7)	94 (-6)	92 (-8)	1.86	2.17	2.14	2.20	2.14
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	56 (-4)		93 (-7)	91 (-9)	91 (-9)	90 (-10)		2.18	2.21	2.31	2.35
24-June	Mid-century (2021-50)	61	59 (-2)	58 (-3)	59 (-2)	58 (-3)	101	97 (-4)	96 (-5)	97 (-4)	96 (-5)	1.42	1.56	1.58	1.59	1.58
	End-century (2051-95)		58 (-3)	56 (-5)	56 (-5)	56 (-5)		96 (-5)	92 (-9)	92 (-9)	90 (-11)		1.56	1.63	1.61	1.69

*Deviation from baseline in DAS

Table 4.85: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Abohar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	56	54 (-2)*	54 (-2)	54 (-2)	54 (-2)	96	92 (-4)	91 (-5)	92 (-4)	91 (-5)	1.77	1.87	1.83	1.87	1.86
	End-century (2051-95)		54 (-2)	53 (-3)	53 (-3)	52 (-4)		91 (-5)	90 (-6)	87 (-9)	71 (-25)		1.83	1.83	1.88	1.58
06-June	Mid-century (2021-50)	56	53 (-3)	53 (-3)	53 (-3)	52 (-4)	97	91 (-6)	90 (-7)	91 (-6)	90 (-7)	1.64	1.57	1.54	1.55	1.52
	End-century (2051-95)		53 (-3)	52 (-4)	52 (-4)	52 (-4)		90 (-7)	89 (-8)	83 (-14)	74 (-23)		1.51	1.61	1.56	1.56
15-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	55 (-2)	53 (-4)	98	94 (-4)	92 (-6)	94 (-4)	92 (-6)	1.60	1.87	1.88	1.88	1.89
	End-century (2051-95)		54 (-3)	52 (-5)	52 (-5)	52 (-5)		93 (-5)	89 (-9)	89 (-9)	88 (-10)		1.86	1.87	1.92	1.97
24-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	55 (-2)	55 (-2)	99	95 (-4)	93 (-6)	94 (-5)	93 (-6)	1.26	1.44	1.51	1.46	1.52
	End-century (2051-95)		55 (-2)	54 (-3)	55 (-2)	53 (-4)		94 (-5)	91 (-8)	92 (-7)	89 (-10)		1.46	1.56	1.60	1.63

*Deviation from baseline in DAS

Table 4.86: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Faridkot, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	6501.0	6558.6 (+0.9)*	5750.3 (-11.6)	6443.2 (-0.9)	5848.2 (-10.0)	6411.1	6774.1 (+5.7)	5248.8 (-18.1)	6164.8 (-3.8)	5348.4 (-16.6)
	End-century (2051-95)		6397.6 (-1.6)	4491.5 (-30.9)	4553.6 (-29.9)	1839.1 (-71.7)		5631.7 (-12.2)	4088.6 (-36.2)	4227.0 (-34.1)	1709.8 (-73.3)
06-June	Mid-century (2021-50)	6331.6	7049.7 (+11.3)	5764.5 (-9.0)	6576.7 (+3.9)	6119.0 (-3.4)	6290.7	7055.9 (+12.2)	5702.5 (-9.3)	6540.7 (+4.0)	6090.7 (-3.2)
	End-century (2051-95)		6339.3 (+0.1)	4976.0 (-21.4)	5084.5 (-19.7)	861.4 (-86.4)		6376.3 (+1.4)	4955.9 (-21.2)	4973.4 (-20.9)	1244.6 (-80.2)
15-June	Mid-century (2021-50)	6581.2	7236.2 (+9.9)	6647.4 (+1.0)	7154.1 (+8.7)	6736.9 (+2.4)	6337.1	6985.5 (+10.2)	5603.2 (-11.5)	6541.2 (+3.2)	5905.0 (-6.8)
	End-century (2051-95)		7206.5 (+9.5)	4571.6 (-30.5)	5209.2 (-20.9)	1858.2 (-71.8)		6283.8 (-0.8)	4534.5 (-28.4)	4776.2 (-24.6)	2009.5 (-68.3)
24-June	Mid-century (2021-50)	5690.0	4165.3 (-26.8)	4363.2 (-23.3)	4501.4 (-20.9)	4852.6 (-14.7)	5614.2	4543.1 (-19.1)	4806.5 (-14.4)	4823.7 (-14.1)	5580.6 (-0.6)
	End-century (2051-95)		4225.1 (-25.7)	3371.0 (-40.8)	3958.0 (-30.4)	1673.0 (-70.6)		4724.0 (-15.8)	4542.2 (-19.1)	5060.2 (-9.9)	2007.9 (-64.2)

*% deviation from baseline value

Table 4.87: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by CSIRO-Mk-3-6-0 model during 21st century at Faridkot, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	60	59 (-1)*	59 (-1)	59 (-1)	58 (-2)	98	97 (-1)	95 (-3)	96 (-2)	94 (-4)	3.54	3.03	3.07	2.98	2.87
	End-century (2051-95)		59 (-1)	55 (-5)	56 (-4)	55 (-5)		95 (-3)	91 (-7)	91 (-7)	83 (-15)		2.94	2.50	2.71	2.03
06-June	Mid-century (2021-50)	60	58 (-2)	57 (-3)	58 (-2)	57 (-3)	98	95 (-3)	94 (-4)	95 (-3)	94 (-4)	3.34	3.74	3.74	3.78	3.75
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	56 (-4)		94 (-4)	92 (-6)	92 (-6)	74 (-24)		3.74	3.38	3.76	2.98
15-June	Mid-century (2021-50)	60	60 (0)	59 (-1)	59 (-1)	58 (-2)	99	98 (-1)	96 (-3)	97 (-2)	95 (-4)	3.37	4.03	3.96	3.99	3.98
	End-century (2051-95)		59 (-1)	57 (-3)	57 (-3)	56 (-4)		97 (-2)	93 (-6)	93 (-6)	90 (-9)		3.99	3.91	3.98	4.04
24-June	Mid-century (2021-50)	60	59 (-1)	59 (-1)	59 (-1)	59 (-1)	100	98 (-2)	97 (-3)	98 (-2)	96 (-4)	2.51	3.02	2.97	2.99	3.04
	End-century (2051-95)		59 (-1)	59 (-1)	59 (-1)	56 (-4)		97 (-3)	95 (-5)	95 (-5)	90 (-10)		2.98	3.05	3.04	3.03

*Deviation from baseline in DAS

Table 4.88: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by IPSL-CM5A-MR model during 21st century at Faridkot, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	56	55 (-1)*	55 (-1)	55 (-1)	55 (-1)	96	94 (-2)	93 (-3)	94 (-2)	93 (-3)	3.29	2.71	2.80	2.65	2.64
	End-century (2051-95)		55 (-1)	54 (-2)	54 (-2)	52 (-4)		93 (-3)	91 (-5)	91 (-5)	83 (-13)		2.57	2.14	2.65	1.61
06-June	Mid-century (2021-50)	56	56 (0)	55 (-1)	56 (0)	54 (-2)	96	95 (-1)	93 (-3)	94 (-2)	92 (-4)	3.01	3.28	3.22	3.31	3.22
	End-century (2051-95)		55 (-1)	53 (-3)	53 (-3)	52 (-4)		94 (-2)	90 (-6)	90 (-6)	74 (-22)		3.25	2.91	3.06	2.50
15-June	Mid-century (2021-50)	56	56 (0)	55 (-1)	56 (0)	55 (-1)	97	96 (-1)	93 (-4)	95 (-2)	93 (-4)	2.90	3.40	3.39	3.41	3.41
	End-century (2051-95)		55 (-1)	53 (-3)	54 (-2)	52 (-4)		94 (-3)	91 (-6)	92 (-5)	88 (-9)		3.39	3.41	3.42	3.47
24-June	Mid-century (2021-50)	56	56 (0)	55 (-1)	56 (0)	55 (-1)	98	97 (-1)	95 (-3)	97 (-1)	94 (-4)	2.37	2.71	2.67	2.71	2.72
	End-century (2051-95)		55 (-1)	53 (-3)	55 (-1)	54 (-2)		95 (-3)	93 (-5)	93 (-5)	90 (-8)		2.67	2.77	2.76	2.80

*Deviation from baseline in DAS

The maximum shortening was observed under RCP8.5 during the end-century. The LAI was found to be higher than the baseline except on 28th May. The PMH2 (Table 4.88) cultivar showed shortening of anthesis and maturity was by 0-1 days from the baseline (56 DAS) and 1-4 days from the baseline (96-98 DAS), respectively during mid-century. The end-century indicated a shortening of anthesis and maturity by 1-4 days and 2-22 days, respectively. The LAI obtained for the 85 year period was higher than the baseline except on 28th May where it was lower for both the centuries.

Ensemble model

PMH1 (Table 4.89) cultivar showed a yield decline at Abohar ranging 5.9% to 49.1% during the mid-century while 17.2% to 91.9% during the end-century from the baseline (3218.3 kg ha⁻¹ to 3831.6 kg ha⁻¹). The PMH2 (Table 4.89) cultivar observed the yield decrement ranging 0.6% to 55.8% during the mid-century and 5.2% to 97.3% during the end-century from the baseline (3113.5 kg ha⁻¹ to 3522.3 kg ha⁻¹). The major decline in yield was observed under RCP8.5 during the end-century for both the cultivars under the four scenarios and dates of sowing.

The anthesis (Fig. 4.36) for PMH1 cultivar (Table 4.90) in Abohar showed shortening by 2-4 days during the mid-century and by 3-5 days during the end-century from the baseline (60-61DAS) while the maturity period (Fig. 4.37) was projected to shorten by 4-7 days and 4-27 days during the mid and end-century, respectively from the baseline (99-101 DAS). The maximum shortening was observed under RCP8.5 during the end-century for both anthesis and maturity. The LAI (Fig. 4.38) was found to be higher than the baseline for most of the scenarios and dates of sowing. The PMH2 (Table 4.91) cultivar showed shortening of anthesis (Fig. 4.39) and maturity (Fig. 4.40) was by 2-3 days from the baseline (56-57 DAS) and 4-7 days from the baseline (96-99 DAS), respectively during mid-century. The end-century indicated a shortening of anthesis and maturity by 2-5 days and 4-29 days, respectively. The LAI (Fig. 4.41) obtained for the 85 year period was higher than the baseline except on 28th May and 6th June where it was lower for both the centuries.

The yield decline for PMH1 at Faridkot ranged (Table 4.92) 0.6% to 24.5% during the mid-century while 3.0% to 90.6% during the end-century from the baseline (5690.0 kg ha⁻¹ to 6581.2 kg ha⁻¹). An increment in yield was observed on 6th June by 8.9%, 3.5 and 10.0, respectively under RCP2.6, RCP4.5 and RCP6.0. Significant yield increase was also found during mid-century on 15th June (11.3%, 10.9%, 12.5% and 7.8%) under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively and a yield increase by 15.2% during end-century under RCP2.6. The PMH2 (Table 4.92) cultivar observed the yield decrement ranging 0.2% to 19.1% during the mid-century and 7.0% to 83.5% during the end-century from the baseline (5614.2 kg ha⁻¹ to 6411.1 kg ha⁻¹). The major decline in yield was observed under RCP8.5 during the end-century.

Similar results as previous models were obtained where PMH1 cultivar (Table 4.93) in Faridkot showed shortening of anthesis days (Fig. 4.42) by 1-3 days during the mid-century and by 1-5 days during the end-century from the baseline (60 DAS) while the maturity period (Fig. 4.43) was projected to shorten by 1-4 days and 1-26 days during the mid and end-century, respectively from the baseline (98-100 DAS). The maximum shortening was observed under RCP8.5 during the end-century. The LAI (Fig. 4.44) was found to be higher than the baseline except on 28th May. The PMH2 (Table 4.94) cultivar showed shortening of anthesis (Fig. 4.45) and maturity (Fig. 4.46) by 0-2 days from the baseline (56 DAS) and 0-3 days from the baseline (96-98 DAS), respectively during mid-century. The end-century indicated a shortening of anthesis and maturity by 1-4 days and 0-24 days, respectively. The LAI (Fig. 4.47) obtained for the 85 year period was higher than the baseline except on 28th May where it was lower for both the centuries.

Similar simulation results were obtained by Lin *et al.* (2017) in Northeast China which is situated at high latitude dominated by continental monsoon type climate. The results for the flat, fertile soil projected the maize yield to decrease on an average by 2.1 to 22.7% and 6.3 to 47.5% from 2020s to 2080s under RCP4.5 and RCP8.5. As the RCP2.6 predicts the diminishing of greenhouse gases and pollutants over the time, the rate of decrease in yield for this scenario is low. Navneet-Kaur and Kaur (2019) reported the same, a lower yield decrement (35 to 59 kg ha⁻¹) under B2 which is a low emission scenario while higher under A1B scenario where the observed temperature deviations from baseline are more in Punjab. They also reported shortening of the maize growing period which was due to increasing temperatures during the end-century. Almost all the models project the decreasing rate of yield to be low on 24 June for both the cultivars and FIO-ESM projects maximum increase in yield on this date so the second fortnight of June may be considered as a good sowing date under future temperature and rainfall conditions. The yield decline observed for the future crop years is under the impact of high temperature stress at its key development stages thus adaptation measure to mitigate the temperature effects is required. The stress also reduces the duration of the crop thus impacting the grain yield under temperature stress. Though the maximum temperature is increasing under future conditions but the major impact is observed under increasing minimum temperature which is very harmful for crop production. Commuri and Jones (2001) reported the impact of heat stress during kernel development and observed its negative affect on the cell division, sugar metabolism and starch biosynthesis which ultimately led to subsequent dry matter accumulation in kernels. Makadho (1996) and Vucetic (2011) also reported similar shortening of growing period of maize leading to reduced grain yield. Shrestha et al (2015) observed a yield decline in maize hybrids by 15-20% with temperature increase by 2^oC. The current sowing dates for all the agroclimatic zones under high emission scenario indicated major yield decline at the end of 21st century thus suitable strategies to mitigate the climate change impact are required in Punjab.

Table 4.89: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by Ensemble model during 21st century at Abohar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1				PMH 2					
28-May	Mid-century (2021-50)	3743.8	2607.1 (-30.4)*	2409.8 (-35.6)	2598.7 (-30.6)	2226.9 (-40.5)	3480.6	2012.0 (-50.4)	1920.1 (-52.7)	2023.0 (-50.1)	1793.7 (-55.8)
	End-century (2051-95)		2260.3 (-39.6)	1622.4 (-56.7)	1506.3 (-59.8)	777.6 (-79.2)		1821.3 (-55.1)	1403.7 (-65.4)	1304.4 (-67.8)	109.6 (-97.3)
06-June	Mid-century (2021-50)	3831.6	2632.7 (-31.3)	2415.8 (-37.0)	2609.6 (-31.9)	2272.7 (-40.7)	3522.3	2218.9 (-37.0)	2058.8 (-41.5)	2218.4 (-37.0)	1908.9 (-45.8)
	End-century (2051-95)		2411.6 (-37.0)	1259.7 (-67.1)	1126.0 (-70.6)	308.6 (-91.9)		2024.2 (-42.5)	1103.2 (-68.7)	998.0 (-71.7)	343.5 (-90.2)
15-June	Mid-century (2021-50)	3543.2	3230.7 (-8.8)	2913.7 (-17.8)	3335.0 (-5.9)	2827.1 (-20.2)	3374.7	2776.6 (-17.7)	2561.4 (-24.1)	2862.9 (-15.2)	2559.2 (-24.2)
	End-century (2051-95)		2933.3 (-17.2)	2181.1 (-38.4)	1995.1 (-43.7)	906.2 (-74.4)		2517.2 (-25.4)	1857.9 (-44.9)	1815.0 (-46.2)	882.1 (-73.9)
24-June	Mid-century (2021-50)	3218.3	1657.7 (-48.5)	1505.4 (-53.2)	1671.9 (-48.0)	1639.3 (-49.1)	3113.5	2708.0 (-13.0)	2957.9 (-5.0)	3095.2 (-0.6)	2924.8 (-6.1)
	End-century (2051-95)		1564.3 (-51.4)	1682.1 (-47.7)	1431.8 (-55.5)	938.7 (-70.8)		2952.7 (-5.2)	2392.1 (-23.2)	2123.3 (-31.8)	1164.3 (-62.6)

*% deviation from baseline value

Table 4.90: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by Ensemble model during 21st century at Abohar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	60	58 (-2)*	56 (-4)	57 (-3)	56 (-4)	99	94 (-5)	92 (-7)	93 (-6)	92 (-7)	1.85	1.81	1.83	1.81	1.84
	End-century (2051-95)		56 (-4)	56 (-4)	56 (-4)	55 (-5)		92 (-7)	86 (-13)	86 (-13)	81 (-18)		1.80	1.93	1.90	1.65
06-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	56 (-4)	99	93 (-6)	93 (-6)	93 (-6)	92 (-7)	1.99	1.96	1.95	1.93	1.94
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	55 (-5)		93 (-6)	82 (-17)	82 (-17)	72 (-27)		1.94	2.00	1.94	1.96
15-June	Mid-century (2021-50)	60	57 (-3)	57 (-3)	57 (-3)	57 (-3)	100	94 (-6)	94 (-6)	94 (-6)	93 (-7)	1.86	2.26	2.26	2.25	2.28
	End-century (2051-95)		57 (-3)	56 (-4)	56 (-4)	55 (-5)		94 (-6)	92 (-8)	91 (-9)	84 (-16)		2.25	2.31	2.24	2.38
24-June	Mid-century (2021-50)	61	59 (-2)	59 (-2)	59 (-2)	58 (-3)	101	97 (-4)	97 (-4)	97 (-4)	96 (-5)	1.42	1.64	1.60	1.61	1.64
	End-century (2051-95)		58 (-3)	56 (-5)	57 (-4)	56 (-5)		97 (-4)	93 (-8)	93 (-8)	90 (-11)		1.61	1.60	1.55	1.64

*Deviation from baseline in DAS

Table 4.91: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by Ensemble model during 21st century at Abohar, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
			Anthesis					Maturity					LAI			
28-May	Mid-century (2021-50)	56	54 (-2)*	54 (-2)	54 (-2)	54 (-2)	96	92 (-4)	92 (-4)	92 (-4)	91 (-5)	1.77	1.65	1.67	1.65	1.68
	End-century (2051-95)		54 (-2)	53 (-3)	53 (-3)	51 (-5)		92 (-4)	86 (-10)	86 (-10)	67 (-29)		1.65	1.72	1.71	1.45
06-June	Mid-century (2021-50)	56	53 (-3)	53 (-3)	53 (-3)	53 (-3)	97	91 (-6)	91 (-6)	91 (-6)	90 (-7)	1.64	1.58	1.58	1.55	1.58
	End-century (2051-95)		53 (-3)	52 (-4)	52 (-4)	52 (-4)		91 (-6)	81 (-16)	80 (-17)	72 (-25)		1.56	1.63	1.57	1.63
15-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	55 (-2)	55 (-2)	98	94 (-4)	93 (-5)	94 (-4)	93 (-5)	1.60	1.95	1.94	1.94	1.96
	End-century (2051-95)		55 (-2)	53 (-4)	53 (-4)	52 (-5)		94 (-4)	90 (-8)	90 (-8)	81 (-17)		1.93	1.95	1.90	1.99
24-June	Mid-century (2021-50)	57	55 (-2)	55 (-2)	55 (-2)	55 (-2)	99	95 (-4)	94 (-5)	95 (-4)	94 (-5)	1.26	1.52	1.50	1.49	1.55
	End-century (2051-95)		55 (-2)	55 (-2)	54 (-3)	52 (-5)		94 (-5)	92 (-7)	92 (-7)	88 (-11)		1.53	1.53	1.50	1.62

*Deviation from baseline in DAS

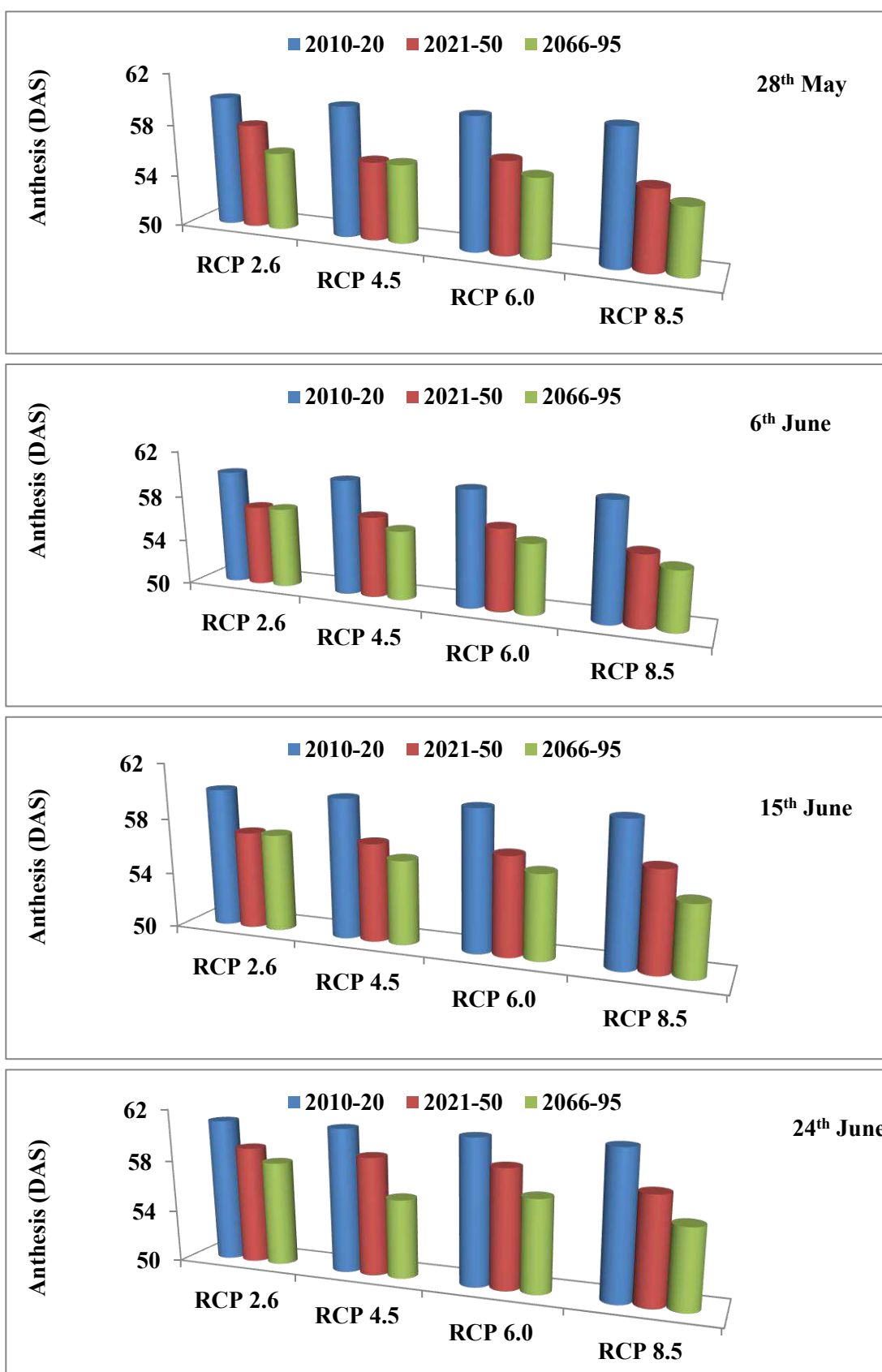


Fig. 4.36: Simulated changes in anthesis (DAS) of PMH1 by Ensemble model at agroclimatic zone V (Abohar)

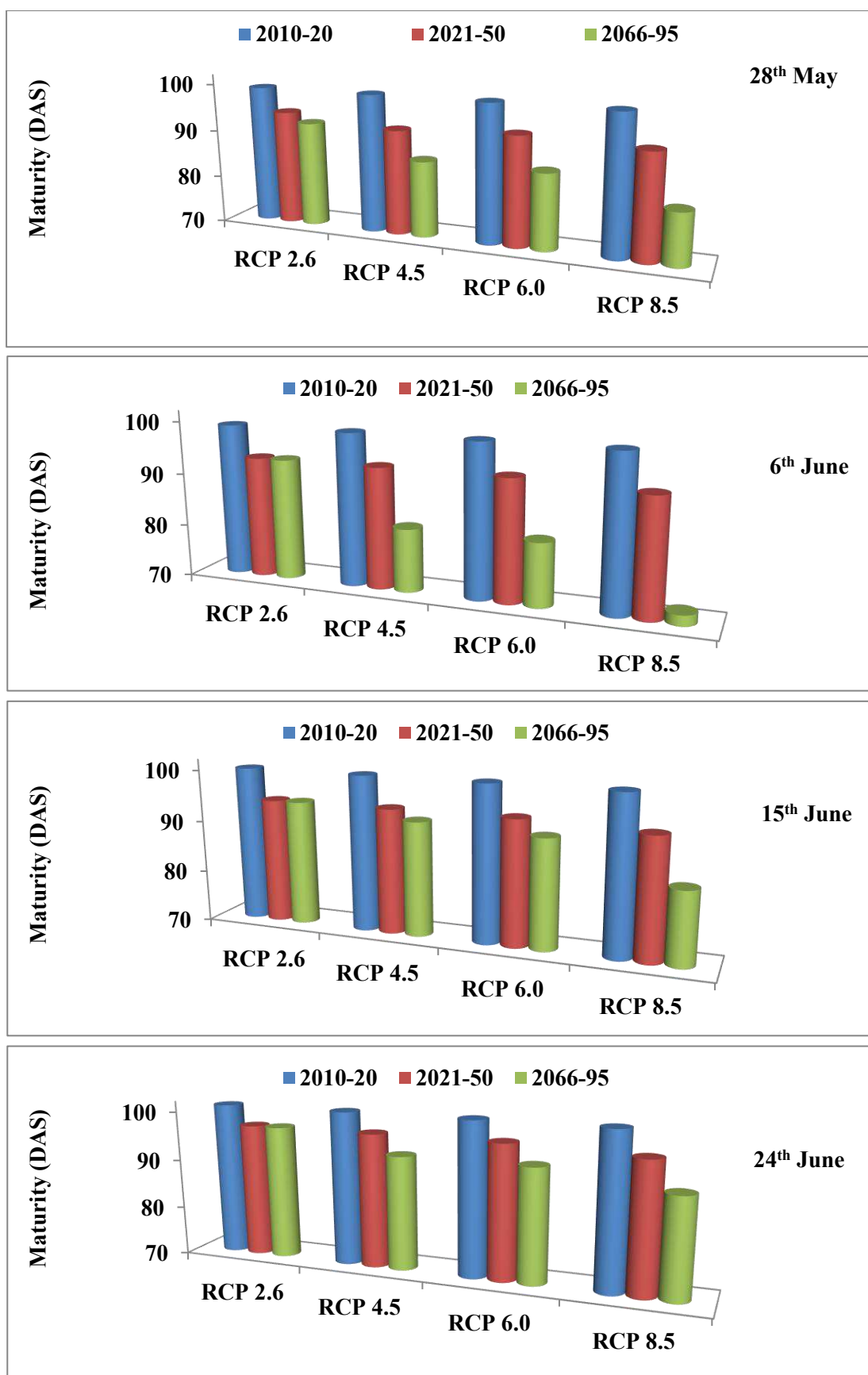


Fig. 4.37: Simulated changes in maturity (DAS) of PMH1 by Ensemble model at agroclimatic zone V (Abohar)

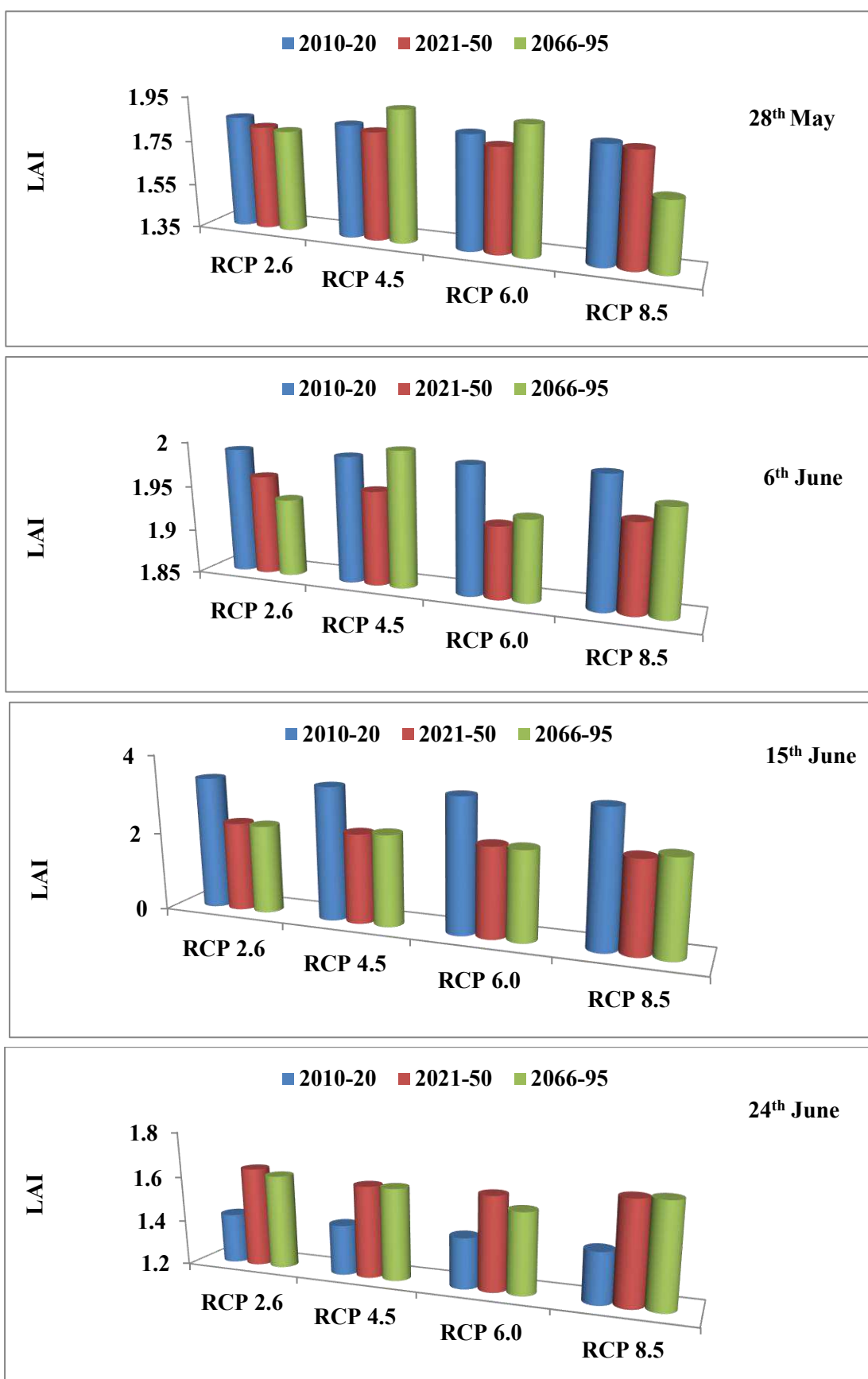


Fig. 4.38: Simulated changes in LAI of PMH1 by Ensemble model at agroclimatic zone V (Abohar)

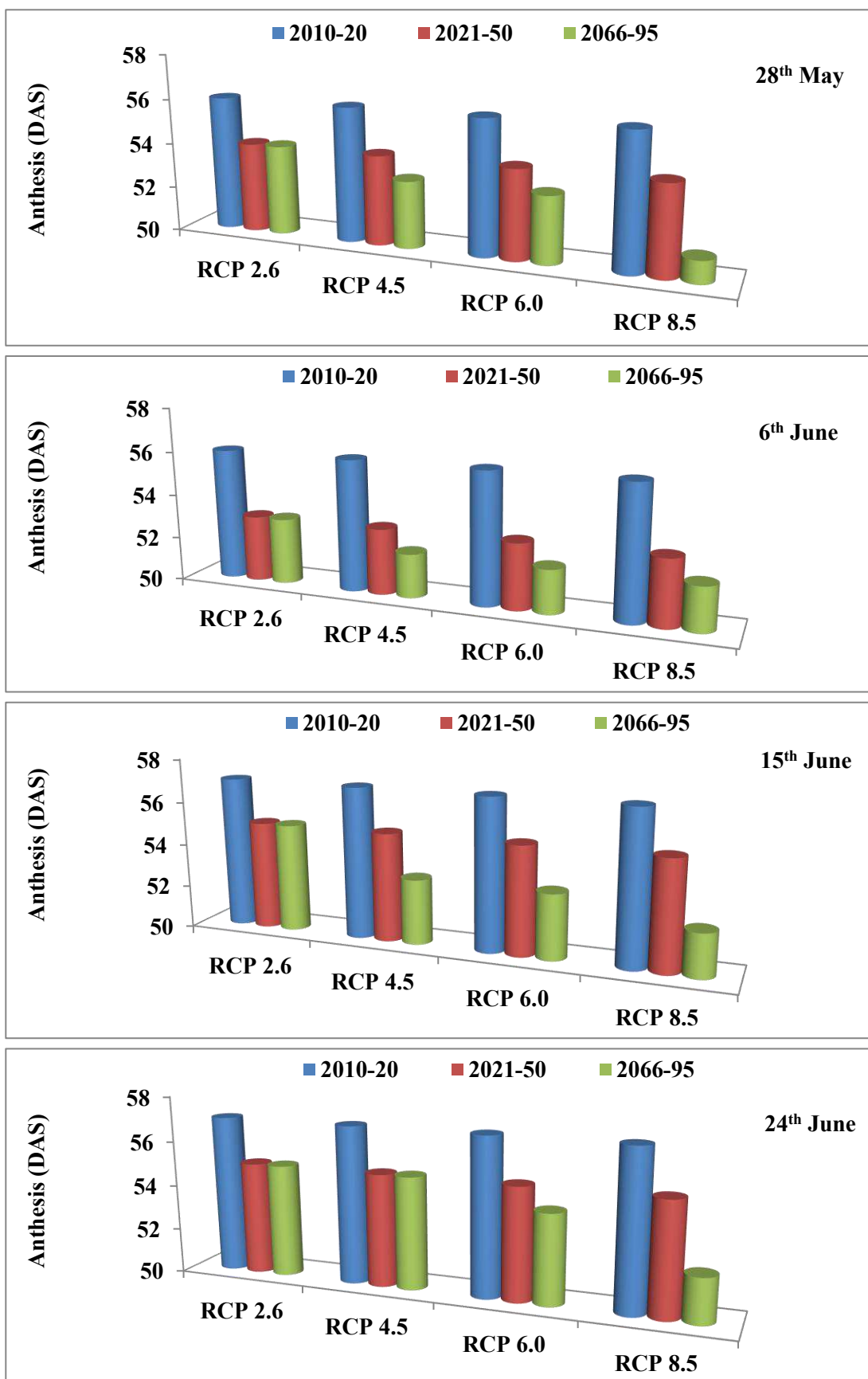


Fig. 4.39: Simulated changes in anthesis (DAS) of PMH2 by Ensemble model at agroclimatic zone V (Abohar)

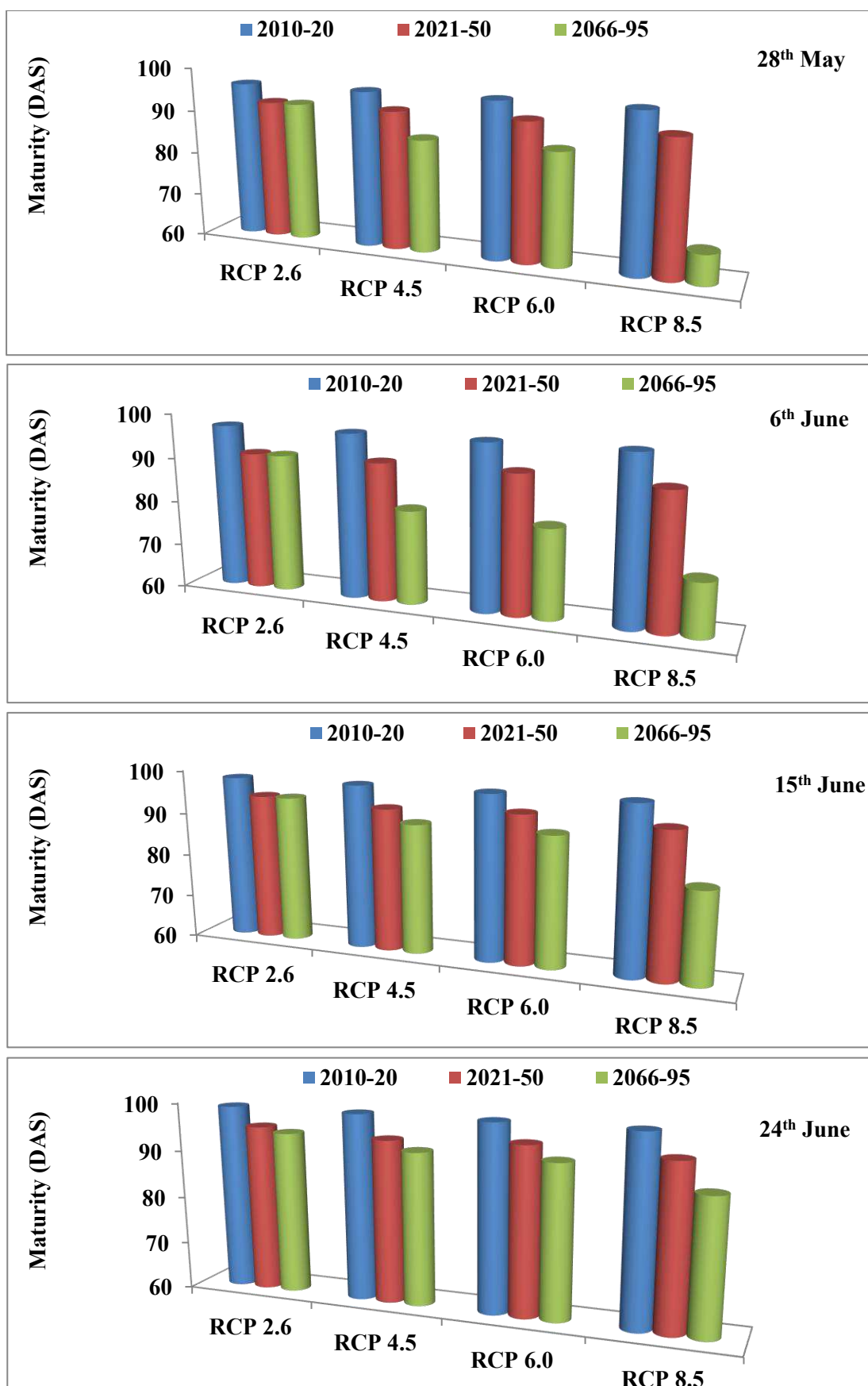


Fig. 4.40: Simulated changes in maturity (DAS) of PMH2 by Ensemble model at agroclimatic zone V (Abohar)

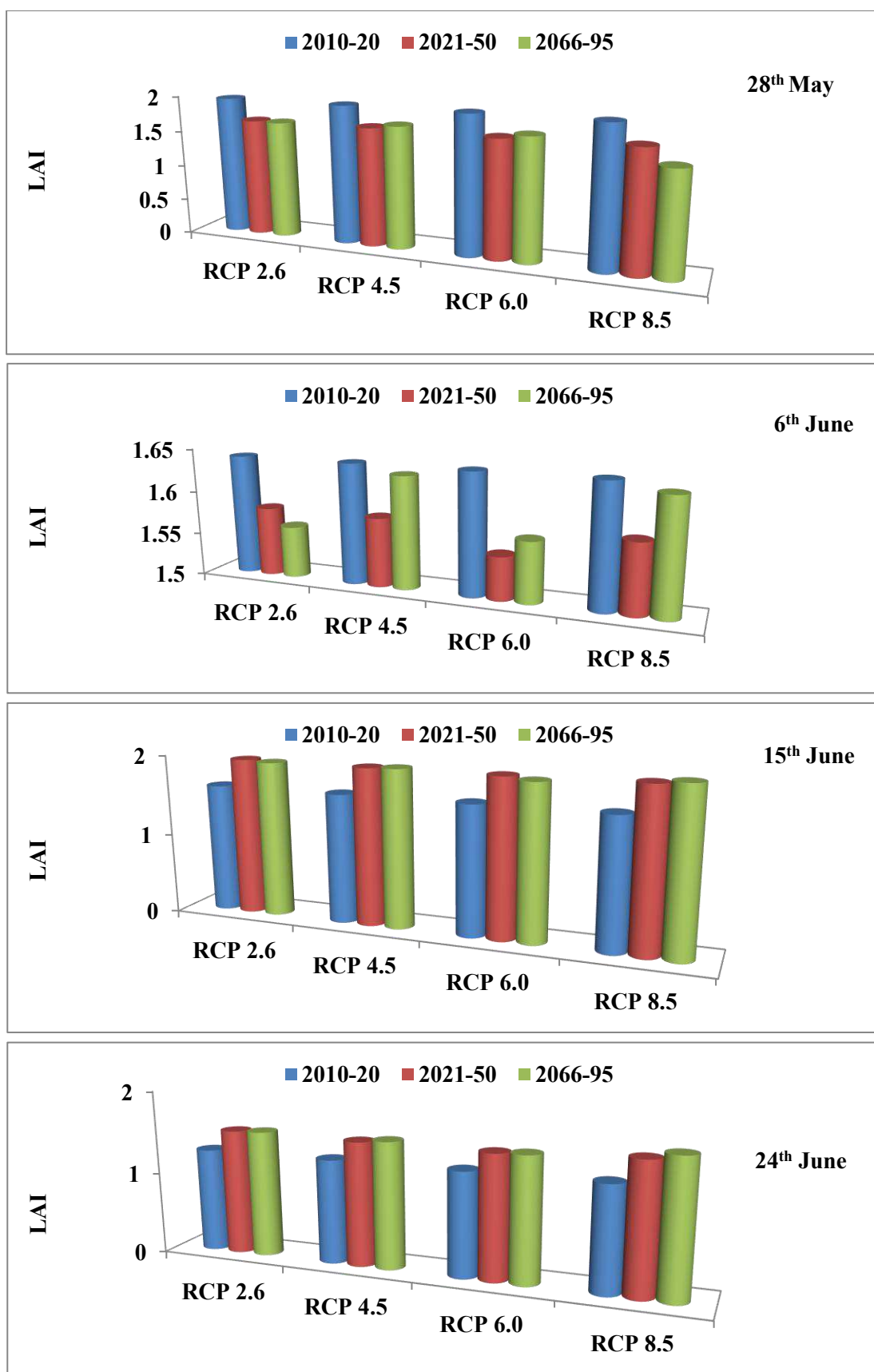


Fig. 4.41: Simulated changes in LAI of PMH2 by Ensemble model at agroclimatic zone V (Abohar)

Table 4.92: Simulation of changes in yield (kg ha⁻¹) of maize cultivars under different sowing dates as simulated by Ensemble model during 21st century at Faridkot, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5	Baseline period (2010-20)	RCP2.6	RCP4.5	RCP6.0	RCP8.5
		PMH 1					PMH 2				
28-May	Mid-century (2021-50)	6501.00	6678.3 (+2.7)*	6318.4 (-2.8)	6459.6 (-0.6)	6044.2 (-7.0)	6411.09	6656.3 (+3.8)	5959.4 (-7.0)	6498.3 (+1.4)	5607.7 (-12.5)
	End-century (2051-95)		6304.8 (-3.0)	4731.6 (-27.2)	4784.4 (-27.0)	1644.9 (-74.7)		6082.8 (-5.1)	4424.8 (-31.0)	4394.5 (-31.4)	1646.4 (-74.3)
06-June	Mid-century (2021-50)	6331.64	6897.0 (+8.9)	6551.5 (+3.5)	6966.2 (+10.0)	6238.4 (-1.5)	6290.73	6835.4 (+8.7)	6477.5 (+3.0)	7041.2 (+11.9)	6280.6 (-0.2)
	End-century (2051-95)		6737.3 (+6.4)	5208.7 (-17.7)	5040.7 (-20.4)	592.7 (-90.6)		6801.0 (+8.1)	5440.1 (-13.5)	5201.5 (-17.3)	1036.8 (-83.5)
15-June	Mid-century (2021-50)	6581.18	7326.3 (+11.3)	7299.6 (+10.9)	7405.7 (+12.5)	7096.4 (+7.8)	6337.09	7080.9 (+11.7)	6506.9 (+2.7)	7172.3 (+13.2)	6364.6 (+0.4)
	End-century (2051-95)		7580.7 (+15.2)	5406.9 (-17.8)	5488.9 (-16.6)	2320.7 (-64.7)		6851.8 (+8.1)	4878.7 (-23.0)	4894.6 (-22.8)	2200.7 (-65.3)
24-June	Mid-century (2021-50)	5690.00	4414.3 (-22.4)	4296.1 (-24.5)	4556.2 (-19.9)	4457.8 (-21.7)	5614.18	4735.5 (-15.7)	4743.9 (-15.5)	4822.8 (-14.1)	4921.2 (-12.3)
	End-century (2051-95)		4512.7 (-20.7)	3767.1 (-33.8)	3905.6 (-31.4)	2578.5 (-54.7)		4650.1 (-17.2)	5012.0 (-10.7)	5149.0 (-8.3)	3046.4 (-45.7)

*% deviation from baseline value

Table 4.93: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH1 under different sowing dates as simulated by Ensemble model during 21st century at Faridkot, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	60	59 (-1)*	59 (-1)	59 (-1)	58 (-2)	98	97 (-1)	96 (-2)	97 (-1)	95 (-3)	3.54	3.15	3.01	3.02	2.99
	End-century (2051-95)		59 (-1)	56 (-4)	56 (-4)	55 (-5)		96 (-2)	92 (-6)	92 (-6)	81 (-17)		3.04	2.77	2.77	2.45
06-June	Mid-century (2021-50)	60	58 (-2)	58 (-2)	58 (-2)	57 (-3)	98	95 (-3)	94 (-4)	95 (-3)	94 (-4)	3.34	3.78	3.78	3.78	3.72
	End-century (2051-95)		58 (-2)	57 (-3)	57 (-3)	56 (-4)		95 (-3)	93 (-5)	93 (-5)	72 (-26)		3.76	3.72	3.66	3.45
15-June	Mid-century (2021-50)	60	59 (-1)	59 (-1)	59 (-1)	58 (-2)	99	98 (-1)	97 (-2)	98 (-1)	96 (-3)	3.37	4.02	3.99	3.99	3.98
	End-century (2051-95)		59 (-1)	57 (-3)	57 (-3)	56 (-4)		98 (-1)	93 (-6)	93 (-6)	90 (-9)		4.00	4.00	3.99	4.03
24-June	Mid-century (2021-50)	60	60 (0)	59 (-1)	60 (0)	59 (-1)	100	99 (-1)	98 (-2)	99 (-1)	97 (-3)	2.51	3.01	2.98	3.00	2.97
	End-century (2051-95)		59 (-1)	58 (-2)	58 (-2)	56 (-4)		98 (-2)	96 (-4)	95 (-5)	91 (-9)		2.94	3.02	3.03	2.89

*Deviation from baseline in DAS

Table 4.94: Simulation of changes in anthesis (days), maturity (days) and Leaf area index of PMH2 under different sowing dates as simulated by Ensemble model during 21st century at Faridkot, Punjab

Date of sowing	Time period	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5	Baseline period (2010-20)	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
		Anthesis					Maturity					LAI				
28-May	Mid-century (2021-50)	56	55 (-1)*	55 (-1)	55 (-1)	55 (-1)	96	94 (-2)	94 (-2)	94 (-2)	92 (-3)	3.29	2.84	2.66	2.61	2.73
	End-century (2051-95)		55 (-1)	55 (-1)	55 (-1)	52 (-4)		94 (-2)	92 (-4)	92 (-4)	81 (-15)		2.76	2.60	2.57	2.06
06-June	Mid-century (2021-50)	56	56 (0)	55 (-1)	56 (0)	54 (-2)	96	95 (-1)	94 (-2)	95 (-1)	93 (-3)	3.01	3.32	3.30	3.33	3.22
	End-century (2051-95)		56 (0)	53 (-3)	53 (-3)	52 (-4)		95 (-1)	91 (-5)	90 (-6)	72 (-24)		3.30	3.19	3.15	2.92
15-June	Mid-century (2021-50)	56	56 (0)	56 (0)	56 (0)	55 (-1)	97	96 (-1)	95 (-2)	96 (-1)	94 (-3)	2.90	3.41	3.38	3.39	3.39
	End-century (2051-95)		56 (0)	55 (-1)	55 (-1)	52 (-4)		95 (-2)	93 (-4)	93 (-4)	88 (-9)		3.38	3.43	3.42	3.48
24-June	Mid-century (2021-50)	56	57 (1)	56 (0)	57 (1)	56 (0)	98	98 (0)	96 (-2)	98 (0)	96 (-2)	2.37	2.72	2.68	2.71	2.69
	End-century (2051-95)		57 (1)	55 (-1)	55 (-1)	53 (-3)		98 (0)	93 (-5)	93 (-5)	90 (-8)		2.69	2.73	2.74	2.79

*Deviation from baseline in DAS

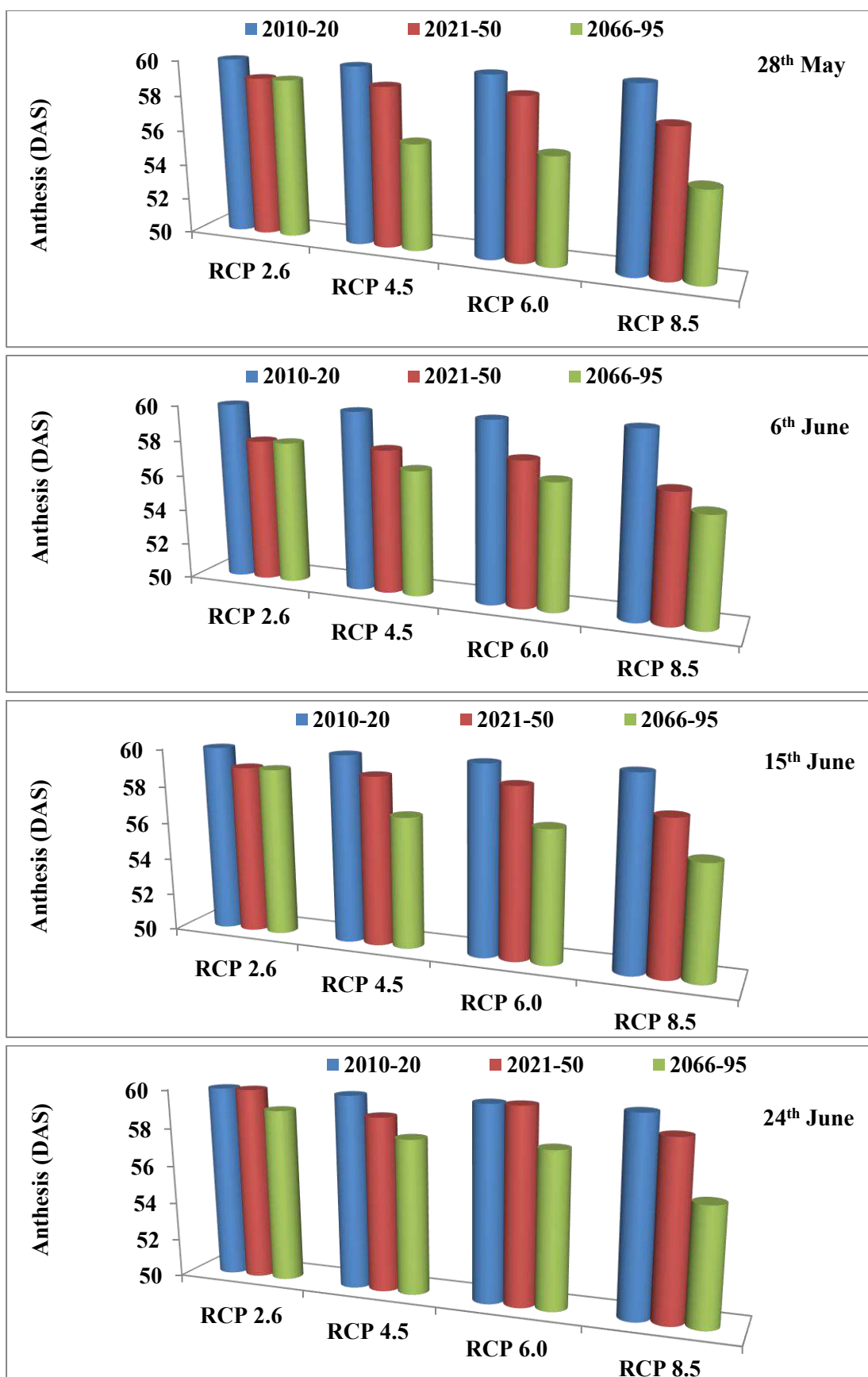


Fig. 4.42: Simulated changes in anthesis (DAS) of PMH1 by Ensemble model at agroclimatic zone V (Faridkot)

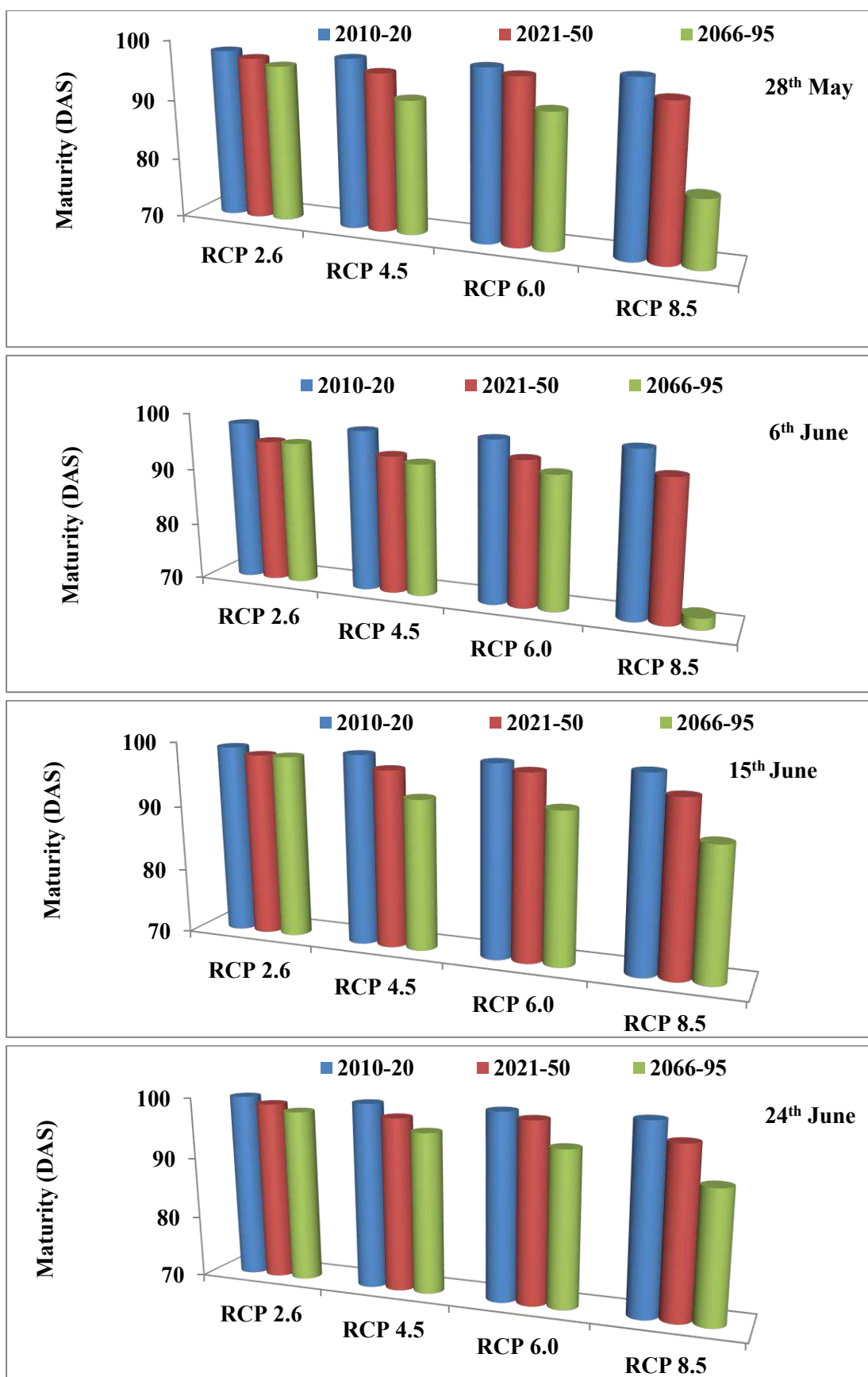


Fig. 4.43: Simulated changes in maturity (DAS) of PMH1 by Ensemble model at agroclimatic zone V (Faridkot)

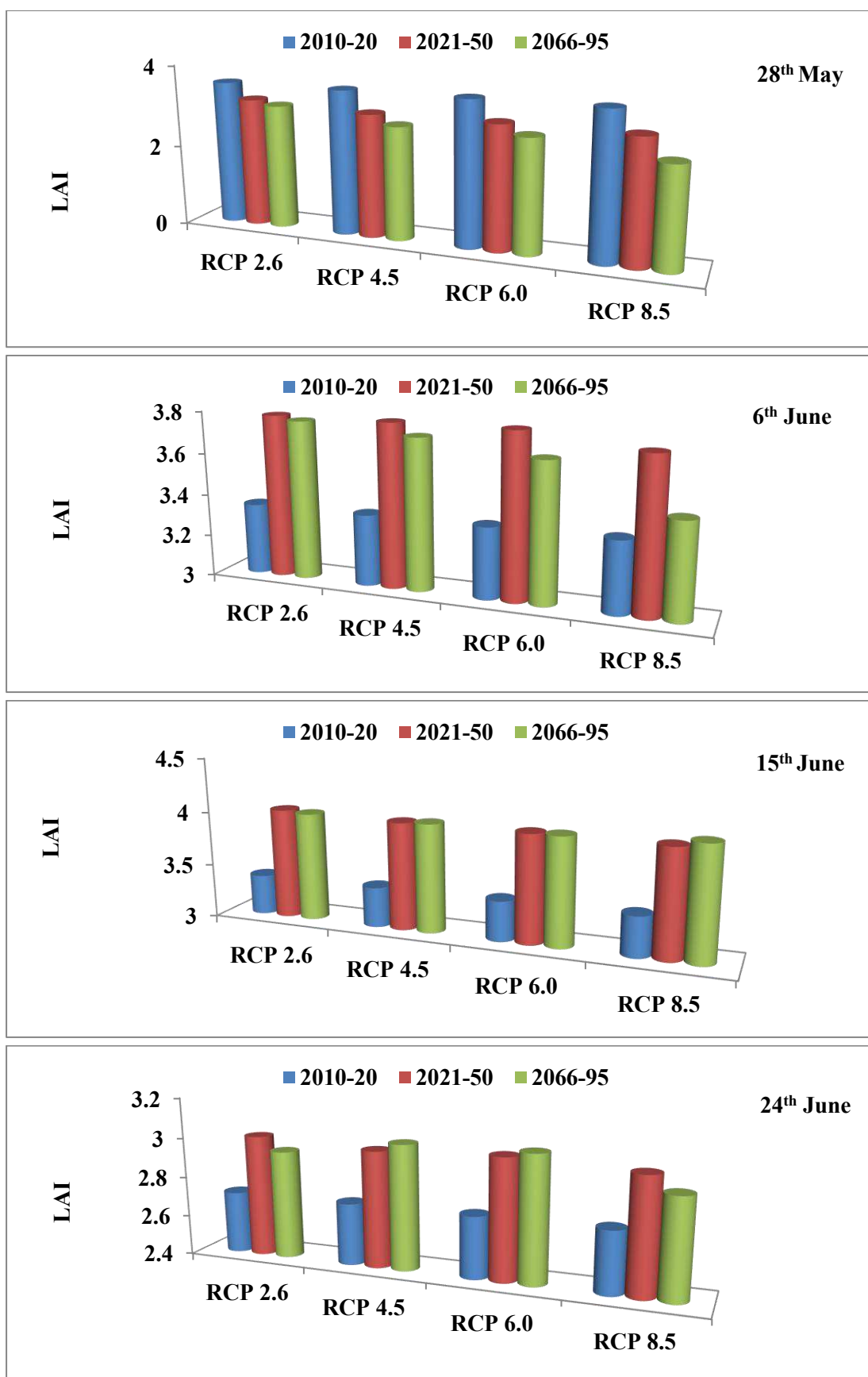


Fig. 4.44: Simulated changes in LAI of PMH1 by Ensemble model at agroclimatic zone V (Faridkot)

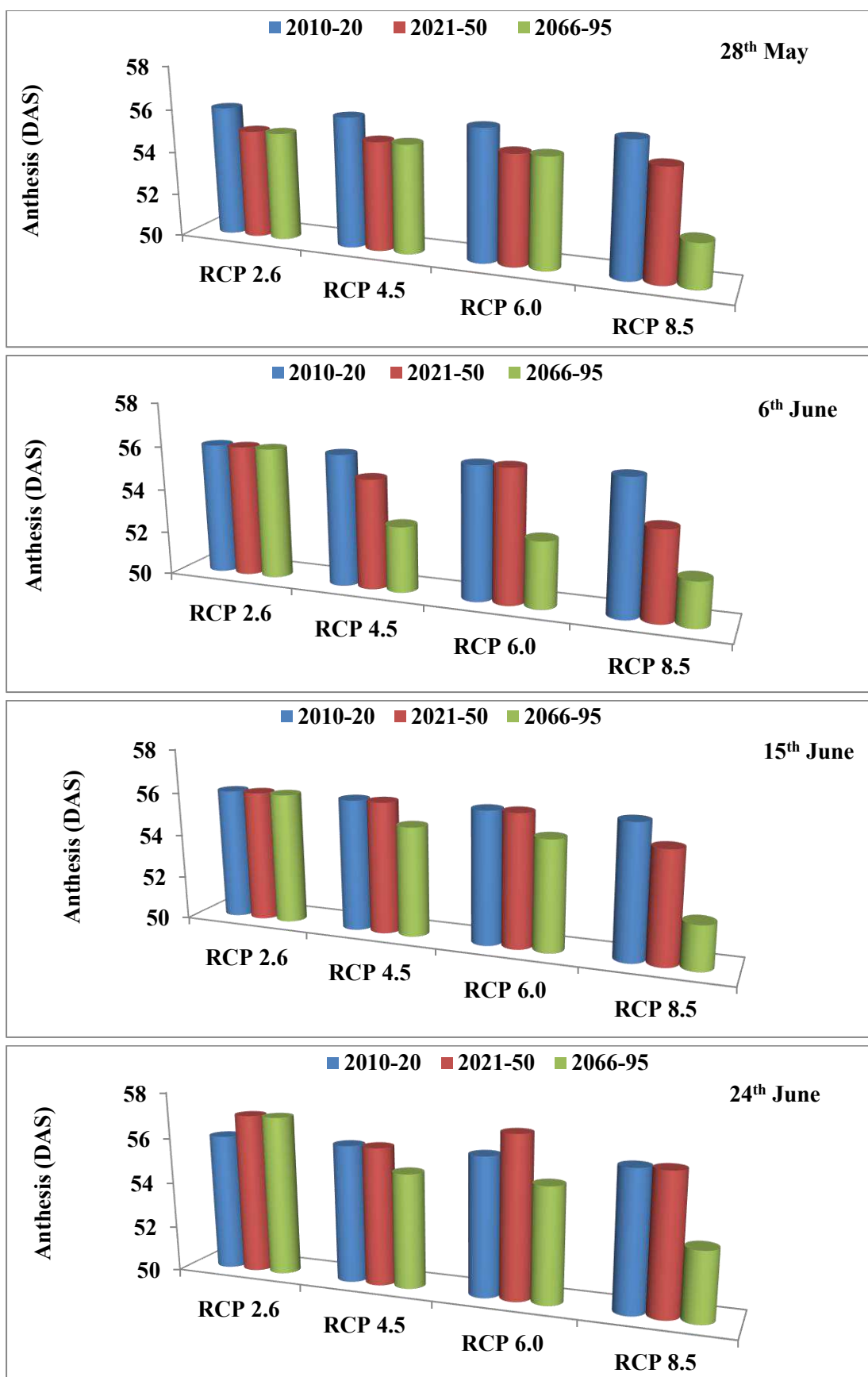


Fig. 4.45: Simulated changes in anthesis (DAS) of PMH2 by Ensemble model at agroclimatic zone V (Faridkot)

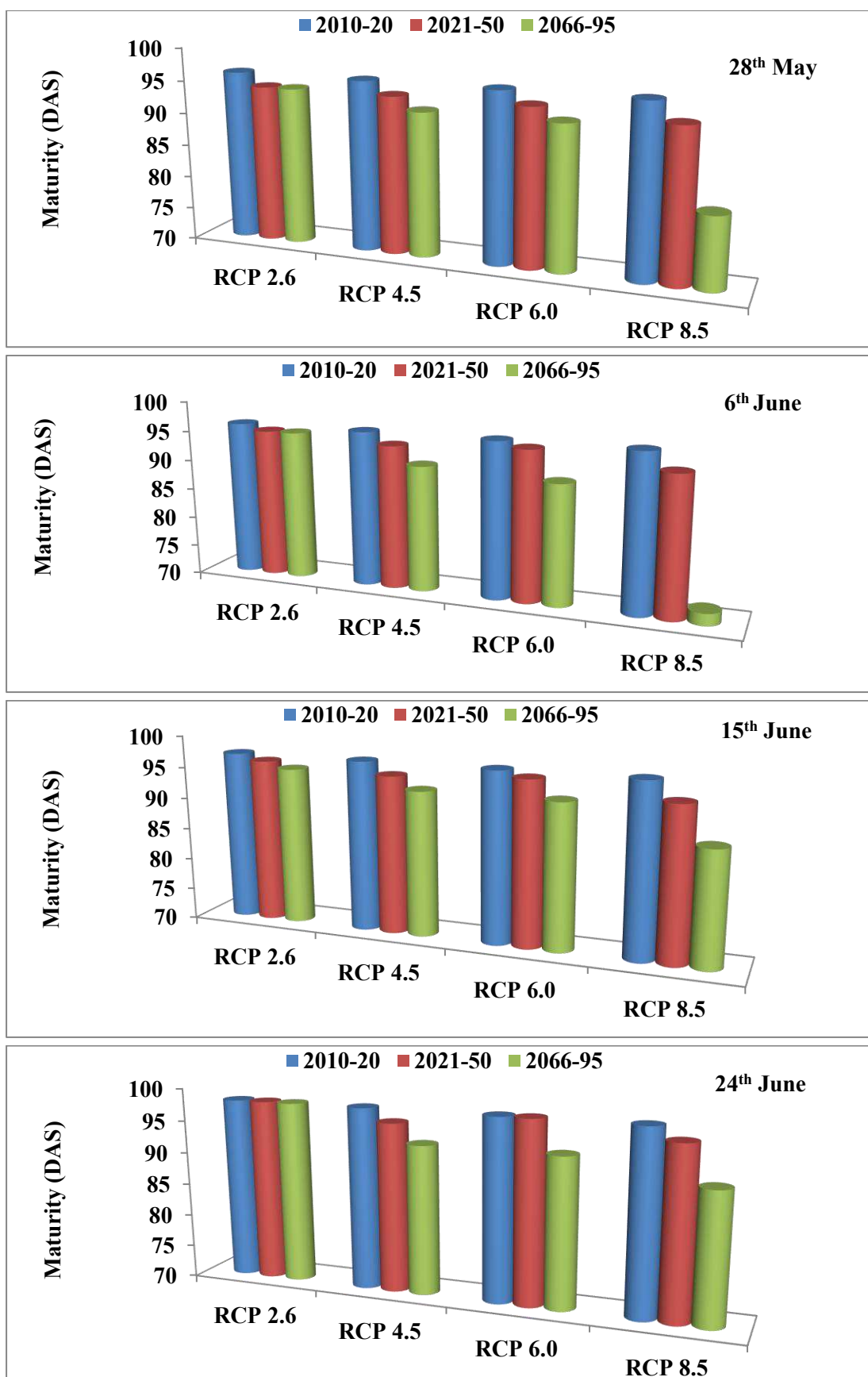


Fig.4.46: Simulated changes in maturity (DAS) of PMH2 by Ensemble model at agroclimatic zone V (Faridkot)

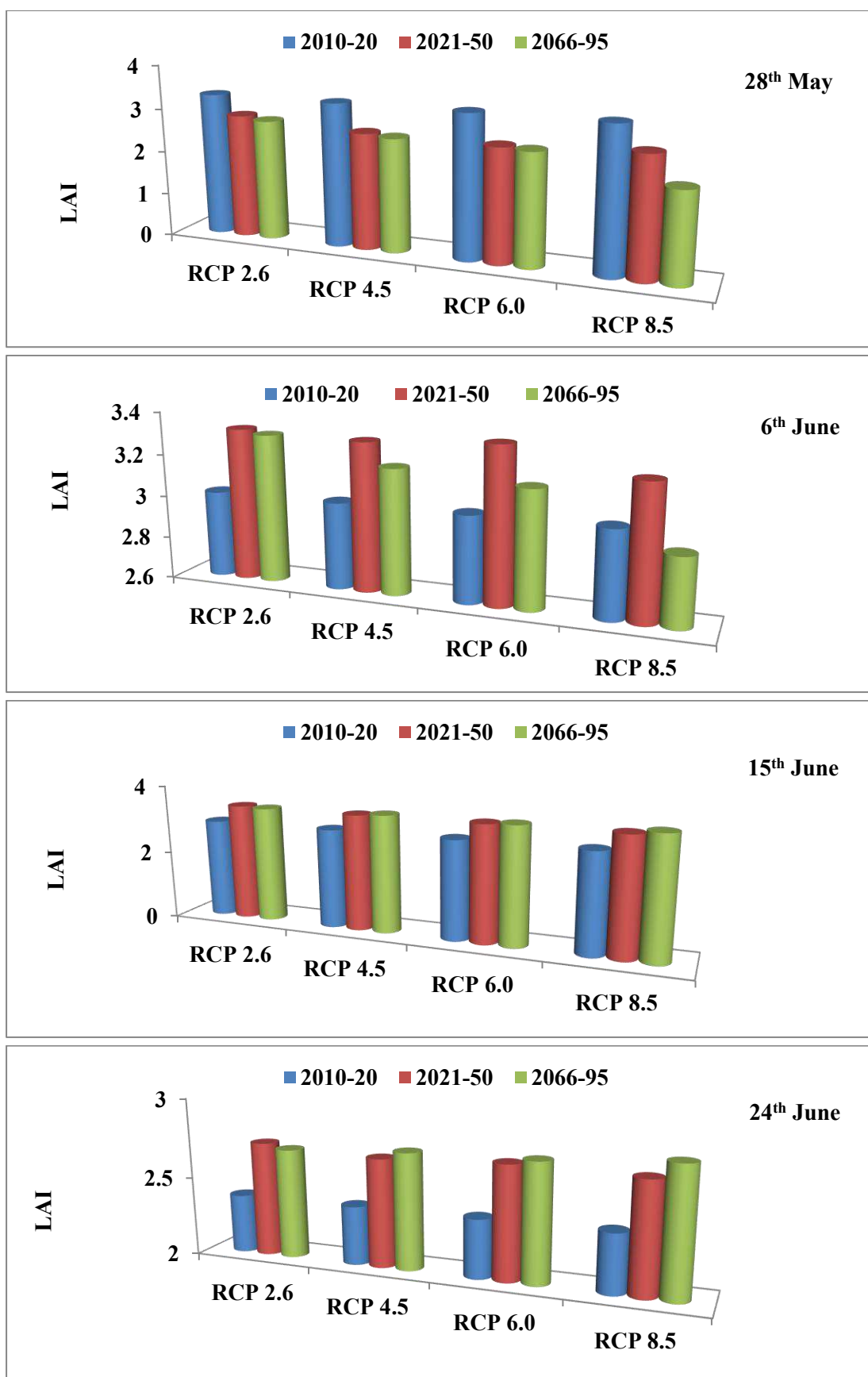


Fig. 4.47: Simulated changes in LAI of PMH2 by Ensemble model at agroclimatic zone V (Faridkot)

4.5 Optimization of sowing dates in maize cultivars under future projections

The sowing window of maize was optimized from 10th May to 14th July at 5 days interval and deviations were evaluated from the baseline yield simulated on 4th June for different zones of Punjab. The following results were obtained

Agroclimatic zone II (Ballowal Saunkhri)

The zone observed the yield to decline during early sowing of maize cultivar PMH1 while late sowing showed an increment in yield. The CSIRO-Mk-3-6-0 model (Table 4.95) projected yield increment on 19th and 24th June ranging by 1.1% to 18.6% during mid and end-century. The mid-century showed increment under all the four scenarios for the respective dates but end-century showed this increment only under RCP2.6. The FIO-ESM (Table 4.96) too projected yield increase from 9th to 14th July where increment during the mid-century varied 1.7% to 40.1% on 9th, 14th, 19th and 24th under all the four RCPs and during the end-century varied 10.7% to 38.7%, mostly under RCP2.6 and RCP4.5 on 9th, 14th, 19th, 24th, 29th June and 4th, 9th and 14th July. The IPSL-CM5A-MR (Table 4.97) projected the increase ranging 4.0% to 24.6% during the mid-century under all the four RCPs on 14th, 19th and 24th June and the end-century observed the increase ranging 0.9% to 6.8% under RCP2.6 on the same dates. The Ensemble model (Table 4.98) too depicted the significant increase on 14th and 19th June ranging 2.4% to 17.5% during the mid-century and 7.9% to 12.5% during the end-century on same dates. However none of the models depicted an increase in yield under RCP8.5 during the end-century.

The anthesis observed the shortening for PMH1 (Table 4.95, 4.96, 4.97 and 4.98) during the mid-century by 2-8 days as projected by the models during mid-century and 3-9 days during the end-century under all the four RCPs. The maturity days also were projected to shorten by 5-13 days during mid-century and 4-25 days during the end-century for all the four RCPs. The LAI for the future projections was higher for all the dates of sowing except the early 10th May to 25th May.

The zone for PMH2 observed similar results with small rise in yield at late dates of sowing. The CSIRO-Mk-3-6-0 (Table 4.99) model showed the increase only under RCP2.6 and RCP4.5 on 19th June (7.9% and 10.1 %) and 24th June (2.6% and 5.3%) during the mid-century. FIO-ESM model (Table 4.100) which overestimated the yield projected the yield to increase in the range 1.9% to 26.7% during the mid-century for all the dates from 25th May to 24th June under all the four RCPs. The end-century depicted the increase for end-century ranging 11.9% to 39.7% under RCP2.6 for the respective dates of sowing. The other RCPs did not show a significant increase in yield during the end-century.

Table 4.95: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ballowal Saunkhri, Punjab

DOS	Time period	BASELINE: Yield=4-June (4245.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (64 DAS)				BASELINE: Maturity=4-June (105 DAS)				BASELINE: LAI=4-June (2.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	2564.4 (-39.6)*	2584.0 (-39.1)	2909.1 (-31.5)	2623.0 (-38.2)	56 (-8)**	56 (-8)	57 (-7)	56 (-8)	92 (-13)**	93 (-12)	94 (-11)	92 (-13)	2.42	2.39	2.43	2.37
	EC	2125.4 (-49.9)	1156.4 (-72.8)	1332.7 (-68.6)	350.0 (-91.8)	56 (-8)	55 (-9)	55 (-9)	55 (-9)	91 (-14)	88 (-17)	90 (-15)	76 (-29)	2.39	2.25	2.28	1.48
15-May	MC	2798.5 (-34.1)	3094.6 (-27.1)	2827.8 (-33.4)	3232.2 (-23.9)	57 (-7)	57 (-7)	58 (-6)	56 (-8)	92 (-13)	93 (-12)	94 (-11)	93 (-12)	2.37	2.30	2.38	2.30
	EC	3068.1 (-27.7)	2345.9 (-44.7)	2497.9 (-41.2)	613.4 (-85.6)	56 (-8)	55 (-9)	55 (-9)	55 (-9)	91 (-14)	90 (-15)	90 (-14)	78 (-27)	2.32	2.05	2.09	1.29
20-May	MC	2436.8 (-42.6)	2498.5 (-41.1)	2789.0 (-34.3)	2441.7 (-42.5)	60 (-4)	60 (-4)	60 (-4)	59 (-5)	94 (-11)	96 (-9)	97 (-8)	95 (-10)	2.35	2.26	2.37	2.20
	EC	2059.5 (-51.5)	1469.3 (-65.4)	1579.1 (-62.8)	421.4 (-90.1)	60 (-4)	57 (-7)	57 (-7)	57 (-7)	93 (-12)	91 (-14)	91 (-14)	77 (-28)	2.09	2.23	2.14	1.72
25-May	MC	2637.4 (-37.9)	2579.8 (-39.2)	2888.4 (-32.0)	2452.1 (-42.2)	60 (-4)	60 (-4)	61 (-3)	59 (-5)	95 (-10)	96 (-9)	98 (-7)	96 (-9)	2.7	2.67	2.69	2.61
	EC	2116.5 (-50.1)	1283.3 (-69.8)	1390.7 (-67.2)	586.6 (-86.2)	59 (-5)	58 (-6)	58 (-6)	57 (-7)	94 (-11)	86 (-19)	88 (-17)	81 (-24)	2.5	2.69	2.62	2.17
30-May	MC	2565.6 (-39.6)	2549.5 (-40.0)	2753.4 (-35.1)	2423.6 (-42.9)	60 (-4)	60 (-4)	61 (-3)	60 (-4)	96 (-9)	96 (-9)	98 (-3)	96 (-4)	3.08	3.07	3.01	3.06
	EC	2210.4 (-47.9)	1031.5 (-75.7)	1260.2 (-70.3)	575.2 (-86.4)	59 (-5)	58 (-6)	58 (-6)	57 (-7)	95 (-10)	82 (-23)	85 (-20)	79 (-26)	3.06	3.11	3.08	2.60

DOS	Time period	BASELINE: Yield=4-June (4245.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (64 DAS)				BASELINE: Maturity=4-June (105 DAS)				BASELINE: LAI=4-June (2.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	3221.0 (-24.1)	3091.2 (-27.2)	3596.5 (-15.3)	2928.2 (-31.0)	60 (-4)	60 (-4)	61 (-3)	60 (-4)	95 (-10)	97 (-8)	98 (-7)	96 (-9)	3.30	3.32	3.27	3.32
	EC	2710.1 (-36.2)	2141.3 (-49.6)	1827.3 (-57.0)	325.8 (-92.3)	59 (-5)	58 (-6)	58 (-6)	57 (-7)	93 (-12)	93 (-12)	93 (-12)	76 (-29)	3.34	3.42	3.42	3.35
14-June	MC	5311.4 (+25.1)	5167.3 (+21.7)	5122.9 (+20.7)	4916.4 (+15.8)	60 (-4)	60 (-4)	61 (-3)	60 (-4)	97 (-8)	97 (-8)	99 (-6)	97 (-8)	3.46	3.49	3.43	3.49
	EC	5435.1 (+28.0)	1936.4 (-54.4)	2089.6 (-50.8)	342.2 (-91.9)	59 (-5)	58 (-6)	58 (-6)	57 (-7)	95 (-10)	93 (-12)	93 (-12)	77 (-28)	3.53	3.59	3.58	3.59
19-June	MC	5062.7 (+19.2)	4736.1 (+11.5)	5034.6 (+18.6)	4512.9 (+6.3)	59 (-5)	59 (-5)	59 (-5)	59 (-5)	94 (-11)	97 (-8)	98 (-7)	96 (-9)	3.59	3.63	3.59	3.63
	EC	4470.5 (+5.3)	3123.0 (-26.4)	3169.6 (-25.3)	1891.9 (-55.4)	59 (-5)	56 (-8)	56 (-8)	58 (-6)	94 (-11)	91 (-14)	92 (-13)	87 (-18)	3.64	3.75	3.73	2.77
24-June	MC	4279.4 (+0.8)	3951.8 (-6.9)	4293.3 (+1.1)	3822.4 (-10.0)	58 (-6)	59 (-5)	59 (-5)	58 (-6)	95 (-10)	97 (-8)	97 (-8)	96 (-9)	3.40	3.45	3.47	3.45
	EC	3854.3 (-9.2)	2585.4 (-39.1)	2661.1 (-37.3)	1043.4 (-75.4)	58 (-6)	57 (-7)	57 (-7)	55 (-9)	94 (-11)	92 (-13)	93 (-12)	87 (-18)	3.41	3.74	3.71	3.78
29-June	MC	3599.1 (-15.2)	3246.5 (-23.5)	3733.1 (-12.1)	3141.0 (-10.0)	58 (-6)	58 (-6)	58 (-6)	58 (-6)	94 (-11)	96 (-9)	96 (-9)	96 (-9)	3.07	3.11	3.20	3.11
	EC	3217.5 (-24.2)	2131.0 (-49.8)	2114.2 (-50.2)	781.1 (-81.6)	58 (-6)	56 (-8)	57 (-7)	55 (-9)	93 (-12)	92 (-13)	92 (-13)	86 (-19)	3.03	3.55	3.52	3.74

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.96: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ballawal Saunkhri, Punjab

DOS	Time period	BASELINE: Yield= 4-June (4245.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (64 DAS)				BASELINE: Maturity=4-June (105 DAS)				BASELINE: LAI=4-June (2.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	2787.3 (-34.3)*	2080.8 (-51.0)	2904.0 (-31.6)	2963.0 (-30.2)	58 (-6)**	58 (-6)	58 (-6)	58 (-6)	95 (-10)**	95 (-10)	92 (-13)	92 (-13)	2.38	2.40	2.36	2.35
	EC	2121.3 (-50.0)	1551.8 (-63.4)	1491.1 (-64.9)	462.9 (-89.1)	59 (-5)	58 (-6)	57 (-7)	55 (-9)	96 (-9)	94 (-11)	91 (-14)	91 (-14)	2.39	2.35	2.31	1.98
15-May	MC	2999.2 (-29.4)	2558.8 (-39.7)	2860.0 (-32.6)	2562.8 (-39.6)	58 (-6)	58 (-6)	58 (-6)	58 (-6)	95 (-10)	95 (-10)	92 (-13)	92 (-13)	2.38	2.45	2.35	2.31
	EC	2350.9 (-44.6)	1921.2 (-54.8)	1929.2 (-54.6)	706.7 (-83.3)	58 (-6)	58 (-6)	58 (-6)	55 (-9)	95 (-10)	95 (-10)	91 (-14)	91 (-14)	2.41	2.37	2.29	1.88
20-May	MC	3246.8 (-23.5)	2819.0 (-33.6)	3197.6 (-24.7)	3291.6 (-22.5)	61 (-3)	61 (-3)	61 (-3)	60 (-4)	98 (-7)	98 (-7)	94 (-11)	94 (-11)	2.36	2.60	2.39	2.26
	EC	2752.7 (-35.2)	2572.8 (-39.4)	2379.8 (-44.0)	1032.7 (-75.7)	61 (-3)	60 (-4)	60 (-4)	57 (-7)	98 (-7)	97 (-8)	93 (-12)	93 (-12)	2.51	2.45	2.20	2.22
25-May	MC	3164.3 (-25.5)	2943.4 (-30.7)	3045.1 (-28.3)	3244.8 (-23.6)	62 (-2)	61 (-3)	62 (-2)	61 (-3)	99 (-6)	99 (-6)	95 (-10)	95 (-10)	2.72	2.93	2.72	2.65
	EC	3055.6 (-28.0)	2615.8 (-38.4)	2411.6 (-43.2)	1145.4 (-73.0)	61 (-3)	61 (-3)	60 (-4)	58 (-6)	99 (-6)	98 (-7)	94 (-11)	94 (-11)	2.83	2.90	2.69	2.68
30-May	MC	2933.2 (-30.9)	2942.3 (-30.7)	2921.5 (-31.2)	3282.5 (-22.7)	62 (-2)	62 (-2)	62 (-2)	60 (-4)	100 (-5)	100 (-5)	96 (-9)	96 (-9)	2.96	3.08	3.00	2.99
	EC	3072.5 (-27.6)	2565.7 (-39.6)	2144.3 (-49.5)	903.1 (-78.7)	62 (-2)	61 (-3)	59 (-5)	58 (-6)	100 (-5)	99 (-6)	95 (-10)	95 (-10)	2.98	3.06	3.02	2.93
09-June	MC	4316.5 (+1.7)	4406.5 (+3.8)	4364.2 (+2.8)	4658.4 (+9.7)	61 (-3)	61 (-3)	61 (-3)	60 (-4)	99 (-6)	99 (-6)	95 (-10)	95 (-10)	3.23	3.28	3.25	3.30
	EC	4960.0 (+16.8)	3245.7 (-23.6)	2410.8 (-43.2)	1704.0 (-59.9)	62 (-2)	60 (-4)	59 (-5)	58 (-6)	102 (-3)	97 (-8)	93 (-12)	93 (-12)	3.25	3.35	3.34	3.29
14-June	MC	5488.4 (+29.3)	5720.1 (+34.7)	5386.1 (+26.9)	5540.7 (+30.5)	62 (-2)	61 (-3)	62 (-2)	61 (-3)	101 (-4)	100 (-5)	97 (-8)	97 (-8)	3.39	3.44	3.41	3.45
	EC	5628.9 (+32.6)	4699.8 (+10.7)	3339.7 (-21.3)	2187.9 (-48.5)	61 (-3)	61 (-3)	60 (-4)	58 (-6)	101 (-4)	99 (-6)	95 (-10)	95 (-10)	3.40	3.46	3.49	3.54

DOS	Time period	BASELINE: Yield= 4-June (4245.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (64 DAS)				BASELINE: Maturity=4-June (105 DAS)				BASELINE: LAI=4-June (2.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
19-June	MC	5555.5 (+30.9)	5948.4 (+40.1)	5403.3 (+27.3)	5469.2 (+28.8)	60 (-4)	59 (-5)	60 (-4)	59 (-5)	99 (-6)	98 (-7)	94 (-11)	94 (-11)	3.58	3.61	3.61	3.63
	EC	5887.6 (+38.7)	4953.0 (+16.7)	3696.1 (-12.9)	2298.1 (-45.9)	59 (-5)	59 (-5)	59 (-5)	56 (-8)	100 (-5)	98 (-7)	94 (-11)	94 (-11)	3.58	3.65	3.67	3.69
24-June	MC	4691.5 (+10.5)	5085.5 (+19.8)	4640.4 (+9.3)	4512.6 (+6.3)	60 (-4)	59 (-5)	59 (-5)	59 (-5)	100 (-5)	99 9-6)	95 (-10)	95 (-10)	3.50	3.51	3.52	3.50
	EC	5286.3 (+24.5)	4203.3 (-1.0)	2960.0 (-30.3)	1806.2 (-57.5)	61 (-3)	59 (-5)	58 (-6)	56 (-8)	101 (-4)	98 (-7)	94 (-11)	94 (-11)	3.53	3.60	3.66	3.81
29-June	MC	3914.2 (-7.8)	4660.2 (+9.8)	4039.1 (-4.9)	3989.2 (-6.0)	59 (-5)	59 (-5)	59 (-5)	59 (-5)	97 (-8)	98 (-7)	98 (-7)	94 (-11)	3.49	3.35	3.39	3.41
	EC	4718.2 (+11.1)	3699.6 (-12.9)	2367.7 (-44.2)	1230.0 (-71.0)	60 (-4)	59 (-5)	58 (-6)	56 (-8)	99 (-6)	95 (-10)	91 (-14)	93 (-12)	3.49	3.54	3.58	3.77
4-July	MC	4097.1 (-3.5)	4266.0 (+0.5)	2448.4 (-42.3)	2878.9 (-32.2)	61 (-3)	60 (-4)	61 (-3)	61 (-3)	93 (-12)	100 (-5)	91 (-14)	95 (-10)	3.43	3.33	3.43	3.47
	EC	5164.7 (+21.7)	3283.0 (-22.7)	2475.6 (-41.7)	1824.5 (-57.0)	61 (-3)	59 (-5)	59 (-5)	56 (-8)	95 (-10)	96 (-9)	95 (-10)	92 (-13)	3.52	3.55	3.63	3.72
9-July	MC	3687.7 (-13.1)	3732.7 (-12.1)	3020.5 (-28.9)	3280.0 (-22.7)	61 (-3)	60 (-4)	61 (-3)	60 (-4)	102 (-3)	102 (-3)	102 (-3)	101 (-4)	3.44	3.28	3.45	3.58
	EC	5683.4 (+33.9)	2789.4 (-34.3)	2133.6 (-49.8)	1295.4 (-69.5)	62 (-2)	59 (-5)	59 (-5)	57 (-7)	104 (-1)	99 (-6)	98 (-7)	94 (-11)	3.62	3.73	3.73	3.83
14-July	MC	2970.7 (-30.0)	2709.6 (-36.2)	2515.1 (-40.8)	2280.8 (-46.3)	60 (-4)	60 (-4)	60 (-4)	61 (-3)	103 (-2)	102 (-3)	102 (-3)	102 (-3)	3.49	3.27	3.52	3.68
	EC	5031.5 (+18.5)	3043.2 (-28.3)	1711.9 (-59.7)	1038.6 (-75.5)	62 (-2)	59 (-5)	58 (-6)	57 (-7)	105 (0)	100 (-5)	99 (-6)	94 (-11)	3.61	29.05	3.76	3.82

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.97: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ballawal Saunkhri, Punjab

DOS	Time period	BASELINE: Yield= 4-June (4245.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (64 DAS)				BASELINE: Maturity=4-June (105 DAS)				BASELINE: LAI=4-June (2.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	2683.4 (-36.8)*	2336.4 (-45.0)	2579.8 (-39.2)	2616.4 (-23.3)	58 (-6)**	56 (-8)	57 (-7)	56 (-8)	95 (-10)**	93 (-12)	94 (-11)	92 (-13)	2.38	2.43	2.36	2.34
	EC	2480.9 (-41.6)	1809.6 (-57.4)	2061.8 (-51.4)	348.2 (-91.8)	56 (-8)	55 (-9)	55 (-9)	55 (-9)	93 (-12)	91 (-14)	91 (-14)	74 (-31)	2.41	2.38	2.35	1.63
15-May	MC	3196.5 (-24.7)	2808.2 (-33.9)	2843.5 (-33.0)	3255.3 (-23.3)	58 (-6)	57 (-7)	57 (-7)	56 (-8)	95 (-10)	93 (-12)	94 (-11)	92 (-13)	2.34	2.41	2.30	2.30
	EC	3016.0 (-29.0)	3479.8 (-18.0)	3247.1 (-23.5)	1677.7 (-60.5)	57 (-7)	55 (-9)	56 (-8)	55 (-9)	93 (-12)	91 (-14)	91 (-14)	89 (-16)	2.33	2.34	2.21	2.21
20-May	MC	3117.9 (-26.6)	2478.4 (-41.6)	2756.5 (-35.1)	2658.5 (-37.4)	61 (-3)	60 (-4)	61 (-3)	59 (-5)	98 (-7)	97 (-8)	98 (-7)	96 (-9)	2.40	2.46	2.36	2.19
	EC	2568.6 (-39.5)	2430.4 (-42.8)	2324.4 (-45.2)	1520.7 (-64.2)	60 (-4)	57 (-7)	58 (-6)	57 (-7)	97 (-8)	93 (-12)	93 (-12)	91 (-14)	2.33	2.12	2.05	1.73
25-May	MC	2992.1 (-29.5)	2599.8 (-38.8)	2771.8 (-34.71)	2673.5 (-37.0)	61 (-3)	60 (-4)	60 (-4)	59 (-5)	99 (-6)	97 (-8)	98 (-7)	96 (-9)	2.83	2.80	2.74	2.65
	EC	2847.8 (-32.9)	2375.5 (-44.0)	2168.6 (-48.9)	1431.0 (-66.3)	61 (-3)	58 (-6)	58 (-6)	57 (-7)	98 (-7)	94 (-11)	93 (-12)	86 (-19)	2.77	2.49	2.54	2.23
30-May	MC	2866.1 (-32.5)	2497.2 (-41.2)	2799.6 (-34.1)	2695.8 (-36.5)	62 (-2)	61 (-3)	61 (-3)	60 (-4)	100 (-5)	98 (-7)	98 (-7)	96 (-9)	3.05	3.04	3.00	3.10
	EC	2686.9 (-36.7)	2305.0 (-45.7)	2156.5 (-49.2)	1117.4 (-73.7)	61 (-3)	58 (-6)	59 (-5)	58 (-6)	99 (-6)	94 (-11)	94 (-11)	81 (-24)	3.06	3.00	3.07	2.69
09-June	MC	4059.5 (-4.4)	3169.1 (-25.3)	3824.1 (-9.9)	3168.9 (-25.4)	61 (-3)	60 (-4)	60 (-4)	60 (-4)	99 (-6)	96 (-9)	98 (-7)	97 (-8)	3.27	3.28	3.26	3.32
	EC	3470.9 (-18.2)	2193.7 (-48.3)	2183.1 (-48.6)	1467.5 (-65.4)	60 (-4)	59 (-5)	59 (-5)	58 (-6)	97 (-8)	95 (-10)	95 (-10)	92 (-13)	3.30	3.42	3.43	3.36

DOS	Time period	BASELINE: Yield= 4-June (4245.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (64 DAS)				BASELINE: Maturity=4-June (105 DAS)				BASELINE: LAI=4-June (2.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
14-June	MC	5238.1 (+23.4)	4640.5 (+9.3)	4795.0 (+12.9)	4916.0 (+15.8)	62 (-2)	61 (-3)	61 (-3)	60 (-4)	100 (-5)	98 (-7)	100 (-5)	97 (-8)	3.43	3.43	3.43	3.50
	EC	4524.3 (+6.6)	2947.9 (-30.6)	4285.5 (+0.9)	1241.4 (-70.8)	60 (-4)	59 (-5)	59 (-5)	58 (-6)	98 (-7)	95 (-10)	95 (-10)	92 (-13)	3.47	3.58	3.60	3.61
19-June	MC	5290.4 (+24.6)	4873.2 (+14.8)	4853.4 (+14.3)	4662.4 (+9.8)	60 (-4)	59 (-5)	59 (-5)	59 (-5)	98 (-7)	97 (-8)	98 (-7)	96 (-9)	3.60	3.60	3.61	3.64
	EC	4534.4 (+6.8)	3413.4 (-19.6)	3558.5 (-16.2)	1607.7 (-62.1)	59 (-5)	57 (-7)	57 (-7)	56 (-8)	97 (-8)	93 (-12)	93 (-12)	89 (-16)	3.65	3.73	3.73	3.69
24-June	MC	4414.1 (+4.0)	4118.1 (-3.0)	3936.5 (-7.3)	3950.9 (-6.9)	59 (-5)	59 (-5)	59 (-5)	59 (-5)	98 (-7)	97 (-8)	98 (-7)	96 (-9)	3.37	3.46	3.40	3.51
	EC	3712.2 (-12.6)	2808.3 (-33.9)	2741.2 (-35.4)	1510.3 (-64.4)	59 (-5)	59 (-5)	59 (-5)	56 (-8)	97 (-8)	95 (-10)	95 (-10)	88 (-17)	3.54	3.68	3.49	3.65
29-June	MC	3769.9 (-11.2)	3365.6 (-20.7)	3406.3 (-19.8)	3205.6 (-24.5)	59 (-5)	58 (-6)	59 (-5)	58 (-6)	97 (-8)	96 (-9)	97 (-8)	95 (-10)	3.19	3.21	3.19	3.24
	EC	3170.1 (-25.3)	2194.2 (-48.3)	2140.7 (-49.6)	1144.6 (-73.0)	59 (-5)	59 (-5)	59 (-5)	56 (-8)	96 (-9)	95 (-10)	94 (-11)	87 (-18)	3.33	3.33	3.07	3.41
4-July	MC	3638.6 (-14.3)	3056.1 (-28.0)	2498.7 (-41.1)	2689.8 (-36.6)	60 (-4)	58 (-6)	59 (-5)	58 (-6)	98 (-7)	96 (-9)	92 (-13)	93 (-12)	3.06	3.10	3.18	3.18
	EC	2216.2 (-47.8)	1833.8 (-56.8)	1842.5 (-56.6)	799.3 (-81.2)	59 (-5)	59 (-5)	59 (-5)	56 (-8)	90 (-15)	95 (-10)	94 (-11)	85 (-20)	3.33	3.11	2.77	3.10
9-July	MC	3177.3 (-25.2)	3078.9 (-27.5)	2315.1 (-45.5)	2348.8 (-44.7)	61 (-3)	59 (-5)	60 (-4)	58 (-6)	100 (-5)	98 (-7)	96 (-9)	93 (-12)	2.96	3.04	2.18	3.18
	EC	1794.4 (-25.2)	1520.4 (-64.2)	1788.6 (-57.9)	739.5 (-82.6)	59 (-5)	59 (-5)	58 (-6)	56 (-8)	88 (-17)	94 (-11)	95 (-10)	86 (-19)	3.33	3.09	2.77	3.01
14-July	MC	2502.4 (-41.1)	2486.5 (-41.4)	2293.1 (-46.0)	2194.4 (-48.3)	60 (-4)	59 (-5)	60 (-4)	59 (-5)	101 (-4)	100 (-5)	101 (-4)	99 (-6)	2.92	3.12	2.18	3.30
	EC	1849.2 (-56.4)	1421.1 (-66.5)	1721.8 (-59.4)	543.2 (-87.2)	60 (-4)	58 (-6)	58 (-6)	56 (-8)	101 (-4)	95 (-10)	95 (-10)	84 (-21)	3.39	3.19	2.65	3.15

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.98: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ballawal Saunkhri, Punjab

DOS	Time period	BASELINE: Yield= 4-June (4245.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (64 DAS)				BASELINE: Maturity=4-June (105 DAS)				BASELINE: LAI=4-June (2.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	3219.9 (-24.2)*	2973.7 (-30.0)	3057.0 (-28.0)	2616.4 (-38.4)	58 (-6)**	56 (-8)	58 (-6)	56 (-8)	95 (-10)**	93 (-12)	95 (-10)	92 (-13)	2.38	2.42	2.38	2.34
	EC	2950.6 (-30.5)	2767.4 (-34.8)	2577.6 (-39.3)	348.2 (-91.8)	58 (-6)	56 (-8)	55 (-9)	55 (-9)	96 (-9)	91 (-14)	91 (-14)	74 (-31)	2.39	2.32	2.31	1.63
15-May	MC	3263.3 (-23.1)	3273.6 (-22.9)	3354.9 (-21.0)	3255.3 (-23.3)	58 (-6)	58 (-6)	58 (-6)	56 (-8)	95 (-10)	95 (-10)	95 (-10)	92 (-13)	2.36	2.34	2.32	2.30
	EC	3025.9 (-28.7)	3557.9 (-16.2)	3507.6 (-17.4)	1677.7 (-60.5)	58 (-6)	56 (-8)	56 (-8)	55 (-9)	95 (-10)	91 (-14)	91 (-14)	89 (-16)	2.35	2.10	2.14	2.21
20-May	MC	2867.6 (-32.5)	2766.2 (-34.8)	2986.6 (-29.7)	2658.5 (-37.4)	61 (-3)	60 (-4)	60 (-4)	59 (-5)	98 (-7)	97 (-8)	98 (-7)	96 (-9)	2.36	2.25	2.28	2.19
	EC	2713.8 (-36.1)	2481.3 (-41.6)	2444.2 (-42.4)	1520.7 (-64.2)	61 (-3)	58 (-6)	58 (-6)	57 (-7)	98 (-7)	94 (-11)	94 (-11)	91 (-14)	2.37	2.04	2.05	1.73
25-May	MC	2812.5 (-33.8)	2863.3 (-32.5)	3072.5 (-27.6)	2673.5 (-37.0)	62 (-2)	61 (-3)	61 (-3)	59 (-5)	99 (-6)	98 (-7)	99 (-6)	96 (-9)	2.87	2.78	2.71	2.65
	EC	2677.3 (-36.9)	2297.2 (-45.9)	2295.8 (-45.9)	1431.0 (-66.3)	61 (-3)	59 (-5)	59 (-5)	57 (-7)	99 (-6)	94 (-11)	94 (11)	86 (-19)	2.87	2.72	2.62	2.23
30-May	MC	2897.8 (-31.75)	2856.9 (-32.7)	2992.1 (-29.5)	2695.8 (-36.5)	61 (-3)	61 (-3)	62 (-2)	60 (-4)	99 (-6)	98 (-7)	99 (-6)	96 (-9)	3.08	3.10	3.03	3.10
	EC	2833.9 (-33.2)	2381.8 (-43.9)	2274.9 (-46.4)	1117.4 (-73.7)	60 (-4)	59 (-5)	59 (-5)	58 (-6)	97 (-8)	95 (-10)	95 (-10)	81 (-24)	3.05	3.19	3.13	2.69

DOS	Time period	BASELINE: Yield= 4-June (4245.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (64 DAS)				BASELINE: Maturity=4-June (105 DAS)				BASELINE: LAI=4-June (2.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	4290.7 (+1.1)	3829.9 (-9.8)	4124.1 (-2.9)	3168.9 (-25.4)	61 (-3)	61 (-3)	61 (-3)	60 (-4)	99 (-6)	98 (-7)	99 (-6)	97 (-8)	3.27	3.29	3.27	3.32
	EC	4000.3 (-5.8)	2918.3 (-31.3)	2603.1 (-38.7)	1467.5 (-65.4)	61 (-3)	60 (-4)	60 (-4)	58 (-6)	98 (-7)	96 (-9)	96 (-9)	92 (-13)	3.25	3.35	3.35	3.36
14-June	MC	4889.3 (+15.2)	4603.3 (+8.4)	4988.1 (+17.5)	4916.0 (+15.8)	62 (-2)	61 (-3)	62 (-2)	60 (-4)	100 (-5)	99 (-6)	100 (-5)	97 (-8)	3.44	3.47	3.43	3.50
	EC	4777.9 (+12.5)	3816.0 (-10.1)	4581.1 (+7.9)	1241.4 (-70.8)	61 (-3)	59 (-5)	59 (-5)	58 (-6)	100 (-5)	96 (-9)	95 (-10)	92 (-13)	3.42	3.55	3.54	3.61
19-June	MC	4660.1 (+9.8)	4346.3 (+2.4)	4732.2 (+11.5)	4662.4 (+9.8)	60 (-4)	60 (-4)	60 (-4)	59 (-5)	98 (-7)	98 (-7)	98 (-7)	96 (-9)	3.61	3.64	3.62	3.64
	EC	4676.1 (+10.1)	4239.3 (-0.1)	4219.7 (-0.6)	1607.7 (-62.1)	59 (-5)	59 (-5)	59 (-5)	56 (-8)	98 (-7)	96 (-9)	95 (-10)	89 (-16)	3.57	3.66	3.67	3.69
24-June	MC	3700.6 (-12.8)	3390.7 (-20.1)	3801.3 (-10.5)	3950.9 (-6.9)	59 (-5)	59 (-5)	59 (-5)	59 (-5)	98 (-7)	98 (-7)	98 (-7)	96 (-9)	3.37	3.41	3.47	3.51
	EC	3746.7 (-11.8)	3447.7 (-18.8)	3459.6 (-18.5)	1510.3 (-64.4)	58 (-6)	59 (-5)	59 (-5)	56 (-8)	98 (-7)	96 (-9)	95 (-10)	88 (-17)	3.36	3.31	3.40	3.65
29-June	MC	2994.0 (-29.5)	2820.8 (-33.6)	3073.6 (-27.6)	3205.6 (-24.5)	59 (-5)	59 (-5)	59 (-5)	58 (-6)	98 (-7)	98 (-7)	97 (-8)	95 (-10)	3.22	3.24	3.28	3.24
	EC	3264.2 (-23.1)	2790.8 (-34.3)	2766.3 (-34.8)	1144.6 (-73.0)	59 (-5)	58 (-6)	58 (-6)	56 (-8)	98 (-7)	98 (-7)	95 (-10)	87 (-18)	3.17	2.87	3.01	3.41

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.99: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ballawal Saunkhri, Punjab

DOS	Time period	BASELINE: Yield =4-June (5584.2 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (102 DAS)				BASELINE: LAI=4-June (3.81)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	3817.7 (-31.6)*	2857.8 (-48.8)	3053.4 (-45.3)	2619.1 (-53.1)	54 (-6)**	54 (-6)	54 (-6)	54 (-6)	92 (-10)**	92 (-10)	93 (-9)	92 (-10)	3.21	3.10	3.47	3.05
	EC	2922.8 (-47.7)	871.2 (-84.4)	1170.2 (-79.0)	257.6 (-95.4)	54 (-6)	52 (-8)	52 (-8)	51 (-9)	91 (-11)	86 (-16)	88 (-14)	73 (-29)	3.00	2.29	2.32	1.29
15-May	MC	5473.1 (-2.0)	5161.8 (-7.6)	5178.1 (-7.3)	4990.1 (-10.6)	54 (-6)	54 (-6)	54 (-6)	54 (-6)	92 (-10)	92 (-10)	93 (-9)	92 (-10)	2.82	2.71	3.10	2.76
	EC	4693.8 (-15.9)	2013.2 (-64.0)	2406.5 (-56.9)	438.8 (-92.1)	54 (-6)	52 (-8)	52 (-8)	51 (-9)	91 (-11)	88 (-14)	89 (-13)	73 (-29)	2.60	2.14	2.15	1.18
20-May	MC	4687.4 (-16.1)	4715.1 (-15.6)	4551.0 (-18.5)	4475.5 (-19.9)	56 (-4)	56 (-4)	56 (-4)	56 (-4)	94 (-8)	94 (-8)	95 (-7)	94 (-8)	2.66	2.46	2.62	2.44
	EC	4092.7 (-26.7)	2269.8 (-59.3)	2497.6 (-55.3)	688.4 (-87.7)	56 (-4)	55 (-5)	55 (-5)	53 (-7)	93 (-9)	90 (-12)	91 (-11)	77 (-25)	2.34	2.29	2.19	1.44
25-May	MC	5008.5 (-10.3)	5163.0 (-7.5)	6008.4 (+7.6)	4985.4 (-10.7)	57 (-3)	57 (-3)	57 (-3)	57 (-3)	95 (-7)	95 (-7)	96 (-6)	95 (-7)	3.28	3.06	2.92	3.02
	EC	4146.8 (-25.7)	2447.9 (-56.2)	2594.4 (-53.5)	496.4 (-91.1)	57 (-3)	55 (-5)	55 (-5)	53 (-7)	94 (-8)	86 (-16)	88 (-14)	72 (-30)	3.01	2.92	2.80	1.84
30-May	MC	4595.7 (-17.7)	4799.6 (-14.0)	5209.4 (-6.7)	4559.8 (-18.3)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	96 (-6)	96 (-6)	97 (-5)	96 (-6)	3.90	3.68	3.63	3.68
	EC	3988.6 (-28.6)	2377.1 (-57.4)	2651.7 (-52.5)	837.9 (-85.0)	57 (-3)	54 (-6)	55 (-5)	53 (-7)	95 (-7)	82 (-20)	85 (-17)	79 (-23)	3.73	3.38	3.31	2.30

DOS	Time period	BASELINE: Yield =4-June (5584.2 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (102 DAS)				BASELINE: LAI=4-June (3.81)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	4900.4 (-12.2)	4383.7 (-21.5)	4790.6 (-14.2)	4308.4 (-22.9)	56 (-4)	56 (-4)	57 (-3)	56 (-4)	95 (-7)	95 (-7)	96 (-6)	94 (-8)	4.64	4.56	4.66	4.56
	EC	4783.9 (-14.3)	596.2 (-89.3)	1368.6 (-75.5)	289.1 (-94.8)	55 (-5)	54 (-6)	55 (-5)	54 (-6)	93 (-9)	72 (-30)	78 (-24)	69 (-33)	4.51	4.38	4.35	3.73
14-June	MC	5421.2 (-2.9)	4818.7 (-13.7)	5272.1 (-5.6)	4527.4 (-18.9)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	97 (-5)	96 (-6)	97 (-5)	96 (-6)	5.00	4.95	4.97	4.95
	EC	4430.7 (-20.7)	2635.5 (-52.8)	2637.7 (-52.8)	385.7 (-93.1)	57 (-3)	54 (-6)	55 (-5)	54 (-6)	95 (-7)	91 (-11)	92 (-10)	72 (-30)	4.99	4.66	4.68	4.26
19-June	MC	6025.6 (+7.9)	5580.4 (-0.1)	6148.7 (+10.1)	5292.1 (-5.2)	56 (-4)	55 (-5)	56 (-4)	55 (-5)	94 (-8)	94 (-8)	95 (-7)	94 (-8)	5.06	5.04	5.04	5.05
	EC	5293.5 (-5.2)	2890.8 (-48.2)	3015.4 (-46.0)	1080.6 (-80.7)	55 (-5)	55 (-5)	55 (-5)	54 (-6)	94 (-8)	91 (-11)	91 (-11)	88 (-14)	5.06	4.83	4.88	4.53
24-June	MC	5728.0 (+2.6)	5459.8 (-2.2)	5882.8 (+5.3)	5289.8 (-5.3)	55 (-5)	55 (-5)	56 (-4)	55 (-5)	95 (-7)	95 (-7)	96 (-6)	94 (-8)	4.92	4.96	5.02	4.96
	EC	5254.7 (-5.9)	3638.7 (-34.8)	3720.0 (-33.4)	1381.1 (-75.27)	55 (-5)	54 (-6)	54 (-6)	52 (-8)	94 (-8)	91 (-11)	91 (-11)	86 (-16)	4.85	4.86	4.90	4.52
29-June	MC	4494.3 (-19.5)	4238.4 (-24.1)	4914.9 (-12.0)	4174.2 (-25.2)	54 (-6)	54 (-6)	54 (-6)	54 (-6)	94 (-8)	94 (-8)	95 (-7)	93 (-9)	4.51	4.70	4.79	4.70
	EC	3815.0 (-31.7)	3279.4 (-41.3)	3274.8 (-41.4)	1206.2 (-78.4)	54 (-6)	54 (-6)	54 (-6)	51 (-9)	93 (-9)	91 (-11)	91 (-11)	85 (-17)	4.49	4.76	4.83	4.53

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.100: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ballawal Saunkhri, Punjab

DOS	Time period	BASELINE: Yield = 4-June (5584.2 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (102 DAS)				BASELINE: LAI=4-June (3.81)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	3856.5 (-30.9)*	3510.6 (-37.1)	3731.1 (-33.2)	3528.9 (-36.8)	54 (-6)**	54 (-6)	54 (-6)	54 (-6)	93 (-9)**	93 (-9)	93 (-9)	92 (-10)	3.42	3.25	3.04	3.16
	EC	3577.7 (-35.9)	2846.9 (-49.0)	2259.7 (-59.5)	469.1 (-91.6)	54 (-6)	54 (-6)	54 (-6)	52 (-8)	93 (-9)	92 (-10)	91 (-11)	77 (-25)	3.47	2.93	2.83	1.88
15-May	MC	5119.2 (-8.3)	4878.8 (-12.6)	4992.9 (-10.6)	4439.1 (-20.5)	54 (-6)	54 (-6)	54 (-6)	54 (-6)	93 (-9)	93 (-9)	93 (-9)	93 (-9)	3.11	3.05	2.85	2.73
	EC	4494.0 (-19.5)	2935.5 (-47.4)	2356.0 (-57.8)	579.1 (-89.6)	54 (-6)	54 (-6)	54 (-6)	52 (-8)	93 (-9)	92 (-10)	91 (-11)	86 (-16)	3.26	2.82	2.67	1.81
20-May	MC	5407.8 (-3.2)	4726.4 (-15.4)	5267.9 (-5.7)	4969.0 (-11.02)	57 (-3)	57 (-3)	57 (-3)	56 (-4)	96 (-6)	95 (-7)	96 (-6)	95 (-7)	2.58	2.93	2.59	2.42
	EC	4433.6 (-20.6)	3696.0 (-33.8)	2824.9 (-49.4)	942.0 (-83.1)	57 (-3)	57 (-3)	56 (-4)	55 (-5)	96 (-6)	95 (-7)	94 (-8)	87 (-15)	2.93	2.75	2.50	2.14
25-May	MC	6895.7 (+23.5)	6091.3 (+9.1)	6730.5 (+20.5)	6857.3 (+22.8)	57 (-3)	57 (-3)	57 (-3)	57 (-3)	97 (-5)	96 (-6)	97 (-5)	96 (-6)	2.97	3.57	3.03	2.83
	EC	6041.2 (+8.2)	5178.7 (-7.3)	4457.1 (-20.2)	1454.1 (-74.0)	57 (-3)	57 (-3)	57 (-3)	55 (-5)	97 (-5)	96 (-6)	94 (-8)	83 (-19)	3.36	3.45	2.98	2.41
30-May	MC	5917.7 (+6.0)	5689.4 (+1.9)	5726.1 (+2.5)	6555.7 (+17.4)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	98 (-4)	97 (-5)	97 (-5)	97 (-5)	3.51	3.95	3.59	3.49
	EC	5655.4 (+1.3)	4700.4 (-15.8)	4340.0 (-22.3)	1608.0 (-71.2)	58 (-2)	58 (-2)	57 (-3)	55 (-5)	98 (-4)	96 (-6)	95 (-7)	82 (-20)	3.93	4.07	3.46	2.79
09-June	MC	5008.4 (-10.3)	5364.4 (-3.9)	4833.6 (-13.4)	5362.0 (-4.0)	58 (-2)	58 (-2)	58 (-2)	57 (-3)	99 (-3)	98 (-4)	98 (-4)	97 (-5)	4.59	4.73	4.67	4.55
	EC	4895.4 (-12.3)	3977.2 (-28.8)	3725.4 (-33.3)	841.6 (-84.9)	58 (-2)	58 (-2)	56 (-4)	54 (-6)	99 (-3)	97 (-5)	94 (-8)	74 (-28)	4.69	4.55	4.30	3.78

DOS	Time period	BASELINE: Yield = 4-June (5584.2 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (102 DAS)				BASELINE: LAI=4-June (3.81)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
14-June	MC	5776.0 (+3.4)	6371.3 (+14.1)	5774.3 (+3.4)	6223.4 (+11.4)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	98 (-4)	98 (-4)	98 (-4)	98 (-4)	4.88	4.94	4.91	4.88
	EC	6525.7 (+16.9)	4848.3 (-13.2)	3769.2 (-32.5)	1988.3 (-64.4)	57 (-3)	57 (-3)	57 (-3)	55 (-5)	99 (-3)	97 (-5)	96 (-6)	92 (-10)	4.85	4.88	4.76	4.26
19-June	MC	6947.7 (+24.4)	7350.7 (+31.6)	6815.1 (+22.0)	7073.5 (+26.7)	56 (-4)	56 (-4)	56 (-4)	56 (-4)	96 (-4)	96 (-6)	96 (-6)	96 (-6)	4.99	5.01	5.01	4.97
	EC	7804.5 (+39.7)	6251.1 (+11.9)	4609.9 (-17.4)	2710.3 (-51.5)	55 (-5)	55 (-5)	55 (-5)	54 (-6)	97 (-5)	95 (-7)	94 (-8)	91 (-11)	4.97	4.95	4.90	4.53
24-June	MC	5931.5 (+6.2)	6835.5 (+22.4)	5960.8 (+6.7)	6340.7 (+13.5)	57 (-3)	56 (-4)	57 (-3)	56 (-4)	99 (-3)	97 (-5)	98 (-4)	97 (-5)	5.09	5.03	5.08	5.03
	EC	7443.2 (+33.3)	6462.2 (+15.7)	4883.2 (-12.6)	2709.1 (-51.5)	57 (-3)	55 (-5)	55 (-5)	54 (-6)	99 (-3)	95 (-7)	94 (-8)	92 (-10)	5.05	4.97	4.94	4.71
29-June	MC	5252.1 (-6.0)	6016.2 (+7.7)	5407.6 (-3.2)	5540.4 (-0.8)	57 (-3)	55 (-5)	56 (-4)	55 (-5)	98 (-4)	96 (-6)	97 (-5)	97 (-5)	4.95	4.88	4.94	4.91
	EC	6784.4 (+21.5)	4853.6 (-13.1)	3444.8 (-38.3)	1630.3 (-70.8)	56 (-4)	54 (-6)	54 (-6)	54 (-6)	99 (-3)	95 (-7)	94 (-8)	91 (-11)	4.92	4.94	4.96	4.61
4-July	MC	5155.3 (-7.7)	5582.7 (-0.02)	5073.6 (-9.1)	5170.7 (-7.4)	57 (-3)	55 (-5)	56 (-4)	55 (-5)	99 (-3)	97 (-5)	97 (-5)	97 (-5)	4.70	4.57	4.66	4.74
	EC	6343.6 (+13.6)	4913.9 (-12.0)	3714.4 (-33.5)	2029.9 (-63.7)	57 (-3)	55 (-5)	55 (-5)	53 (-7)	100 (-2)	96 (-6)	94 (-8)	91 (-11)	4.78	4.83	4.87	4.64
9-July	MC	4155.9 (-25.6)	4900.1 (-12.2)	3999.9 (-28.4)	3939.8 (-29.4)	57 (-3)	57 (-3)	57 (-3)	57 (-3)	100 (-2)	100 (-2)	100 (-2)	99 (-3)	4.63	4.44	4.63	4.77
	EC	5196.6 (-6.9)	4278.6 (-23.4)	3505.7 (-37.2)	2237.8 (-59.9)	57 (-3)	55 (-5)	55 (-5)	54 (-6)	102 (0)	97 (-5)	96 (-6)	93 (-9)	4.77	4.90	4.87	4.66
14-July	MC	3598.9 (-35.6)	4280.2 (-23.3)	3478.9 (-37.7)	3112.0 (-44.3)	54 (-6)	54 (-6)	54 (-6)	54 (-6)	97 (-5)	98 (-4)	97 (-5)	97 (-5)	4.58	4.32	4.61	4.86
	EC	5043.3 (-9.7)	3147.1 (-43.6)	2168.1 (-61.2)	1132.8 (-79.7)	55 (-5)	55 (-5)	54 (-6)	54 (-6)	100 (-2)	97 (-5)	96 (-6)	91 (-11)	4.79	4.81	4.69	4.30

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.101: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ballawal Saunkhri, Punjab

DOS	Time period	BASELINE: Yield =4-June (5584.2 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (102 DAS)				BASELINE: LAI=4-June (3.81)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	3911.8 (-30.0)*	3038.6 (-45.6)	3277.0 (-41.3)	2312.4 (-58.6)	54 (-6)**	54 (-6)	54 (-6)	54 (-6)	93 (-9)**	93 (-9)	93 (-9)	92 (-10)	3.26	3.42	3.23	2.79
	EC	3005.6 (-46.2)	1255.8 (-77.5)	1260.2 (-77.4)	227.8 (-95.9)	54 (-6)	52 (-8)	52 (-8)	51 (-9)	93 (-9)	89 (-13)	89 (-13)	72 (-30)	3.18	2.59	2.49	1.37
15-May	MC	5228.8 (-6.4)	5095.9 (-8.7)	4993.3 (-10.6)	4844.2 (-13.2)	54 (-6)	54 (-6)	54 (-6)	54 (-6)	93 (-9)	93 (-9)	93 (-9)	92 (-10)	3.00	3.17	3.05	2.56
	EC	4930.3 (-11.7)	3733.9 (-33.1)	3458.8 (-38.1)	501.8 (-91.0)	54 (-6)	54 (-6)	53 (-7)	51 (-9)	92 (-10)	91 (-11)	90 (-12)	70 (-32)	2.95	2.63	2.37	1.31
20-May	MC	5459.0 (-2.2)	4316.3 (-22.7)	5080.1 (-9.0)	4084.7 (-26.9)	57 (-3)	57 (-3)	57 (-3)	56 (-4)	96 (-6)	95 (-7)	95 (-7)	94 (-8)	2.71	2.76	2.74	2.34
	EC	4789.0 (-14.2)	3785.1 (-32.2)	3886.3 (-30.4)	1705.0 (-69.5)	56 (-4)	56 (-4)	56 (-4)	54 (-6)	95 (-7)	93 (-9)	92 (-10)	89 (-13)	2.61	2.34	2.21	1.47
25-May	MC	6475.9 (+16.0)	5374.0 (-3.8)	6061.7 (+8.6)	5453.3 (-2.3)	57 (-3)	57 (-3)	57 (-3)	57 (-3)	97 (-5)	96 (-6)	96 (-6)	95 (-7)	3.29	3.05	3.12	3.02
	EC	5808.8 (+4.0)	4780.5 (-14.4)	4487.8 (-19.6)	1715.4 (-69.3)	57 (-3)	56 (-4)	56 (-4)	54 (-6)	96 (-6)	93 (-9)	93 (-9)	86 (-16)	3.09	2.72	2.84	1.96
30-May	MC	5561.3 (-0.4)	4801.4 (-14.0)	5314.2 (-4.8)	5149.8 (-7.8)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	97 (-5)	96 (-6)	97 (-5)	96 (-6)	3.69	3.62	3.74	3.57
	EC	5216.7 (-6.6)	4795.3 (-14.1)	4555.9 (-18.4)	1783.0 (-68.1)	58 (-2)	57 (-3)	57 (-3)	54 (-6)	96 (-6)	94 (-8)	94 (-8)	81 (-21)	3.65	3.41	3.52	2.44
09-June	MC	4904.3 (-12.2)	3921.0 (-29.8)	4463.5 (-20.1)	4253.4 (-23.8)	58 (-2)	57 (-3)	58 (-2)	56 (-4)	98 (-4)	96 (-6)	97 (-5)	95 (-7)	4.74	4.62	4.75	4.50
	EC	4164.1 (-25.4)	3557.3 (-36.3)	3716.3 (-33.4)	511.5 (-90.8)	58 (-2)	55 (-5)	55 (-5)	54 (-6)	97 (-5)	93 (-9)	92 (-10)	71 (-31)	4.70	4.43	4.48	3.80

DOS	Time period	BASELINE: Yield =4-June (5584.2 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (102 DAS)				BASELINE: LAI=4-June (3.81)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
14-June	MC	5678.3 (+1.7)	4906.7 (-12.1)	5347.1 (-4.2)	4909.6 (-12.1)	58 (-2)	58 (-2)	58 9-2)	58 (-2)	98 (-4)	96 (-6)	97 (-5)	96 (-6)	4.94	4.91	4.94	4.92
	EC	5000.7 (-10.4)	3585.7 (-35.8)	3783.4 (-32.2)	1976.7 (-64.6)	58 (-2)	55 (-5)	56 (-4)	54 (-6)	97 (-5)	93 (-9)	94 (-8)	90 (-12)	4.94	4.76	4.78	4.37
19-June	MC	6592.7 (+18.1)	4906.7 (-35.8)	6180.1 (+10.7)	5750.3 (+3.0)	56 (-4)	58 (-2)	55 (-5)	55 (-5)	96 (-6)	96 (-6)	95 (-7)	94 (-8)	5.03	4.91	5.03	5.03
	EC	5760.1 (+3.1)	4917.7 (-11.9)	4329.7 (-22.5)	2136.2 (-61.8)	56 (-4)	55 (-5)	55 (-5)	54 (-6)	95 (-7)	93 (-9)	93 (-9)	89 (-13)	5.05	4.93	4.93	4.60
24-June	MC	5874.1 (+5.2)	5631.6 (+0.9)	5769.7 (+3.3)	5641.8 (+1.0)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	97 (-5)	94 (-8)	95 (-7)	94 (-8)	4.99	5.01	4.96	4.97
	EC	5708.0 (+2.2)	4219.6 (-24.4)	4098.9 (-26.6)	2197.3 (-60.7)	55 (-5)	55 (-5)	55 (-5)	53 (-7)	95 (-7)	93 (-9)	92 (-10)	88 (-14)	4.99	4.96	4.79	4.48
29-June	MC	4999.1 (-10.5)	5569.2 (-0.3)	4585.7 (-17.9)	4450.0 (-20.3)	55 (-5)	56 (-4)	54 (-6)	54 (-6)	95 (-7)	96 (-6)	95 (-7)	94 (-8)	4.71	5.01	4.73	4.80
	EC	4458.8 (-20.1)	3216.4 (-42.4)	2872.6 (-48.6)	1643.4 (-70.6)	54 (-6)	55 (-5)	54 (-6)	53 (-7)	94 (-8)	93 (-9)	92 (-10)	86 (-16)	4.85	4.79	4.48	4.37
4-July	MC	4397.0 (-21.3)	4477.8 (-19.8)	4204.1 (-24.7)	3850.6 (-31.0)	55 (-5)	54 (-6)	55 (-5)	54 (-6)	96 (-6)	94 (-8)	96 (-6)	94 (-8)	4.18	4.80	4.30	4.40
	EC	3978.6 (-28.8)	2280.7 (-59.2)	2168.8 (-61.2)	1022.8 (-81.7)	55 (-5)	54 (-6)	55 (-5)	53 (-7)	95 (-7)	92 (-2)	92 (-10)	84 (-18)	4.48	4.36	4.02	4.09
9-July	MC	3852.5 (-31.0)	3886.1 (-30.4)	3295.5 (-41.0)	3449.8 (-38.2)	57 (-3)	55 (-5)	57 (-3)	55 (-5)	99 (-3)	95 (-7)	99 (-3)	95 (-7)	3.99	4.33	4.20	4.16
	EC	3566.9 (-36.1)	2193.2 (-60.72)	2022.3 (-63.8)	1012.6 (-81.9)	56 (-4)	55 (-5)	54 (-6)	54 (-6)	97 (-5)	93 (-9)	92 (-10)	85 (-17)	4.29	4.04	3.48	3.96
14-July	MC	3419.5 (-38.8)	3335.43 (-40.3)	2842.5 (-49.1)	3064.0 (-45.1)	54 (-6)	54 (-6)	54 (-6)	54 9-6)	96 (-6)	95 (-7)	97 (-5)	95 (-7)	3.78	4.01	4.23	4.29
	EC	2891.4 (-48.2)	1864.0 (-66.6)	1894.7 (-66.1)	686.3 (-87.7)	54 (-6)	54 (-6)	54 (-6)	54 (-6)	96 (-6)	92 (-10)	92 (-10)	83 (-19)	4.26	3.97	3.39	4.03

*%deviation from baseline value**Deviation from baseline in DAS

Table 4.102: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ballawal Saunkhri, Punjab

DOS	Time period	BASELINE: Yield =4-June (5584.2 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (102 DAS)				BASELINE: LAI=4-June (3.81)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	4047.5 (-27.5)*	3360.5 (-39.8)	3200.1 (-42.7)	3304.2 (-40.8)	54 (-6)**	54 (-6)	56 (-4)	54 (-6)	93 (-9)**	93 (-9)	93 (-9)	92 (-10)	3.18	3.42	3.33	2.99
	EC	3897.1 (-30.2)	2099.2 (-62.4)	2168.2 (-61.2)	296.7 (-94.7)	54 (-6)	52 (-8)	56 (-4)	51 (-9)	93 (-9)	90 (-12)	90 (-10)	73 (-29)	3.29	2.67	2.70	1.56
15-May	MC	5623.0 (+0.7)	5414.9 (-3.0)	5464.9 (-2.1)	4996.5 (-10.5)	54 (-6)	54 (-6)	57 (-3)	54 (-6)	93 (-9)	93 (-9)	93 (-9)	92 (-10)	2.94	3.06	2.95	2.76
	EC	5632.6 (+0.9)	4304.7 (-22.9)	4447.2 (-20.4)	1580.0 (-71.7)	54 (-6)	54 (-6)	57 (-3)	51 (-9)	93 (-9)	91 (-11)	91 (-11)	87 (-15)	3.02	2.28	2.37	1.27
20-May	MC	6111.2 (+9.4)	5578.0 (-0.1)	6044.9 (+8.2)	5007.3 (-10.3)	57 (-3)	56 (-4)	58 (-2)	56 (-4)	96 (-6)	95 (-7)	95 (-7)	95 (-7)	2.60	2.54	2.48	2.53
	EC	5475.0 (-2.0)	4443.2 (-20.4)	4582.3 (-17.9)	1629.1 (-70.8)	57 (-3)	56 (-4)	56 (-4)	54 (-6)	95 (-7)	94 (-8)	94 (-8)	88 (-14)	2.75	2.21	2.20	1.48
25-May	MC	5963.1 (+6.8)	5871.2 (+5.1)	6192.5 (+10.9)	5475.4 (-1.9)	57 (-3)	57 (-3)	57 (-3)	57 (-3)	97 (-5)	96 (-6)	96 (-6)	96 (-6)	3.22	3.00	2.92	3.23
	EC	5394.3 (-3.4)	4896.4 (-12.3)	4894.5 (-12.3)	2027.9 (-63.7)	57 (-3)	57 (-3)	57 (-3)	54 (-6)	96 (-6)	94 (-8)	94 (-8)	85 (-17)	3.37	3.01	2.92	1.86
30-May	MC	5203.7 (-6.8)	5297.0 (-5.1)	5646.6 (+1.1)	5036.8 (-9.8)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	97 (-5)	97 (-5)	97 (-5)	96 (-6)	3.89	3.78	3.67	3.77
	EC	4921.8 (-11.9)	4471.9 (-19.9)	4625.6 (-17.2)	2024.0 (-63.8)	58 (-2)	57 (-3)	56 (-4)	54 (-6)	97 (-5)	95 (-7)	94 (-8)	81 (-21)	3.99	3.74	3.64	2.61
09-June	MC	4777.9 (-14.4)	4485.8 (-19.7)	4894.9 (-12.3)	5204.1 (-6.8)	58 (-2)	57 (-3)	58 (-2)	57 (-3)	98 (-4)	97 (-5)	98 (-4)	96 (-6)	4.77	4.70	4.63	4.66
	EC	4509.1 (-19.2)	4954.7 (-11.3)	3879.2 (-30.5)	648.3 (-88.4)	58 (-2)	56 (-4)	56 (-4)	54 (-6)	98 (-4)	93 (-9)	93 (-9)	72 (-30)	4.81	4.51	4.50	4.10
14-June	MC	5218.6 (-6.6)	4902.3 (-12.2)	5347.6 (-4.2)	5302.4 (-5.0)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	98 (-4)	97 (-5)	98 (-4)	97 (-5)	4.98	5.00	4.90	5.01
	EC	5250.3 (-6.0)	4552.2 (-18.5)	4246.3 (-24.0)	2390.5 (-57.2)	58 (-2)	57 (-3)	57 (-30)	54 (-6)	98 (-4)	95 (-7)	95 (-7)	90 (-12)	5.02	4.99	4.98	4.50

DOS	Time period	BASELINE: Yield =4-June (5584.2 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (102 DAS)				BASELINE: LAI=4-June (3.81)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
19-June	MC	6064.1 (+8.6)	5670.2 (+1.5)	6086.7 (+9.0)	6166.4 (+10.4)	56 (-4)	56 (-4)	56 (-4)	55 (-5)	96 (-6)	95 (-7)	96 (-6)	95 (-7)	5.07	5.08	5.03	5.07
	EC	6139.7 (+9.9)	5350.9 (-4.2)	4974.6 (-11.0)	2844.4 (-49.1)	56 (-4)	55 (-5)	55 (-5)	54 (-6)	96 (-6)	94 (-8)	93 (-9)	91 (-11)	5.07	5.05	5.08	4.73
24-June	MC	4958.0 (-11.2)	5134.4 (-8.0)	5458.4 (-2.2)	5582.6 (-0.03)	56 (-4)	56 (-4)	56 (-4)	55 (-5)	98 (-4)	96 (-6)	97 (-5)	95 (-7)	5.00	4.98	5.03	4.95
	EC	5457.9 (-2.3)	4970.6 (-11.0)	4922.8 (-11.8)	2977.0 (-46.7)	56 (-4)	55 (-5)	55 (-5)	54 (-6)	97 (-5)	93 (-9)	93 (-9)	90 (-12)	4.96	4.86	5.08	4.80
29-June	MC	4242.2 (-24.0)	4068.8 (-27.1)	4435.0 (-20.6)	4398.5 (-21.2)	56 (-4)	54 (-6)	55 (-5)	54 (-6)	96 (-6)	95 (-7)	96 (-6)	95 (-7)	4.74	4.77	4.87	4.64
	EC	4403.9 (-21.1)	3540.1 (-36.6)	3576.0 (-36.0)	2437.1 (-56.4)	54 (-6)	54 (-6)	54 (-6)	53 (-7)	95 (-7)	93 (-9)	93 (-9)	90 (-12)	4.70	4.45	4.62	4.54
4-July	MC	3838.1 (-31.3)	3404.7 (-39.0)	3801.6 (-31.9)	3839.8 (-31.2)	55 (-5)	56 (-4)	56 (-4)	55 (-5)	97 (-5)	96 (-6)	98 (-4)	95 (-7)	4.38	4.41	4.54	4.14
	EC	3981.9 (-28.7)	2945.1 (-47.3)	2938.1 (-47.4)	1826.5 (-67.3)	55 (-5)	55 (-5)	54 (-6)	53 (-7)	96 (-6)	93 (-9)	93 (-9)	90 (-12)	4.31	3.74	3.98	4.49
9-July	MC	2392.3 (-57.2)	2393.4 (-57.1)	2770.0 (-50.4)	3167.0 (-43.3)	57 (-3)	57 (-3)	57 (-3)	56 (-4)	99 (-3)	98 (-4)	99 (-3)	97 (-5)	4.34	4.26	4.42	3.93
	EC	2631.7 (-52.9)	3046.0 (-45.4)	2905.8 (-48.0)	1854.0 (-66.8)	57 (-3)	54 (-6)	54 (-6)	54 (-6)	99 (-3)	94 (-8)	93 (-9)	91 (-11)	4.22	3.34	3.45	4.49
14-July	MC	2191.3 (-60.8)	2072.6 (-62.9)	2391.0 (-57.2)	2810.4 (-49.7)	54 (-6)	54 (-6)	54 (-6)	54 (-6)	97 (-5)	96 (-6)	97 (-5)	96 (-6)	4.31	4.30	4.42	3.93
	EC	2308.9 (-58.7)	2823.7 (-49.4)	2813.0 (-49.6)	1344.0 (-75.9)	54 (-6)	54 (-6)	54 (-6)	53 (-7)	96 (-6)	94 (-8)	94 (-8)	91 (-11)	4.22	3.40	3.51	4.38

*%deviation from baseline value

**Deviation from baseline in DAS

The IPSL-CM5A-MR (Table 4.101) model observed the yield to increase under RCP2.6 for the dates 25th May (16%), 14th June (1.7%), and 19th June (18.1%). The slight yield increment observed on 24th June was under all the RCPs. The end-century did not show significant increase in yield. The ensemble model (Table 4.102) gave similar results with slight increase in yield on 19th June under all the RCPs.

The anthesis for PMH2 variety (Table 4.99, 4.100, 4.101 and 4.102) in the zone reduced by 2-6 days during mid-century and 3-9 days during the end-century while maturity by 4-10 days and 8-30 days for the respective centuries. The LAI for the future projections was higher for all the dates of sowing except the early 10th May to 25th May.

Agroclimatic zone III (Ludhiana, Amritsar and Patiala)

All the locations in the zone observed the yield to decline during early sowing of maize cultivar PMH1 while late sowing showed an increment in yield. The CSIRO-Mk-3-6-0 model (Table 4.103) projected no yield increment on any of the dates of sowing during mid and end-century at any locations in this zone. At Ludhiana (Table 4.104) the FIO-ESM model projected yield increase on 14th, 19th, 24th and 29th June in the range 11.9% to 65.8% during the mid-century. 19th and 24th June observed this increase under all the scenarios during the mid-century while the end-century observed this increase only under RCP6.0 on respective dates of sowing ranging 1.4% to 36.8%. Similarly IPSL-CM5A-MR (Table 4.105) projected the yield increase during mid-century on 19th and 24th June under RCP4.5, RCP6.0 and RCP8.5 in the range 16.3% to 24.9% while the ensemble model (Table 4.106) observed this increase on 14th, 19th, 24th and 29th June in the range 2.6% to 53.9%. Both the models projected slight yield increment under RCP4.5. None of the models projected a yield increase under RCP8.5 during the end-century. The anthesis observed the shortening for PMH1 (Table 4.103, 4.104, 4.105 and 4.106) during the mid-century by 3-6 days during mid-century and 4-7 days during the end-century under all the four RCPs. The maturity days were projected to shorten by 2-8 days during mid-century and 5-28 days during the end-century for all the four RCPs. The shortening of days was higher for the end-century under RCP8.5. The LAI for the future projections was higher for all the dates of sowing except 10th May to 25th May

The PMH2 cultivar in Ludhiana observed similar results. CSIRO-Mk-3-6-0 model (Table 4.107) observed no yield increase under any of the sowing dates and RCPs. FIO-ESM (Table 4.108) observed an increase in yield on 14th June, 19th June, 24th June and 4th July under RCP6.0 ranging 4.2 to 54.1% during the mid-century. The end-century observed the yield increment only under RCP2.6 ranging 6.7% to 34.1%. The IPSL-CM5A-MR model (Table 4.109) observed significant increase on 19th and 24th June under RCP4.5, RCP6.0 and RCP8.5

ranging 15.8% to 25.5% while the Ensemble model (Table 4.110) showed the yield increment similar as PMH1 on 19th, 24th and 29th June under RCP4.5 and RCP6.0 ranging 2.9% to 40.9% during the mid-century. The end-century observed a slight increase in yield from the baseline. The anthesis for PMH2 (Table 4.107, 4.108, 4.109 and 4.110) as projected by the four GCMs observed the shortening by 2-4 days during the mid-century and 4-7 days during the end-century while maturity observed the reduction by 3-8 days and 5-25 days during mid and end-century, respectively.

Amritsar too gave similar results for both the varieties as Ludhiana where the CSIRO-Mk-3-6-0 model observed no increase in yield for PMH1 (Table 4.111) as well as PMH2 (Table 4.115). The location observed an increase on 14th and 19th June as projected by FIO-ESM (Table 4.112) ranging 3.2% to 13.0% for PMH1 under all the RCPs during the mid-century while the end-century observed the increase only under RCP2.6 and RCP4.5 on 14th June (15.0% and 11.7%) and 19th June (10.5% and 10.6%). The IPSL-CM5A-MR (Table 4.113) and Ensemble (Table 4.114) model projected slight increase in the yield on 14th June under RCP2.6 by 4.6% and 0.4%, respectively during the mid-century. No yield increase was observed under RCP8.5 during the end-century. The anthesis for PMH1 (Table 4.111, 4.112, 4.113 and 4.114) shortened by 1-4 days on an average during mid-century and 2-7 days during end-century while the maturity period as projected by the models shortened by 3-8 days and 1-18 days during mid and end-century. The dates beneficial for the yield at the location also showed the maturity period to be same as the baseline. The LAI as predicted by the model was higher for the sowing window considered except during early sowing in May and late sowing during end of June.

The PMH2 variety in Amritsar as per FIO-ESM (Table 4.116) projection did not observe any significant yield except on 19th June under RCP2.6 during the end-century by 13.2% from the baseline. The IPSL-CM5A-MR (Table 4.117) and Ensemble model (Table 4.118) showed no increase in yield at any dates of sowing under all the RCPs. The anthesis period (4.115, 4.116, 4.117, 4.118) for the location shortened by 0-4 days during mid-century and 1-5 days during the end-century while the maturity period reduced by 1-6 days and 3-16 days during the mid and end-century, respectively. The observed LAI was higher for this cultivar under all the dates of sowing and RCPs except 10th May to 25th May.

At Patiala the PMH1 variety observed an increase in yield from the baseline at later dates of sowing. The CSIRO-Mk-3-6-0 model (Table 4.119) predicted a yield increase under RCP2.6 (2.9%) and RCP6.0 (4.5%) while the FIO-ESM model (Table 4.120) observed the significant yield increment on 14th and 19th June ranging 13.5% to 22.4% under all the RCPs

during the mid-century and 5.7% to 18.7% during the end-century under RCP2.6 and RCP4.5. IPSL-CM5A-MR model (Table 4.121) too projected a significant yield increase on 14th and 19th June ranging 4.3% to 19.3% for both mid and end-century. The increase during the end-century was observed only under RCP2.6. The Ensemble model (Table 4.122) also projected a significant yield increment on 14th and 19th June under all the scenarios for mid-century and under RCP2.6 during end-century. The anthesis for PMH1 (Table 4.119, 4.120, 4.121 and 4.122) shortened by 0-4 days on an average during mid-century and 2-5 days during end-century while the maturity period as projected by the models shortened by 2-6 days and 1-18 days during mid and end-century. The dates beneficial for the yield at the location also showed the maturity period to be same as the baseline. The LAI as predicted by the model was higher for the sowing window considered except during early sowing in May and late sowing during end of June.

The PMH2 cultivar at Patiala performed well at later dates of sowing. The CSIRO-Mk-3-6-0 model (Table 4.123) gave no yield increment at any date of sowing. The FIO-ESM (Table 4.124) model showed yield increment on 14th and 19th June ranging 0.9% to 6.3% under all the scenarios during mid-century while increment by 1.8% (14th June) and 12.4% (19th June) under RCP2.6 was observed. The IPSL-CM5A-MR (Table 4.125) and Ensemble model (Table 4.126) showed no significant yield increment even at later dates of sowing. The anthesis period (4.123, 4.124, 4.125, 4.126) for the location shortened by 0-2 days during mid-century and 1-4 days during the end-century while the maturity period reduced by 0-4 days and 2-16 days during the mid and end-century, respectively. The observed LAI was higher for this cultivar under all the dates of sowing and RCPs except 10th May to 25th May.

Table 4.103: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ludhiana, Punjab

DOS	Time period	BASELINE: Yield= 4-June (3689.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (100 DAS)				BASELINE: LAI=4-June (2.85)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	2422.4 (-34.3)*	2837.9 (-23.1)	2396.5 (-35.0)	2469.8 (-33.0)	56 (-6)**	56 (-6)	56 (-6)	56 (-6)	91 (-9)**	91 (-9)	92 (-8)	90 (-10)	1.53	1.53	1.69	1.43
	EC	1450.5 (-60.7)	69.9 (-98.1)	136.5 (-96.3)	7.5 (-99.8)	56 (-6)	55 (-7)	55 (-7)	55 (-7)	91 (-9)	70 (-30)	71 (-29)	68 (-32)	1.39	0.79	0.78	1.47
15-May	MC	3253.0 (-11.8)	3250.6 (-11.9)	3199.7 (-13.3)	2913.6 (-21.0)	56 (-6)	56 (-6)	56 (-6)	56 (-6)	91 (-9)	91 (-9)	92 (-8)	91 (-9)	1.65	1.74	1.50	1.61
	EC	2170.4 (-41.2)	707.0 (-80.8)	930.5 (-74.8)	502.1 (-86.4)	56 (-6)	55 (-7)	55 (-7)	55 (-7)	91 (-9)	83 (-17)	86 (-14)	76 (-24)	1.33	0.87	0.82	1.32
20-May	MC	2907.3 (-21.2)	2536.9 (-31.2)	2549.6 (-30.9)	2380.7 (-35.5)	56 (-6)	56 (-6)	56 (-6)	56 (-6)	90 (-10)	90 (-10)	91 (-9)	90 (-10)	2.11	2.12	2.02	1.98
	EC	2158.0 (-41.5)	770.4 (-79.1)	1012.4 (-72.6)	569.4 (-84.6)	56 (-6)	55 (-7)	55 (-7)	55 (-7)	89 (-11)	80 (-20)	84 (-16)	76 (-24)	1.78	1.17	1.06	1.62
25-May	MC	1990.2 (-46.0)	1843.3 (-50.0)	1919.9 (-48.0)	1732.8 (-53.0)	56 (-6)	56 (-6)	56 (-6)	59 (-3)	86 (-14)	87 (-14)	89 (-11)	82 (-18)	2.61	2.51	2.58	2.93
	EC	1651.9 (-55.2)	564.6 (-84.7)	812.3 (-78.0)	482.8 (-86.9)	56 (-6)	55 (-7)	55 (-7)	57 (-5)	84 (-16)	77 (-23)	80 (-20)	79 (-21)	2.39	1.65	1.43	2.58
30-May	MC	1184.4 (-67.9)	1132.5 (-67.9)	1479.5 (-59.9)	1061.8 (-71.2)	59 (-3)	59 (-3)	59 (-3)	59 (-3)	83 (-17)	84 (-16)	88 (-12)	82 (-18)	3.21	3.03	3.12	2.93
	EC	750.0 (-79.7)	741.3 (-79.7)	766.9 (-79.2)	690.1 (-81.3)	59 (-3)	58 (-4)	58 (-4)	57 (-5)	79 (-21)	80 (-20)	80 (-20)	79 (-21)	2.96	2.36	2.09	2.58

DOS	Time period	BASELINE: Yield= 4-June (3689.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (100 DAS)				BASELINE: LAI=4-June (2.85)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	2415.2 (-34.5)	2093.4 (-43.3)	2162.7 (-41.4)	1592.8 (-56.8)	57 (-5)	57 (-5)	57 (-5)	57 (-5)	92 (-8)	92 (-8)	93 (-7)	87 (-13)	3.84	3.57	3.51	3.53
	EC	2113.3 (-42.7)	13.2 (-99.6)	39.0 (-98.9)	53.3 (-98.5)	57 (-5)	56 (-6)	56 (-6)	55 (-7)	92 (-8)	70 (-30)	70 (-30)	69 (-31)	3.71	3.25	3.13	3.27
14-June	MC	2207.8 (-40.2)	2064.0 (-44.0)	2422.2 (-34.3)	1773.6 (-51.9)	57 (-5)	57 (-5)	57 (-5)	57 (-5)	92 (-8)	92 (-8)	93 (-7)	90 (-10)	3.94	3.63	3.64	3.64
	EC	1980.4 (-46.3)	87.1 (-97.6)	58.9 (-98.4)	509.4 (-86.2)	57 (-5)	56 (-6)	56 (-6)	55 (-7)	92 (-8)	70 (-30)	70 (-30)	74 (-26)	3.92	3.56	3.53	3.51
19-June	MC	2897.9 (-21.4)	2813.5 (-23.7)	3221.3 (-12.7)	2655.1 (-28.0)	57 (-5)	57 (-5)	58 (-4)	57 (-5)	93 (-7)	93 (-7)	94 (-6)	93 (-7)	4.02	3.59	3.74	3.64
	EC	2222.7 (-39.8)	1315.4 (-64.3)	1264.7 (-65.7)	2222.7 (-39.8)	56 (-6)	56 (-6)	56 (-6)	56 (-6)	92 (-8)	90 (-10)	90 (-10)	92 (-8)	4.01	3.60	3.66	4.01
24-June	MC	2878.1 (-22.0)	2752.2 (-25.4)	2935.8 (-20.4)	2569.6 (-30.3)	58 (-4)	58 (-4)	58 (-4)	58 (-4)	95 (-5)	95 (-5)	95 (-5)	94 (-6)	3.71	3.27	3.52	3.37
	EC	2539.8 (-31.2)	1530.5 (-58.5)	1426.5 (-61.3)	1865.9 (-49.4)	58 (-4)	56 (-6)	56 (-6)	55 (-7)	94 (-6)	90 (-10)	90 (-10)	89 (-11)	3.77	3.51	3.65	3.55

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.104: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ludhiana, Punjab

DOS	Time period	BASELINE: Yield= 4-June (3689.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (100 DAS)				BASELINE: LAI=4-June (2.85)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	3585.5 (-2.8)*	3378.9 (-8.4)	2859.8 (-22.5)	2733.4 (-25.9)	56 (-6)**	56 (-6)	58 (-4)	57 (-5)	93 (-7)**	92 (-8)	95 (-5)	94 (-6)	2.10	1.88	2.30	2.38
	EC	2571.9 (-30.3)	2707.4 (-26.6)	1929.8 (-47.7)	484.6 (-86.9)	56 (-6)	56 (-6)	56 (-4)	55 (-7)	93 (-7)	92 (-8)	92 (-8)	79 (-21)	2.26	1.82	2.42	2.02
15-May	MC	3420.4 (-7.3)	3186.4 (-13.6)	3416.5 (-7.4)	3358.8 (-9.0)	56 (-6)	56 (-6)	58 (-4)	58 (-4)	92 (-8)	92 (-8)	95 (-5)	95 (-5)	1.85	1.82	2.22	2.33
	EC	2363.9 (-35.9)	2360.1 (-36.0)	2176.4 (-41.0)	879.8 (-76.1)	57 (-5)	56 (-6)	57 (-5)	55 (-7)	93 (-7)	91 (-9)	93 (-7)	86 (-14)	2.20	1.89	2.34	2.18
20-May	MC	2419.6 (-34.4)	2319.5 (-37.1)	3133.2 (-15.1)	3124.7 (-15.3)	57 (-5)	56 (-6)	59 (-3)	58 (-4)	93 (-7)	92 (-8)	96 (-4)	95 (-5)	2.20	2.31	2.32	2.36
	EC	1715.6 (-53.5)	1573.5 (-57.3)	2066.7 (-44.0)	830.1 (-77.5)	59 (-3)	56 (-6)	58 (-4)	55 (-7)	94 (-6)	89 (-11)	94 (-6)	84 (-16)	2.54	2.41	2.36	2.47
25-May	MC	2281.6 (-38.1)	2257.2 (-38.8)	3251.8 (-11.9)	3303.8 (-10.4)	57 (-5)	57 (-5)	60 (-2)	59 (-3)	93 (-7)	92 (-8)	97 (-3)	96 (-4)	2.82	2.86	2.80	2.79
	EC	2047.8 (-44.5)	1343.0 (-63.6)	2249.8 (-39.0)	1185.0 (-67.9)	59 (-3)	57 (-5)	57 (-5)	55 (-7)	95 (-5)	84 (-16)	93 (-7)	86 (-14)	3.00	2.85	2.86	2.87
30-May	MC	2257.6 (-38.8)	2238.2 (-39.3)	2866.9 (-22.3)	3263.2 (-11.5)	60 (-2)	59 (-3)	62 (0)	60 (-2)	96 (-4)	95 (-5)	100 (0)	98 (-2)	3.22	3.23	3.04	3.08
	EC	2464.1 (-33.2)	809.5 (-78.1)	2449.3 (-33.6)	1062.5 (-71.2)	61 (-1)	59 (-3)	59 (-3)	58 (-4)	97 (-3)	79 (-21)	95 (-5)	83 (-17)	3.27	3.23	3.12	3.12
09-June	MC	2345.4 (-36.4)	2569.4 (-30.3)	4187.3 (+13.5)	4448.9 (+20.6)	58 (-4)	57 (-5)	59 (-3)	58 (-4)	94 (-6)	94 (-6)	97 (-3)	97 (-3)	3.44	3.50	3.26	3.27
	EC	2729.5 (-26.0)	2528.8 (-31.5)	2898.0 (-21.45)	2048.6 (-44.5)	58 (-4)	57 (-5)	57 (-5)	56 (-6)	94 (-6)	93 (-7)	94 (-6)	89 (-11)	3.47	3.50	3.38	3.37

DOS	Time period	BASELINE: Yield= 4-June (3689.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (100 DAS)				BASELINE: LAI=4-June (2.85)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
14-June	MC	3173.9 (-14.0)	3011.2 (-18.4)	5699.4 (+54.9)	5773.9 (+56.5)	57 (-5)	57 (-5)	60 (-2)	60 (-2)	94 (-6)	94 (-6)	99 (-1)	97 (-3)	3.62	3.63	3.45	3.47
	EC	4289.9 (+16.3)	2754.2 (-25.3)	4405.6 (+19.4)	2256.6 (-38.8)	57 (-5)	57 (-5)	58 (-4)	58 (-4)	95 (-5)	93 (-7)	95 (-5)	89 (-11)	3.60	3.58	3.53	3.53
19-June	MC	4327.2 (+17.30)	4127.3 (+11.9)	6114.6 (+65.7)	6050.4 (64.0)	59 (-3)	59 (-3)	59 (-3)	59 (-3)	97 (-3)	96 (-4)	99 (-1)	99 (-1)	3.70	3.70	3.60	3.61
	EC	5398.1 (46.3)	2559.2 (-30.6)	5046.1 (+36.8)	3241.3 (-12.1)	59 (-3)	58 (-4)	59 (-3)	56 (-6)	97 (-3)	92 (-8)	97 (-3)	92 (-8)	3.66	3.00	3.67	3.69
24-June	MC	3803.9 (+3.1)	3660.4 (-0.8)	5654.3 (+53.3)	5359.6 (+45.3)	59 (-3)	59 (-3)	59 (-3)	59 (-3)	97 (-3)	96 (-4)	99 (-1)	99 (-1)	3.37	3.40	3.40	3.31
	EC	5067.1 (+37.3)	3573.3 (-3.1)	4379.8 (+18.7)	3329.0 (-9.8)	58 (-4)	58 (-4)	58 (-4)	58 (-4)	97 (-3)	96 (-4)	97 (-3)	94 (-6)	3.42	3.42	3.53	3.15
29-June	MC	3313.5 (-10.20)	3272.7 (-11.3)	5002.7 (+35.6)	4629.1 (+25.5)	58 (-4)	58 (-4)	59 (-3)	59 (-3)	96 (-4)	96 (-4)	99 (-1)	99 (-1)	2.97	3.00	3.13	3.01
	EC	4637.4 (+25.7)	3282.3 (-11.0)	3944.5 (+6.9)	2459.6 (-33.3)	58 (-4)	58 (-4)	58 (-4)	55 (-7)	97 (-3)	95 (-5)	97 (-3)	92 (-8)	3.16	3.10	3.33	3.62
4-July	MC	2985.9 (-19.1)	2936.4 (-20.4)	4330.- (+17.4)	4137.0 (+12.4)	59 (-3)	59 (-3)	61 (-1)	60 (-2)	97 (-3)	96 (-4)	102 (+2)	101 (+1)	2.61	2.65	3.03	2.85
	EC	4175.3 (+13.2)	2868.6 (-22.2)	3741.2 (+1.4)	2435.3 (-34.0)	59 (-3)	59 (-3)	59 (-3)	57 (-5)	98 (-2)	96 (-4)	98 (-2)	92 (-8)	2.98	2.89	3.27	3.56
9-July	MC	2722.5 (-26.2)	2723.1 (-26.2)	3673.8 (-0.4)	3518.3 (-4.6)	58 (-4)	58 (-4)	61 (-1)	60 (-2)	97 (-3)	97 (-3)	103 (+3)	102 (+2)	2.25	2.39	2.88	2.74
	EC	3913.6 (+6.1)	2653.9 (-28.1)	3295.3 (-10.7)	1950.8 (-47.1)	59 (-3)	59 (-3)	59 (-3)	57 (-5)	99 (-1)	97 (-3)	99 (-1)	94 (-6)	2.93	2.91	3.30	3.68
14-July	MC	2315.1 (-37.2)	2334.1 (-36.7)	2994.3 (-18.8)	2786.1 (-24.5)	58 (-4)	58 (-4)	60 (-2)	61 (-1)	98 (-2)	100 (0)	103 (+3)	103 (+3)	2.10	2.22	2.74	2.58
	EC	3472.7 (-5.9)	2269.9 (-38.5)	2490.3 (-32.5)	1461.5 (-60.4)	59 (-3)	58 (-4)	58 (-4)	57 (-5)	100 (0)	100 (0)	99 (-1)	95 (-5)	2.87	2.84	3.26	3.79

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.105: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ludhiana, Punjab

DOS	Time period	BASELINE: Yield= 4-June (3689.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (100 DAS)				BASELINE: LAI=4-June (2.85)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	2096.4 (-38.4)*	1619.2 (-52.4)	2109.5 (-38.0)	1569.3 (-53.9)	56 (-6)**	56 (-6)	57 (-5)	56 (-6)	92 (-8)**	93 (-7)	93 (-7)	93 (-7)	1.86	2.41	2.36	2.35
	EC	1788.1 (-47.5)	1107.5 (-67.5)	1070.0 (-68.6)	163.0 (-95.2)	56 (-6)	55 (-7)	55 (-7)	55 (-7)	92 (-8)	91 (-9)	91 (-9)	72 (-28)	1.87	2.41	2.29	1.44
15-May	MC	3286.2 (-3.5)	2475.2 (-27.3)	2384.1 (-30.0)	2348.4 (-31.0)	56 (-6)	56 (-6)	57 (-5)	56 (-6)	92 (-8)	93 (-7)	93 (-7)	92 (-8)	1.61	2.33	2.31	2.24
	EC	2974.2 (-12.7)	2389.5 (-29.8)	2783.1 (-18.3)	265.7 (-92.2)	56 (-6)	55 (-7)	56 (-6)	55 (-7)	92 (-8)	91 (-9)	91 (-9)	86 (-14)	1.58	2.33	2.11	1.37
20-May	MC	2693.0 (-20.9)	2328.0 (-31.6)	2291.3 (-32.7)	2069.7 (-39.2)	56 (-6)	58 (-4)	59 (-3)	57 (-5)	92 (-8)	95 (-5)	95 (-5)	93 (-7)	2.03	2.39	2.43	2.38
	EC	2361.5 (-30.7)	2332.6 (-31.5)	2961.2 (-13.0)	1237.3 (-63.7)	56 (-6)	55 (-7)	56 (-6)	55 (-7)	92 (-8)	91 (-9)	91 (-9)	84 (-16)	1.92	2.09	2.01	1.54
25-May	MC	2287.3 (-32.8)	2469.1 (-27.5)	2204.2 (-35.3)	2132.2 (-37.4)	57 (-5)	58 (-4)	58 (-4)	57 (-5)	93 (-7)	95 (-5)	95 (-5)	93 (-7)	2.63	2.74	2.87	2.85
	EC	1796.9 (-47.2)	2088.1 (-38.7)	2017.5 (-40.8)	1072.0 (-68.5)	56 (-6)	56 (-6)	56 (-6)	55 (-7)	92 (-8)	92 (-8)	92 (-8)	80 (-20)	2.52	2.45	2.51	1.96
30-May	MC	1973.9 (-42.0)	2414.5 (-29.1)	2420.8 (-28.9)	2237.1 (-34.3)	59 (-3)	60 (-2)	60 (-2)	60 (-2)	96 (-4)	98 (-2)	98 (-2)	96 (-4)	3.24	3.02	3.06	3.14
	EC	1842.0 (-45.9)	2251.9 (-33.9)	2117.3 (-37.8)	1154.0 (-66.1)	59 (-3)	58 (-4)	59 (-3)	58 (-4)	94 (-6)	94 (-6)	94 (-6)	81 (-19)	3.13	3.05	3.08	2.58
09-June	MC	1859.8 (-45.4)	3071.0 (-9.8)	2780.9 (-18.3)	2372.5 (-30.3)	58 (-4)	58 (-4)	58 (-4)	58 (-4)	94 (-6)	95 (-5)	95 (-5)	95 (-5)	3.44	3.33	3.29	3.39
	EC	1730.8 (-49.2)	2284.5 (-32.9)	1946.0 (-42.9)	480.0 (-85.9)	57 (-5)	57 (-5)	57 (-5)	56 (-6)	93 (-7)	93 (-7)	93 (-7)	72 (-28)	3.50	3.40	3.43	3.16

DOS	Time period	BASELINE: Yield= 4-June (3689.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (100 DAS)				BASELINE: LAI=4-June (2.85)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
14-June	MC	2165.7 (-36.4)	3223.6 (-5.3)	3651.0 (+7.2)	3010.6 (-11.6)	57 (-5)	60 (-2)	60 (-2)	58 (-4)	94 (-6)	97 (-3)	97 (-3)	95 (-5)	3.65	3.45	3.47	3.50
	EC	3029.8 (-11.0)	2680.8 (-21.3)	2156.6 (-36.7)	677.5 (-80.1)	57 (-5)	57 (-5)	57 (-5)	56 (-6)	93 (-7)	93 (-7)	93 (-7)	83 (-17)	3.64	3.60	3.61	3.43
19-June	MC	2751.8 (-19.2)	4167.5 (+22.4)	4273.8 (+25.5)	3960.4 (+16.3)	59 (-3)	59 (-3)	59 (-3)	59 (-3)	96 (-4)	97 (-3)	97 (-3)	97 (-3)	3.71	3.59	3.57	3.62
	EC	3232.9 (-5.1)	5059.2 (+48.6)	3070.4 (-9.8)	1008.5 (-70.4)	58 (-4)	57 (-5)	58 (-4)	56 (-6)	94 (-6)	93 (-7)	93 (-7)	90 (-10)	3.76	3.69	3.67	3.56
24-June	MC	2723.2 (-20.0)	4252.6 (+24.9)	3944.3 (+15.8)	4186.6 (+23.0)	59 (-3)	59 (-3)	59 (-3)	58 (-4)	96 (-4)	98 (-2)	98 (-2)	91 (-9)	3.48	3.42	3.29	3.02
	EC	2586.2 (-24.0)	3116.9 (-8.5)	2959.6 (-13.1)	1654.1 (-51.4)	58 (-4)	59 (-3)	59 (-3)	56 (-6)	95 (-5)	96 (-4)	96 (-4)	90 (-10)	3.56	3.50	3.38	3.55
29-June	MC	2297.9 (-37.7)	3771.1 (+10.8)	3511.5 (-4.8)	3609.0 (+6.0)	58 (-4)	59 (-3)	59 (-3)	58 (-4)	94 (-6)	97 (-3)	98 (-2)	97 (-3)	3.18	3.09	3.02	3.10
	EC	2168.1 (41.2)	2581.7 (-24.2)	2623.1 (-28.9)	1216.0 (-64.3)	58 (-4)	59 (-3)	59 (-3)	56 (-6)	93 (-7)	95 (-5)	95 (-5)	89 (-11)	3.22	3.12	2.91	3.30
4-July	MC	1905.5 (-48.3)	3342.1 (-1.9)	2937.1 (-20.4)	3260.4 (-4.2)	58 (-4)	59 (-3)	60 (-2)	59 (-3)	94 (-6)	98 (-2)	96 (-4)	97 (-3)	3.01	2.92	2.91	2.95
	EC	1817.1 (-50.7)	2082.5 (-38.8)	2271.5 (-38.4)	890.0 (-73.9)	58 (-4)	59 (-3)	58 (-4)	56 (-6)	93 (-7)	95 (-5)	95 (-5)	88 (-12)	3.11	2.67	2.49	2.95
9-July	MC	1590.2 (-56.9)	3252.0 (-4.5)	1857.6 (-49.6)	3043.5 (-10.6)	58 (-4)	59 (-3)	60 (-2)	59 (-3)	94 (-6)	99 (-1)	91 (-9)	98 (-2)	2.95	2.76	2.89	2.84
	EC	2622.7 (-28.9)	1791.0 (-47.4)	2223.7 (-39.7)	861.6 (-74.7)	58 (-4)	59 (-3)	58 (-4)	56 (-6)	93 (-7)	96 (-4)	95 (-5)	87 (-13)	3.31	2.47	2.27	2.72
14-July	MC	1384.3 (-62.5)	3053.2 (-10.3)	2334.7 (-36.7)	2884.1 (-15.3)	60 (-2)	60 (-2)	61 (-1)	61 (-1)	96 (-4)	100 (0)	102 (+2)	99 (-1)	2.95	2.74	2.96	2.89
	EC	2505.2 (-32.1)	1777.8 (-47.8)	2068.7 (-43.9)	747.6 (-78.0)	58 (-4)	58 (-4)	58 (-4)	56 (-6)	94 (-6)	96 (-4)	96 (-4)	86 (-14)	3.26	2.45	2.22	2.64

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.106: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ludhiana, Punjab

DOS	Time period	BASELINE: Yield= 4-June (3689.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (100 DAS)				BASELINE: LAI=4-June (2.85)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	2824.1 (-23.4)*	2781.6 (-24.6)	2566.7 (-30.4)	2009.5 (-45.5)	56 (-6)**	56 (-6)	57 (-5)	56 (-6)	92 (-8)**	93 (-7)	94 (-6)	90 (-10)	1.73	2.40	2.43	1.89
	EC	2702.3 (-26.8)	2813.0 (-23.8)	2234.9 (-39.4)	278.5 (-92.4)	56 (-6)	56 (-6)	55 (-7)	55 (-7)	92 (-8)	91 (-9)	92 (-8)	76 (-24)	1.63	2.17	2.37	0.30
15-May	MC	3345.9 (-9.3)	3136.4 (-15.0)	2872.3 (-22.1)	1702.7 (-53.9)	56 (-6)	57 (-5)	58 (-4)	56 (-6)	92 (-8)	93 (-7)	95 (-5)	89 (-11)	1.45	2.33	2.43	2.37
	EC	3043.8 (-17.5)	3247.5 (-12.0)	3113.7 (-15.6)	403.1 (-89.1)	56 (-6)	56 (-6)	56 (-6)	55 (-7)	92 (-8)	91 (-9)	92 (-8)	83 (-17)	1.48	1.96	2.31	0.48
20-May	MC	2558.4 (-30.7)	2687.2 (-27.2)	2674.5 (-27.5)	1439.8 (-61.0)	56 (-6)	58 (-4)	58 (-4)	59 (-3)	92 (-8)	95 (-5)	96 (-4)	88 (-12)	1.94	2.31	2.62	2.86
	EC	2238.0 (-39.3)	2664.2 (-27.8)	2793.8 (-24.3)	372.0 (-89.9)	56 (-6)	56 (-6)	56 (-6)	57 (-5)	92 (-8)	92 (-8)	92 (-8)	78 (-22)	2.13	2.25	2.46	1.09
25-May	MC	2427.9 (-34.2)	2762.9 (-25.1)	2938.1 (-20.4)	1603.4 (-56.5)	57 (-5)	58 (-4)	59 (-3)	59 (-3)	93 (-7)	95 (-5)	96 (-4)	88 (-12)	2.59	2.84	2.89	3.11
	EC	2168.0 (-41.2)	2217.4 (-39.9)	2486.6 (-32.6)	183.3 (-95.0)	57 (-5)	56 (-6)	56 (-6)	57 (-5)	92 (-8)	92 (-8)	92 (-8)	73 (-27)	2.70	2.89	2.82	2.04
30-May	MC	2254.1 (-38.9)	2917.3 (-20.9)	3109.8 (-15.7)	1929.4 (-47.7)	59 (-3)	60 (-2)	61 (-1)	57 (-5)	96 (-4)	97 (-3)	99 (-1)	86 (-14)	3.19	3.09	3.10	3.24
	EC	2064.0 (-44.0)	2436.8 (-34.0)	2552.9 (-30.8)	9.6 (-99.7)	59 (-3)	59 (-3)	59 (-3)	55 (-7)	95 (-5)	95 (-5)	95 (-5)	73 (-27)	3.16	3.24	3.13	2.62
09-June	MC	2285.6 (-38.0)	3497.7 (-5.2)	3814.4 (+3.4)	3021.8 (-18.1)	57 (-5)	58 (-4)	58 (-4)	58 (-4)	94 (-6)	96 (-4)	96 (-4)	94 (-6)	3.41	3.31	3.37	3.50
	EC	2171.7 (-41.1)	2715.4 (-26.4)	2579.7 (-30.1)	939.9 (-74.5)	57 (-5)	57 (-5)	57 (-5)	56 (-6)	94 (-6)	94 (-6)	94 (-6)	87 (-13)	3.45	3.39	3.38	3.26

DOS	Time period	BASELINE: Yield= 4-June (3689.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (100 DAS)				BASELINE: LAI=4-June (2.85)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
14-June	MC	3049.6 (-17.3)	5132.1 (+39.1)	5501.8 (+49.1)	2553.3 (-30.8)	57 (-5)	59 (-3)	60 (-2)	58 (-4)	96 (-4)	97 (-3)	98 (-2)	95 (-5)	3.62	3.46	3.44	3.28
	EC	2981.8 (-19.2)	3674.7 (-0.4)	3555.1 (-3.6)	1019.0 (-72.4)	57 (-5)	57 (-5)	57 (-5)	56 (-6)	96 (-4)	93 (-7)	94 (-6)	86 (-14)	3.64	3.56	3.50	3.36
19-June	MC	3568.00 (-3.3)	5357.8 (+45.2)	5677.9 (+53.9)	2076.7 (-43.7)	59 (-3)	59 (-3)	59 (-3)	58 (-4)	96 (-4)	98 (-2)	99 (-1)	95 (-5)	3.76	3.59	3.57	2.87
	EC	3627.6 (-1.7)	4507.3 (+22.2)	4424.3 (+19.9)	778.4 (-78.9)	59 (-3)	59 (-3)	58 (-4)	55 (-7)	96 (-4)	98 (-2)	96 (-4)	84 (-16)	3.76	3.46	3.54	3.11
24-June	MC	2991.7 (-18.9)	4311.7 (+16.9)	4597.7 (+24.6)	1851.1 (-49.8)	59 (-3)	59 (-3)	59 (-3)	58 (-4)	96 (-4)	98 (-2)	99 (-1)	95 (-5)	3.50	3.34	3.35	2.69
	EC	3147.3 (-14.7)	3721.1 (+0.9)	3630.6 (-1.6)	731.0 (-80.2)	58 (-4)	59 (-3)	59 (-3)	56 (-6)	96 (-4)	96 (-4)	96 (-4)	87 (-13)	3.55	3.24	3.21	2.89
29-June	MC	2419.9 (-34.4)	3786.0 (+2.6)	4054.6 (+9.9)	1791.7 (-51.4)	58 (-4)	58 (-4)	59 (-3)	58 (-4)	96 (-4)	98 (-2)	98 (-2)	96 (-4)	3.17	3.01	3.05	2.67
	EC	2587.4 (-29.9)	3133.6 (-15.1)	3088.3 (-16.3)	580.7 (-84.2)	58 (-4)	59 (-3)	59 (-3)	55 (-7)	96 (-4)	96 (-4)	96 (-4)	84 (-16)	3.17	3.24	2.71	2.80
4-July	MC	2186.9 (-40.7)	3433.6 (-6.9)	3636.1 (-1.4)	1351.9 (-63.3)	58 (-4)	59 (-3)	59 (-3)	58 (-4)	96 (-4)	99 (-1)	99 (-1)	95 (-5)	3.06	2.87	2.92	2.68
	EC	2303.7 (-37.6)	2941.3 (-20.3)	2771.2 (-24.9)	422.1 (-88.6)	58 (-4)	58 (-4)	59 (-3)	56 (-6)	96 (-4)	96 (-4)	96 (-4)	89 (-11)	2.98	2.59	2.34	2.83
9-July	MC	1920.5 (-47.9)	3234.3 (-12.3)	3228.1 (-12.5)	1017.3 (-72.4)	58 (-4)	60 (-2)	60 (-2)	57 (-5)	97 (-3)	101 (+1)	102 (+2)	95 (-5)	3.07	2.82	2.87	2.68
	EC	2077.0 (-43.7)	3042.5 (-17.5)	2694.4 (-27.0)	312.6 (-91.5)	58 (-4)	58 (-4)	58 (-4)	56 (-6)	97 (-3)	97 (-3)	97 (-3)	89 (-11)	2.96	2.52	2.10	2.83
14-July	MC	1471.1 (-60.1)	2513.7 (-31.9)	2544.4 (-31.0)	942.7 (-74.4)	58 (-4)	60 (-2)	60 (-2)	58 (-4)	98 (-2)	102 (+2)	103 (+3)	96 (-4)	3.14	2.81	2.91	2.70
	EC	1467.9 (-60.2)	2632.2 (-28.7)	2471.7 (-33.0)	429.2 (-88.4)	58 (-4)	59 (-3)	58 (-4)	55 (-7)	97 (-3)	98 (-2)	97 (-3)	91 (-9)	2.91	3.09	2.06	2.81

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.107: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ludhiana, Punjab

DOS	Time period	BASELINE: Yield =4-June (3405.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (2.84)			
		RCP2.6	RCP4.5	RCP6.0	RCP2.6	RCP2.6	RCP2.6	RCP2.6	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	1989.6 (-41.6)*	2396.0 (-29.6)	2348.5 (-31.0)	2166.8 (-36.4)	52 (-6)**	52 (-6)	52 (-6)	52 (-6)	89 (-10)**	89 (-10)	89 (-10)	88 (-11)	1.59	1.52	1.78	1.46
	EC	1132.4 (-66.7)	143.7 (-95.8)	220.9 (-93.5)	37.2 (-98.9)	52 (-6)	51 (-7)	51 (-7)	51 (-7)	88 (-11)	69 (-30)	71 (-28)	66 (-33)	1.40	0.71	0.74	1.52
15-May	MC	2919.4 (-14.3)	3113.1 (-8.6)	3025.0 (-11.2)	2740.4 (-19.5)	53 (-5)	52 (-6)	53 (-5)	52 (-6)	90 (-9)	89 (-10)	91 (-8)	89 (-11)	1.46	1.48	1.51	1.40
	EC	1846.7 (-45.8)	209.0 (-93.9)	203.0 (-94.0)	7.5 (-99.8)	52 (-6)	51 (-7)	51 (-7)	51 (-7)	88 (-11)	71 (-28)	68 (-31)	65 (-34)	1.14	0.77	0.76	1.28
20-May	MC	2528.0 (-25.8)	2519.3 (-26.0)	2623.4 (-23.0)	2336.5 (-31.4)	53 (-5)	53 (-5)	54 (-4)	53 (-5)	90 (-9)	90 (-9)	91 (-8)	89 (-10)	1.79	1.87	1.78	1.75
	EC	2030.7 (-40.4)	676.2 (-80.1)	936.6 (-72.5)	606.3 (-82.2)	52 (-6)	52 (-6)	52 (-6)	51 (-7)	88 (-11)	80 (-19)	83 (-16)	76 (-23)	1.46	0.98	0.92	1.45
25-May	MC	1762.9 (-48.2)	1947.4 (-42.8)	1851.7 (-45.6)	1873.5 (-45.0)	54 (-4)	53 (-5)	55 (-4)	53 (-5)	86 (-13)	87 (-13)	89 (-10)	86 (-13)	2.22	2.23	2.31	2.13
	EC	1692.9 (-50.3)	653.4 (-80.8)	967.3 (-71.6)	510.3 (-85.0)	52 (-6)	52 (-6)	52 (-6)	51 (-7)	84 (-15)	76 (-23)	80 (-19)	72 (-27)	1.91	1.32	1.20	1.81
30-May	MC	2554.1 (-24.99)	1576.3 (-53.7)	1550.8 (-54.4)	1499.9 (-56.0)	54 (-4)	54 (-4)	56 (-2)	54 (-4)	91 (-8)	83 (-16)	89 (-10)	83 (-16)	3.57	2.55	2.74	2.46
	EC	1794.2 (-47.3)	803.9 (-76.4)	914.0 (-73.2)	769.1 (-77.4)	53 (-5)	52 (-6)	52 (-6)	51 (-7)	89 (-10)	80 (-19)	80 (-19)	78 (-21)	3.47	1.62	1.47	2.12

DOS	Time period	BASELINE: Yield =4-June (3405.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (2.84)			
		RCP2.6	RCP4.5	RCP6.0	RCP2.6	RCP2.6	RCP2.6	RCP2.6	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	2463.8 (-27.6)	750.8 (-78.0)	1214.3 (-64.3)	644.6 (-81.1)	55 (-3)	53 (-5)	53 (-5)	53 (-5)	92 (-7)	75 (-24)	83 (-16)	74 (-25)	3.71	3.34	3.38	3.30
	EC	2099.9 (-38.3)	374.6 (-89.0)	378.7 (-88.9)	348.7 (-89.8)	54 (-4)	52 (-6)	52 (-6)	52 (-7)	92 (-7)	70 (-29)	70 (-29)	70 (-29)	3.72	2.91	2.78	2.97
14-June	MC	2142.8 (-37.1)	2457.0 (-27.8)	3081.1 (-9.5)	2174.5 (-36.1)	54 (-4)	54 (-4)	55 (-3)	54 (-4)	92 (-7)	91 (-8)	93 (-6)	89 (-10)	3.33	3.56	3.58	3.55
	EC	1892.3 (-44.4)	1.7 (-100.0)	99.9 (-97.1)	218.6 (-93.6)	54 (-4)	52 (-6)	52 (-6)	52 (-6)	92 (-7)	66 (-33)	68 (-31)	68 (-31)	3.39	3.27	3.25	3.26
19-June	MC	1808.8 (-46.9)	3009.0 (-11.6)	3391.5 (-0.4)	2704.4 (-20.6)	54 (-4)	54 (-4)	55 (-3)	54 (-4)	92 (-7)	92 (-7)	93 (-6)	90 (-9)	2.80	3.59	3.68	3.62
	EC	1553.0 (-54.4)	125.8 (-96.3)	78.9 (-97.7)	584.2 (-82.8)	54 (-4)	52 (-6)	52 (-6)	52 (-6)	92 (-7)	68 (-31)	68 (-31)	73 (-26)	2.92	3.41	3.44	3.40
24-June	MC	2142.8 (-37.1)	2147.4 (-37.0)	2745.2 (-19.4)	2316.1 (-32.0)	54 (-4)	54 (-4)	55 (-3)	54 (-4)	93 (-6)	92 (-7)	93 (-6)	92 (-7)	2.38	3.42	3.75	3.52
	EC	1892.3 (-44.4)	1370.4 (-59.8)	1283.2 (-62.3)	1906.2 (-44.0)	54 (-4)	53 (-5)	53 (-5)	52 (-6)	93 (-6)	89 (-10)	90 (-9)	88 (-11)	2.47	3.44	3.57	3.41

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.108: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ludhiana, Punjab

DOS	Time period	BASELINE: Yield = 4-June (3405.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (2.84)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	2676.9 (-21.4)*	2616.7 (-23.1)	2281.9 (-33.0)	1911.8 (-43.9)	54 (-4)**	52 (-6)	54 (-4)	54 (-4)	92 (-7)**	90 (-9)	93 (-6)	93 (-6)	2.25	1.94	2.18	2.26
	EC	1860.8 (-45.3)	2478.2 (-27.2)	1615.7 (-52.6)	455.4 (-86.6)	54 (-4)	52 (-6)	54 (-4)	52 (-6)	92 (-7)	89 (-10)	92 (-7)	74 (-25)	2.33	1.84	2.33	2.03
15-May	MC	2852.8 (-16.2)	3071.8 (-9.8)	2738.7 (-19.6)	2691.7 (-21.0)	54 (-4)	54 (-4)	54 (-4)	54 (-4)	92 (-7)	91 (-8)	93 (-6)	93 (-6)	1.88	1.74	2.24	2.33
	EC	2039.9 (-40.1)	2311.6 (-32.1)	1939.2 (-43.0)	794.6 (-76.7)	54 (-4)	54 (-4)	54 (-4)	52 (-6)	92 (-7)	91 (-8)	92 (-7)	85 (-14)	2.31	1.78	2.39	2.12
20-May	MC	2313.3 (-32.1)	2293.0 (-32.7)	2748.1 (-19.3)	2624.7 (-22.9)	55 (-3)	54 (-4)	55 (-3)	54 (-4)	92 (-7)	92 (-7)	94 (-5)	93 (-6)	2.02	2.08	2.34	2.39
	EC	1715.6 (-49.6)	1634.3 (-52.0)	1849.4 (-45.7)	768.1 (-77.4)	54 (-4)	54 (-4)	54 (-4)	53 (-5)	92 (-7)	89 (-10)	92 (-7)	84 (-15)	2.29	2.20	2.42	2.34
25-May	MC	2029.6 (-40.4)	2007.8 (-41.0)	2530.0 (-25.7)	2570.9 (-24.5)	55 (-3)	55 (-3)	55 (-3)	55 (-3)	93 (-6)	92 (-7)	95 (-4)	94 (-5)	2.55	2.57	2.69	2.73
	EC	1687.1 (-50.4)	1202.7 (-64.7)	1865.3 (-45.2)	675.1 (-80.2)	55 (-3)	55 (-3)	55 (-3)	53 (-5)	93 (-6)	84 (-15)	92 (-7)	81 (-18)	2.72	2.58	2.71	2.65
30-May	MC	2004.9 (-41.1)	1961.9 (-42.4)	2627.0 (-22.8)	2757.7 (-19.0)	58 (0)	57 (-1)	58 (0)	58 (0)	96 (-3)	95 (-4)	98 (-1)	97 (-2)	3.02	2.97	3.07	3.07
	EC	2095.3 (-38.6)	767.7 (-77.4)	2049.2 (-39.8)	1152.0 (-66.2)	58 (0)	57 (-1)	57 (-1)	53 (-5)	96 (-3)	79 (-20)	95 (-4)	83 (-16)	3.18	2.99	3.14	2.98
09-June	MC	1965.7 (-42.3)	1920.8 (-43.6)	3053.1 (-10.3)	3098.6 (-9.0)	54 (-4)	53 (-5)	56 (-2)	55 (-3)	92 (-7)	91 (-8)	96 (-3)	95 (-4)	3.45	3.40	3.29	3.30
	EC	3577.7 (+5.1)	167.4 (-95.1)	3059.5 (-10.1)	873.5 (-74.3)	55 (-3)	53 (-5)	54 (-4)	52 (-6)	94 (-5)	69 (-30)	93 (-6)	75 (-24)	3.53	3.37	3.40	3.29

DOS	Time period	BASELINE: Yield = 4-June (3405.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (2.84)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
14-June	MC	2423.6 (-28.8)	2292.8 (-32.7)	4105.5 (+20.6)	4280.3 (+25.7)	55 (-3)	55 (-3)	56 (-2)	56 (-2)	94 (-5)	93 (-6)	96 (-3)	96 (-3)	3.54	3.54	3.35	3.35
	EC	4261.8 (+25.2)	2150.8 (-36.8)	3057.4 (-10.2)	2427.7 (-28.7)	55 (-3)	55 (-3)	55 (-3)	53 (-5)	94 (-5)	93 (-6)	94 (-5)	90 (-9)	3.53	3.51	3.43	3.37
19-June	MC	3331.3 (-2.2)	3234.6 (-5.0)	5174.3 (+52.0)	5248.3 (+54.1)	55 (-3)	55 (-3)	56 (-2)	56 (-2)	94 (-5)	94 (-5)	97 (-2)	96 (-3)	3.68	3.65	3.54	3.58
	EC	4098.4 (+20.4)	3032.0 (-11.0)	4140.9 (+21.6)	2470.6 (-27.4)	55 (-3)	55 (-3)	55 (-3)	53 (-5)	95 (-4)	93 (-6)	94 (-5)	91 (-8)	3.60	3.61	3.61	3.53
24-June	MC	3504.7 (+2.9)	3403.6 (-0.04)	4844.0 (+42.3)	4850.4 (+42.4)	55 (-3)	55 (-3)	57 (-1)	56 (-2)	94 (-5)	94 (-5)	99 (0)	98 (-1)	3.63	3.59	3.68	3.65
	EC	4566.3 (+34.1)	3271.6 (-3.9)	4132.8 (+21.4)	2739.9 (-19.5)	55 (-3)	55 (-3)	55 (-3)	54 (-4)	95 (-4)	93 (-6)	95 (-4)	92 (-7)	3.56	3.50	3.76	3.67
29-June	MC	3023.7 (-11.2)	2872.0 (-15.7)	4645.4 (+36.4)	2352.1 (-30.9)	54 (-4)	54 (-4)	55 (-3)	54 (-4)	94 (-5)	94 (-5)	97 (-2)	93 (-6)	3.20	3.17	3.35	3.40
	EC	3965.0 (+16.4)	2797.7 (-17.9)	3547.8 (+4.2)	2217.7 (-34.9)	54 (-4)	54 (-4)	54 (-4)	54 (-4)	95 (-4)	93 (-6)	94 (-5)	92 (-7)	3.29	3.24	3.50	3.60
4-July	MC	2556.3 (-24.9)	2515.4 (-26.1)	4234.6 (+24.4)	3896.8 (+14.4)	55 (-3)	55 (-3)	56 (-2)	55 (-3)	94 (-5)	94 (-5)	98 (-1)	98 (-1)	3.25	2.69	2.95	2.76
	EC	3634.6 (+6.7)	2526.2 (-25.8)	3210.6 (-5.7)	1900.7 (-44.2)	54 (-4)	54 (-4)	55 (-3)	54 (-4)	95 (-4)	94 (-5)	95 (-4)	92 (-7)	3.36	2.96	3.21	3.54
9-July	MC	2299.0 (-32.5)	2344.2 (-31.1)	3715.1 (+9.1)	3470.8 (+1.9)	54 (-4)	54 (-4)	57 (-1)	57 (-1)	95 (-4)	94 (-5)	100 (+1)	100 (+1)	3.45	2.17	2.78	2.59
	EC	3657.7 (+7.4)	2510.8 (-26.3)	3232.0 (-5.1)	1962.7 (-42.4)	55 (-3)	55 (-3)	55 (-3)	54 (-4)	96 (-3)	94 (-5)	96 (-3)	93 (-6)	3.53	2.53	2.99	3.51
14-July	MC	2106.3 (-38.1)	2156.6 (-36.7)	3424.9 (+0.6)	3024.1 (-11.2)	52 (-6)	52 (-6)	54 (-4)	54 (-4)	93 (-6)	93 (-6)	98 (-1)	98 (-1)	1.87	2.02	2.63	2.50
	EC	3395.9 (-0.3)	2277.6 (-13.3)	2950.4 (-13.3)	1771.0 (-48.0)	53 (-5)	52 (-6)	53 (-5)	52 (-6)	95 (-4)	93 (-6)	95 (-4)	91 (-8)	2.58	2.55	3.06	3.58

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.109: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by IPSL-CM5A-MR model during 21st century under optim(MC: Mid-century and EC: End-century)ized sowing dates at Ludhiana, Punjab

DOS	Time period	BASELINE: Yield =4-June (3405.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (2.84)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	2096.4 (-38.4)*	1619.2 (-52.4)	2109.5 (-38.0)	1569.3 (-53.9)	53 (-5)**	54 (-4)	54 (-4)	53 (-5)	91 (-8)**	93 (-6)	93 (-6)	91 (-8)	2.01	2.31	2.23	2.32
	EC	1788.1 (-47.5)	1107.5 (-67.5)	1070.0 (-68.6)	163.0 (-95.2)	52 (-6)	52 (-6)	52 (-6)	51 (-7)	89 (-10)	89 (-10)	89 (-10)	70 (-29)	1.97	2.46	2.39	1.44
15-May	MC	3286.2 (-3.5)	2475.2 (-27.3)	2384.1 (-30.0)	2348.4 (-31.0)	54 (-4)	54 (-4)	54 (-4)	54 (-4)	92 (-7)	93 (-6)	93 (-6)	92 (-7)	1.69	2.34	2.27	2.31
	EC	2974.2 (-12.7)	2389.5 (-29.8)	2783.1 (-18.3)	265.7 (-92.2)	53 (-5)	53 (-5)	52 (-6)	51 (-7)	90 (-9)	90 (-9)	90 (-9)	68 (-31)	1.66	2.48	2.28	1.38
20-May	MC	2693.0 (-20.9)	2328.0 (-31.6)	2291.3 (-32.7)	2069.7 (-39.2)	54 (-4)	55 (-3)	55 (-3)	54 (-4)	92 (-7)	93 (-6)	93 (-6)	92 (-7)	1.84	2.41	2.41	2.36
	EC	2361.5 (-30.7)	2332.6 (-31.5)	2961.2 (-13.0)	1237.3 (-63.7)	54 (-4)	54 (-4)	53 (-5)	51 (-7)	92 (-7)	91 (-8)	90 (-9)	83 (-16)	1.76	2.36	2.15	1.37
25-May	MC	2287.3 (-32.8)	2469.1 (-27.5)	2204.2 (-35.3)	2132.2 (-37.4)	55 (-3)	55 (-3)	55 (-3)	55 (-3)	93 (-6)	94 (-5)	94 (-5)	93 (-6)	2.33	2.67	2.71	2.78
	EC	1796.9 (-47.2)	2088.1 (-38.7)	2017.5 (-40.8)	1072.0 (-68.5)	55 (-3)	54 (-4)	53 (-5)	52 (-6)	92 (-7)	92 (-7)	91 (-8)	80 (-19)	2.27	2.43	2.44	1.71
30-May	MC	1973.9 (-42.0)	2414.5 (-29.1)	2420.8 (-28.9)	2237.1 (-34.3)	58 (0)	58 (0)	58 (0)	57 (-1)	95 (-4)	97 (-2)	97 (-2)	96 (-3)	2.92	2.99	3.07	3.11
	EC	1842.1 (-45.9)	2251.9 (-33.9)	2117.3 (-37.8)	1154.1 (-66.1)	57 (-1)	57 (-1)	54 (-4)	52 (-6)	94 (-5)	94 (-5)	92 (-7)	81 (-18)	2.78	2.88	2.78	2.06
09-June	MC	1859.8 (-45.4)	3071.0 (-9.8)	2780.9 (-18.3)	2372.5 (-30.3)	54 (-4)	55 (-3)	55 (-3)	53 (-5)	92 (-7)	94 (-5)	95 (-4)	92 (-7)	3.41	3.25	3.26	3.37
	EC	1730.8 (-49.2)	2284.5 (-32.9)	1946.0 (-42.9)	480.0 (-85.9)	53 (-5)	53 (-5)	53 (-5)	52 (-6)	90 (-9)	91 (-8)	91 (-8)	71 (-28)	3.31	3.41	3.40	2.86
14-June	MC	2165.7 (-36.4)	3223.6 (-5.3)	3651.0 (+7.2)	3010.6 (-11.6)	56 (-2)	56 (-2)	56 (-2)	55 (-3)	94 (-5)	95 (-4)	95 (-4)	94 (-5)	3.55	3.36	3.36	3.42

DOS	Time period	BASELINE: Yield =4-June (3405.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (2.84)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
	EC	3029.8 (-11.0)	2680.8 (-21.3)	2156.6 (-36.7)	677.5 (-80.1)	55 (-3)	53 (-5)	54 (-4)	52 (-6)	92 (-7)	91 (-8)	91 (-8)	75 (-24)	3.54	3.56	3.52	3.17
19-June	MC	2751.8 (-19.2)	4167.5 (+22.4)	4273.8 (+25.5)	3960.4 (+16.3)	55 (-3)	56 (-2)	55 (-3)	55 (-3)	94 (-5)	95 (-4)	96 (-3)	95 (-4)	3.71	3.50	3.51	3.55
	EC	3232.9 (-5.1)	5059.2 (+48.6)	3070.4 (-9.8)	1008.5 (-70.4)	55 (-3)	55 (-3)	55 (-3)	52 (-6)	93 (-6)	93 (-6)	93 (-6)	81 (-18)	3.68	3.67	3.67	3.36
24-June	MC	2723.2 (-20.0)	4252.6 (+24.9)	3944.3 (+15.8)	4186.6 (+23.0)	55 (-3)	56 (-2)	55 (-3)	55 (-3)	94 (-5)	96 (-3)	96 (-3)	95 (-4)	3.78	3.68	3.57	3.68
	EC	2586.2 (-24.0)	3116.9 (-8.5)	2959.6 (-13.1)	1654.2 (-51.4)	55 (-3)	55 (-3)	55 (-3)	53 (-5)	93 (-6)	93 (-6)	93 (-6)	89 (-10)	3.75	3.69	3.60	3.45
29-June	MC	2188.8 (-35.7)	3771.1 (+10.8)	3335.4 (-2.0)	3609.0 (+6.0)	54 (-4)	54 (-4)	54 (-4)	54 (-4)	93 (-6)	95 (-4)	96 (-3)	94 (-5)	3.42	3.38	3.21	3.38
	EC	2086.6 (-38.7)	2581.7 (-24.1)	2439.0 (-28.4)	1216.0 (-64.3)	54 (-4)	55 (-3)	54 (-4)	53 (-5)	93 (-6)	93 (-6)	92 (-7)	88 (-11)	3.46	3.37	3.19	3.34
4-July	MC	1855.9 (-45.5)	3342.1 (-1.9)	3001.8 (-11.8)	3260.4 (-4.2)	55 (-3)	55 (-3)	55 (-3)	55 (-3)	94 (-5)	96 (-3)	96 (-3)	95 (-4)	2.97	2.87	2.77	2.90
	EC	1713.3 (-49.7)	2082.5 (-38.8)	2044.4 (-40.0)	890.0 (-73.9)	54 (-4)	55 (-3)	55 (-3)	53 (-5)	93 (-6)	93 (-6)	93 (-6)	87 (-12)	3.07	2.79	2.61	3.01
9-July	MC	1798.4 (-47.2)	3252.0 (-4.50)	2910.0 (-14.5)	3043.5 (-10.6)	54 (-4)	56 (-2)	57 (-1)	55 (-3)	94 (-5)	97 (-2)	99 (0)	96 (-3)	2.61	2.60	2.69	2.64
	EC	1503.3 (-55.9)	1791.0 (-47.4)	1822.5 (-46.5)	861.6 (-74.7)	54 (-4)	55 (-3)	55 (-3)	54 (-4)	93 (-6)	93 (-6)	93 (-6)	87 (-12)	2.70	2.32	2.11	2.67
14-July	MC	1577.2 (-53.7)	3053.2 (-10.3)	2681.7 (-21.2)	2884.1 (-15.3)	52 (-6)	54 (-4)	54 (-4)	53 (-5)	92 (-7)	96 (-3)	97 (-2)	95 (-4)	2.53	2.57	2.77	2.68
	EC	1414.3 (-58.5)	1777.8 (-47.8)	1788.1 (-47.5)	747.6 (-78.0)	52 (-6)	52 (-6)	52 (-6)	52 (-6)	91 (-8)	91 (-8)	91 (-8)	84 (-15)	2.80	2.21	2.04	2.38

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.110: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Ludhiana, Punjab

DOS	Time period	BASELINE: 4-June (3405.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (2.84)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	2096.4 (-38.4)*	2112.0 (-38.0)	1973.6 (-42.0)	2123.7 (-37.6)	52 (-6)**	54 (-4)	54 (-4)	52 (-6)	91 (-8)**	93 (-6)	93 (-6)	89 (-10)	1.84	2.30	2.28	1.36
	EC	1788.1 (-47.5)	1768.2 (-48.1)	1354.0 (-60.2)	9.2 (-99.7)	52 (-6)	52 (-6)	52 (-6)	51 (-7)	70 (-29)	89 (-10)	90 (-9)	65 (-34)	1.69	2.30	2.33	0.24
15-May	MC	3358.1 (-1.4)	2575.3 (-24.4)	2279.5 (-33.0)	2848.9 (-16.3)	54 (-4)	54 (-4)	54 (-4)	52 (-6)	92 (-7)	92 (-7)	93 (-6)	90 (-9)	1.48	2.38	2.42	1.26
	EC	3046.0 (-10.5)	2635.2 (-22.6)	2365.8 (-30.5)	221.1 (93.5)	53 (-5)	54 (-4)	54 (-4)	51 (-7)	68 (-31)	91 (-8)	91 (-8)	78 (-21)	1.36	2.16	2.32	0.22
20-May	MC	2774.5 (-18.52)	2500.9 (-26.6)	2516.1 (-26.1)	2498.3 (-26.6)	54 (-4)	54 (-4)	54 (-4)	53 (-5)	92 (-7)	93 (-6)	93 (-6)	90 (-9)	1.73	2.41	2.53	1.67
	EC	2439.8 (-28.3)	2177.9 (-36.0)	2186.0 (-35.8)	240.5 (-92.9)	54 (-4)	54 (-4)	54 (-4)	51 (-7)	83 (-16)	92 (-7)	92 (-7)	76 (-23)	1.85	2.17	2.37	0.26
25-May	MC	2268.4 (-33.4)	2319.4 (-31.9)	2382.6 (-30.0)	2107.3 (-38.1)	55 (-3)	55 (-3)	55 (-3)	53 (-5)	93 (-6)	94 (-5)	94 (-5)	88 (-11)	2.30	2.65	2.71	2.08
	EC	1970.9 (42.1)	1914.1 (-43.8)	2004.5 (-41.1)	204.8 (-94.0)	55 (-3)	55 (-3)	54 (-4)	52 (-6)	80 (-19)	92 (-7)	92 (-7)	71 (-28)	2.36	2.68	2.72	0.35
30-May	MC	2036.0 (-40.2)	2371.1 (-30.4)	2555.0 (-25.0)	1917.8 (-43.7)	57 (-1)	58 (0)	58 (0)	54 (-4)	96 (-3)	97 (-2)	97 (-2)	86 (-13)	2.84	3.14	3.17	2.49
	EC	2119.4 (-37.8)	2144.1 (-37.0)	2195.0 (-35.5)	396.9 (-88.3)	54 (-4)	54 (-4)	55 (-3)	52 (-6)	81 (-18)	92 (-7)	93 (-6)	78 (-21)	2.71	3.05	2.98	0.59
09-June	MC	1909.9 (-43.9)	2636.1 (-22.6)	2810.5 (-17.5)	1136.2 (-66.6)	54 (-4)	55 (-3)	55 (-3)	53 (-5)	92 (-7)	94 (-5)	95 (-4)	82 (-17)	3.42	3.32	3.31	3.36
	EC	1774.1 (-47.9)	2018.0 (-40.7)	2132.2 (-37.4)	255.6 (-92.5)	54 (-4)	53 (-5)	53 (-5)	52 (-6)	71 (-28)	91 (-8)	91 (-8)	68 (-31)	3.42	3.49	3.39	2.23

DOS	Time period	BASELINE: 4-June (3405.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (2.84)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
14-June	MC	2334.1 (-31.4)	3542.3 (+4.0)	3798.3 (+11.5)	2094.4 (-38.5)	55 (-3)	56 (-2)	56 (-2)	55 (-3)	94 (-5)	95 (-4)	96 (-3)	92 (-7)	3.53	3.38	3.35	3.55
	EC	2575.7 (-24.4)	2734.6 (-19.7)	2588.6 (-24.0)	8.5 (-99.8)	55 (-3)	55 (-3)	55 (-3)	52 (-6)	75 (-24)	93 (-6)	94 (-5)	66 (-33)	3.56	3.49	3.43	2.87
19-June	MC	2975.0 (-12.6)	4473.9 (+31.4)	4798.6 (+40.9)	2578.2 (-24.3)	55 (-3)	56 (-2)	56 (-2)	55 (-3)	95 (-4)	96 (-3)	96 (-3)	93 (-6)	3.70	3.52	3.47	3.71
	EC	2985.8 (-12.3)	3626.6 (+6.5)	3391.6 (-0.4)	831.4 (-75.6)	55 (-3)	55 (-3)	55 (-3)	52 (-6)	81 (-18)	94 (-5)	94 (-5)	86 (-14)	3.71	3.63	3.53	3.32
24-June	MC	2971.4 (-12.7)	4089.5 (+20.1)	4295.6 (+26.1)	2620.5 (-23.0)	55 (-3)	56 (-2)	56 (-2)	55 (-3)	95 (-4)	97 (-2)	98 (-1)	93 (-6)	3.76	3.62	3.60	3.71
	EC	3082.3 (-9.5)	3536.5 (+3.9)	3357.9 (-1.4)	973.6 (-71.4)	55 (-3)	55 (-3)	55 (-3)	52 (-6)	89 (-10)	94 (-5)	94 (-5)	85 (-14)	3.82	3.49	3.41	3.32
29-June	MC	2387.6 (-29.9)	3502.5 (+2.9)	3775.4 (+10.9)	2085.5 (-38.8)	54 (-4)	54 (-4)	54 (-4)	54 (-4)	93 (-6)	95 (-4)	96 (-3)	93 (-6)	3.40	3.27	3.30	3.29
	EC	2500.9 (-26.6)	2877.6 (-15.5)	2807.6 (-17.5)	960.9 (-71.8)	54 (-4)	54 (-4)	54 (-4)	52 (-6)	93 (-6)	93 (-7)	94 (-5)	83 (-16)	3.46	3.03	2.99	3.13
4-July	MC	2035.3 (-40.2)	3111.8 (-8.6)	3284.9 (-3.5)	1756.6 (-48.4)	54 (-4)	56 (-2)	56 (-2)	54 (-4)	94 (-5)	96 (-3)	97 (-2)	93 (-6)	2.97	2.79	2.83	2.83
	EC	2105.7 (-38.2)	2567.5 (-24.6)	2422.6 (-28.9)	626.1 (-81.6)	54 (-4)	55 (-3)	55 (-3)	52 (-6)	93 (-5)	94 (-5)	94 (-5)	82 (-17)	2.96	2.48	2.39	3.00
9-July	MC	2003.1 (-41.2)	3010.5 (-11.6)	3181.0 (-6.6)	1264.5 (-62.9)	54 (-4)	57 (-1)	57 (-1)	53 (-5)	94 (-5)	99 (0)	100 (+1)	84 (-15)	2.65	2.65	2.69	3.05
	EC	2171.3 (-36.2)	2635.2 (-22.6)	2183.4 (-35.9)	656.3 (-80.7)	54 (-4)	54 (-4)	55 (-3)	54 (-4)	94 (-5)	94 (-5)	94 (-5)	86 (-13)	2.60	2.31	1.96	2.75
14-July	MC	1665.9 (-51.1)	2858.4 (-16.0)	3058.9 (-10.2)	1621.7 (-52.4)	52 (-6)	54 (-4)	54 (-4)	52 (-6)	92 (-7)	97 (9-2)	98 (-1)	92 (-7)	2.70	2.67	2.73	2.53
	EC	1865.5 (-45.2)	2426.0 (-28.8)	2116.8 (-37.8)	484.5 (-85.8)	52 (-6)	52 (-6)	52 (-6)	52 (-6)	92 (-7)	92 (-7)	93 (-6)	83 (-16)	2.62	2.33	1.87	2.64

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.111: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Amritsar, Punjab

DOS	Time period	BASELINE: Yield= 4-June (5636.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (101 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	4386.9 (-22.2)*	4586.8 (-18.6)	4422.9 (-21.5)	3831.5 (-32.0)	58 (-4)**	57 (-5)	58 (-4)	57 (-5)	94 (-7)**	93 (-8)	95 (-6)	93 (-8)	2.73	2.66	2.74	2.72
	EC	3935.6 (-30.2)	1683.4 (-70.1)	1634.3 (-71.0)	6.0 (-99.9)	58 (-4)	55 (-7)	55 (-7)	55 (-7)	94 (-7)	86 (-15)	84 (-17)	69 (-32)	2.72	2.53	2.54	1.18
15-May	MC	4546.8 (-19.3)	4611.5 (-18.2)	4531.4 (-19.6)	4333.8 (-23.1)	58 (-4)	58 (-4)	58 (-4)	57 (-5)	94 (-7)	94 (-7)	94 (-7)	93 (-8)	2.77	2.66	2.86	2.72
	EC	4224.8 (-25.0)	2697.9 (-52.1)	2494.2 (-55.8)	340.0 (-94.0)	58 (-4)	55 (-7)	55 (-7)	55 (-7)	93 (-8)	90 (-11)	88 (-13)	75 (-26)	2.63	2.30	2.30	1.20
20-May	MC	3995.1 (-29.1)	3770.3 (-33.1)	4237.3 (-24.8)	3736.1 (-33.7)	60 (-2)	60 (-2)	60 (-2)	60 (-2)	96 (-5)	96 (-5)	97 (-4)	95 (-6)	3.10	3.06	3.21	3.06
	EC	3521.7 (-37.5)	2415.8 (-57.1)	2105.4 (-62.7)	371.0 (-93.4)	57 (-5)	57 (-5)	58 (-4)	57 (-5)	95 (-6)	92 (-9)	88 (-13)	76 (-25)	2.99	2.68	2.71	1.35
25-May	MC	4452.2 (-21.0)	4094.9 (-27.3)	5051.3 (-10.4)	3978.1 (-29.4)	61 (-1)	61 (-1)	61 (-1)	60 (-2)	97 (-4)	97 (-4)	98 (-3)	95 (-6)	3.41	3.38	3.45	3.34
	EC	3420.1 (-39.3)	2005.7 (-64.4)	2012.2 (-64.3)	551.3 (-90.2)	61 (-1)	58 (-4)	58 (-4)	57 (-5)	96 (-5)	87 (-14)	88 (-13)	79 (-22)	3.33	3.09	3.08	1.66
30-May	MC	4244.8 (-24.7)	4040.0 (-28.3)	4720.1 (-16.3)	4047.0 (-28.2)	61 (-1)	60 (-2)	61 (-1)	60 (-2)	97 (-4)	96 (-5)	99 (-2)	95 (-6)	3.62	3.59	3.66	3.55
	EC	3804.7 (-32.5)	1577.3 (-72.0)	1750.5 (-68.9)	624.1 (-88.9)	59 (-3)	58 (-4)	58 (-4)	57 (-5)	95 (-6)	82 (-19)	83 (-18)	81 (-20)	3.52	3.15	3.17	1.91

DOS	Time period	BASELINE: Yield= 4-June (5636.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (101 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	3803.7 (-32.5)	3535.4 (-37.3)	4341.9 (-23.0)	3862.5 (-31.5)	60 (-2)	60 (-2)	60 (-2)	59 (-3)	97 (-4)	96 (-5)	97 (-4)	96 (-5)	3.53	3.44	3.53	3.60
	EC	3464.7 (-38.5)	622.0 (-89.0)	1425.2 (-74.7)	21.9 (-99.6)	59 (-3)	58 (-4)	58 (-4)	57 (-5)	95 (-6)	76 (-25)	81 (-20)	71 (-30)	3.65	3.57	3.55	3.03
14-June	MC	4862.0 (-13.8)	4622.0 (-18.0)	5469.9 (-3.0)	4143.9 (-26.5)	60 (-2)	60 (-2)	61 (-1)	60 (-2)	97 (-4)	97 (-4)	99 (-2)	96 (-5)	3.66	3.60	3.64	3.71
	EC	3932.6 (-30.2)	2227.9 (-60.5)	2265.5 (-59.8)	121.4 (-97.8)	59 (-3)	58 (-4)	58 (-4)	57 (-5)	96 (-5)	93 (-8)	93 (-8)	72 (-29)	3.73	3.79	3.76	3.45
19-June	MC	5054.4 (-10.3)	4900.4 (-13.1)	5244.7 (-7.0)	4577.3 (-18.8)	59 (-3)	59 (-3)	59 (-3)	59 (-3)	97 (-4)	96 (-5)	98 (-3)	96 (-5)	3.52	3.47	3.54	3.63
	EC	4725.7 (-16.2)	2747.2 (-51.3)	3008.0 (-46.6)	1076.0 (-80.9)	59 (-3)	58 (-4)	58 (-4)	57 (-5)	96 (-5)	93 (-8)	93 (-8)	88 (-13)	3.57	3.78	3.76	3.54
24-June	MC	4272.9 (-24.2)	4150.2 (-26.4)	4219.6 (-25.1)	3969.0 (-29.6)	59 (-3)	59 (-3)	59 (-3)	59 (-3)	97 (-4)	97 (-4)	98 (-3)	96 (-5)	3.28	3.15	3.34	3.48
	EC	4437.6 (-21.3)	2977.8 (-47.2)	2993.3 (-46.9)	1077.6 (-80.9)	58 (-4)	57 (-5)	57 (-5)	55 (-7)	96 (-5)	92 (-9)	93 (-8)	86 (-15)	3.32	3.58	3.61	3.40
29-June	MC	3432.1 (-39.1)	3344.3 (-40.7)	3329.7 (-40.9)	3009.8 (-46.6)	59 (-3)	58 (-4)	59 (-3)	59 (-3)	97 (-4)	97 (-4)	98 (-3)	97 (-4)	2.80	2.66	2.91	2.98
	EC	3440.8 (-39.0)	2482.7 (-56.0)	2399.6 (-57.4)	955.0 (-83.1)	58 (-4)	56 (-6)	57 (-5)	55 (-7)	96 (-5)	92 (-9)	92 (-9)	85 (-16)	2.74	3.12	3.12	3.17

*%deviation from baseline value**Deviation from baseline in DAS

Table 4.112: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Amritsar, Punjab

DOS	Time period	BASELINE: Yield= 4-June (5636.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (101 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	5265.2 (-6.6)*	4871.7 (-13.6)	5030.8 (-10.8)	5008.1 (-11.1)	59 (-3)**	58 (-4)	58 (-4)	58 (-4)	96 (-5)**	95 (-6)	95 (-6)	95 (-6)	2.70	2.76	2.64	2.68
	EC	4662.2 (-17.3)	4239.8 (-24.8)	3480.4 (-38.3)	1308.6 (-76.8)	59 (-3)	59 (-3)	57 (-5)	56 (-6)	96 (-5)	95 (-6)	93 (-8)	83 (-18)	2.69	2.84	2.78	2.39
15-May	MC	5029.9 (-10.8)	4546.7 (-19.3)	4652.4 (-17.5)	4776.1 (-15.3)	58 (-4)	58 (-4)	58 (-4)	58 (-4)	96 (-5)	95 (-6)	95 (-6)	95 (-6)	2.80	2.86	2.76	2.75
	EC	4389.8 (-22.1)	3963.8 (-29.7)	3325.1 (-41.0)	1644.7 (-70.8)	59 (-3)	58 (-4)	58 (-4)	56 (-6)	96 (-5)	95 (-6)	94 (-7)	85 (-16)	2.88	3.00	2.84	2.59
20-May	MC	4978.0 (-11.7)	4644.2 (-17.6)	4593.5 (-18.5)	4778.0 (-15.2)	61 (-1)	61 (-1)	61 (-1)	60 (-2)	98 (-3)	98 (-3)	98 (-3)	98 (-3)	3.17	3.17	3.12	3.14
	EC	4528.9 (-19.7)	3916.8 (-30.5)	2863.8 (-49.2)	1334.8 (-76.3)	61 (-1)	61 (-1)	60 (-2)	58 (-4)	98 (-3)	97 (-4)	96 (-5)	84 (-17)	3.25	3.27	3.27	2.97
25-May	MC	5723.9 (+1.5)	5568.1 (-1.2)	5319.2 (-5.6)	5665.8 (+0.5)	62 (0)	61 (-1)	61 (-1)	61 (-1)	99 (-2)	99 (-2)	99 (-2)	99 (-2)	3.38	3.38	3.36	3.40
	EC	5985.1 (+6.2)	5194.3 (-7.9)	3636.6 (-35.5)	1624.5 (-71.2)	61 (-1)	61 (-1)	61 (-1)	58 (-4)	99 (-2)	98 (-3)	97 (-4)	88 (-13)	3.43	3.49	3.50	3.24
30-May	MC	5202.0 (-7.7)	5198.1 (-7.8)	4961.9 (-12.0)	5384.6 (-4.5)	62 (0)	62 (0)	62 (0)	62 (0)	100 (-1)	99 (-2)	99 (-2)	99 (-2)	3.49	3.57	3.60	3.64
	EC	5701.3 (+1.1)	5131.4 (-9.0)	3788.9 (-32.8)	1610.6 (-71.4)	62 (0)	61 (-1)	61 (-1)	58 (-4)	100 (-1)	99 (-2)	97 (-4)	83 (-18)	3.62	3.67	3.69	3.37

DOS	Time period	BASELINE: Yield= 4-June (5636.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (101 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	5154.3 (-8.6)	5307.7 (-5.8)	4962.9 (-12.0)	5544.5 (-1.6)	60 (-2)	60 (-2)	60 (-2)	60 (-2)	99 (-2)	98 (-3)	98 (-3)	98 (-3)	3.35	3.43	3.46	3.52
	EC	6332.8 (+12.3)	4863.4 (-13.7)	3441.7 (-38.9)	2417.3 (-57.1)	62 (0)	60 (-2)	59 (-3)	58 (-4)	102 (1)	98 (-3)	96 (-5)	92 (-9)	3.42	3.52	3.61	3.56
14-June	MC	6121.9 (+8.6)	6315.0 (+12.0)	6198.6 (+10.0)	6367.8 (+13.0)	62 (0)	62 (0)	61 (-1)	61 (-1)	101 (0)	100 (-1)	100 (-1)	100 (-1)	3.50	3.59	3.63	3.69
	EC	6484.4 (+15.0)	6297.5 (+11.7)	4413.5 (-21.7)	2231.0 (-60.4)	61 (-1)	61 (-1)	60 (-2)	58 (-4)	101 (0)	100 (-1)	97 (-4)	92 (-9)	3.59	3.61	3.72	3.66
19-June	MC	5973.7 (+6.0)	6086.0 (+8.0)	5820.2 (+3.2)	6107.7 (+8.3)	60 (-2)	59 (-3)	61 (-1)	59 (-3)	99 (-2)	99 (-2)	100 (-1)	99 (-2)	3.44	3.55	3.55	3.64
	EC	6232.0 (+10.6)	6228.8 (+10.5)	4402.1 (-21.9)	2997.7 (-46.8)	59 (-3)	59 (-3)	61 (-1)	58 (-4)	100 (-1)	98 (-3)	98 (-3)	94 (-7)	3.51	3.52	3.68	3.71
24-June	MC	4852.3 (-13.9)	5039.8 (-10.6)	4964.4 (-11.9)	4995.8 (-11.4)	61 (-1)	59 (-3)	59 (-3)	59 (-3)	101 (0)	99 (-2)	98 (-3)	99 (-2)	3.20	3.26	3.28	3.30
	EC	5443.3 (-3.4)	4926.6 (-12.6)	3896.6 (-30.9)	2635.5 (-53.2)	61 (-1)	59 (-3)	58 (-4)	57 (-5)	102 (1)	98 (-3)	96 (-5)	93 (-8)	3.21	3.24	3.39	3.51
29-June	MC	4352.2 (-22.8)	4392.3 (-22.1)	4175.5 (-25.9)	4298.2 (-23.8)	59 (-3)	59 (-3)	59 (-3)	59 (-3)	99 (-2)	99 (-2)	98 (-3)	99 (-2)	2.71	2.80	2.80	2.80
	EC	4552.7 (-19.2)	4094.7 (-27.4)	3109.9 (-44.8)	1982.3 (-64.8)	60 (-2)	59 (-3)	58 (-4)	56 (-6)	101 (0)	98 (-3)	96 (-5)	92 (-9)	2.76	2.85	2.95	3.16

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.113: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Amritsar, Punjab

DOS	Time period	BASELINE: Yield= 4-June (5636.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (101 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	5074.7 (-10.0)*	4387.93 (-22.1)	4680.5 (-17.0)	4350.1 (-22.8)	58 (-4)**	56 (-6)	58 (-4)	56 (-6)	95 (-6)**	93 (-8)	95 (-6)	92 (-9)	2.74	2.77	2.65	2.69
	EC	4125.5 (-26.8)	3520.9 (-37.5)	3223.6 (-42.8)	100.8 (-98.2)	56 (-6)	56 (-6)	55 (-7)	55 (-7)	93 (-8)	91 (-10)	91 (-10)	70 (-31)	2.71	2.68	2.67	1.46
15-May	MC	4819.0 (-14.5)	4663.6 (-17.3)	4526.9 (-19.7)	4752.5 (-15.7)	58 (-4)	57 (-5)	58 (-4)	57 (-5)	95 (-6)	93 (-8)	95 (-6)	93 (-8)	2.83	2.87	2.74	2.60
	EC	4484.0 (-20.4)	4638.1 (-17.7)	3878.4 (-31.2)	1305.2 (-76.8)	58 (-4)	55 (-7)	55 (-7)	55 (-7)	94 (-7)	91 (-10)	91 (-10)	85 (-16)	2.89	2.61	2.78	1.46
20-May	MC	5014.5 (-11.0)	4051.5 (-28.1)	4586.3 (-18.6)	4010.3 (-28.9)	60 (-2)	60 (-2)	61 (-1)	59 (-3)	98 (-3)	97 (-4)	98 (-3)	96 (-5)	3.26	3.16	3.15	3.05
	EC	4276.2 (-24.1)	3983.4 (-29.3)	3198.9 (-43.2)	1330.8 (-76.4)	60 (-2)	59 (-3)	58 (-4)	57 (-5)	97 (-4)	95 (-6)	93 (-8)	85 (-16)	3.27	2.90	3.09	1.75
25-May	MC	5850.6 (+3.8)	4623.0 (-18.0)	5470.8 (-3.0)	4469.2 (-20.7)	61 (-1)	61 (-1)	61 (-1)	60 (-2)	99 (-2)	98 (-3)	98 (-3)	96 (-5)	3.40	3.47	3.44	3.39
	EC	5263.4 (-6.6)	4175.6 (-25.9)	3339.1 (-40.8)	1446.9 (-74.3)	61 (-1)	59 (-3)	58 (-4)	57 (-5)	98 (-3)	95 (-6)	91 (-10)	87 (-14)	3.48	3.33	3.36	2.01
30-May	MC	5279.1 (-6.3)	4346.3 (-22.9)	4826.3 (-14.4)	4476.0 (-20.6)	62 (0)	61 (-1)	62 (0)	60 (-2)	100 (-1)	98 (-3)	99 (-2)	96 (-5)	3.62	3.64	3.59	3.64
	EC	4683.1 (-16.9)	4588.3 (-18.6)	3328.4 (-41.0)	1235.1 (-78.1)	61 (-1)	58 (-4)	58 (-4)	58 (-4)	98 (-3)	94 (-7)	90 (-11)	82 (-19)	3.69	3.44	3.44	2.19

DOS	Time period	BASELINE: Yield= 4-June (5636.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (101 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	5226.5 (-7.3)	3830.0 (-32.0)	4622.0 (-18.0)	3777.7 (-33.0)	61 (-1)	60 (-2)	60 (-2)	60 (-2)	99 (-2)	97 (-4)	98 (-3)	96 (-5)	3.56	3.51	3.52	3.61
	EC	4186.3 (-25.7)	3427.1 (-39.2)	2673.3 (-52.6)	414.9 (-92.6)	60 (-2)	59 (-3)	59 (-3)	58 (-4)	97 (-4)	95 (-6)	94 (-7)	76 (-25)	3.51	3.63	3.55	3.21
14-June	MC	5897.6 (+4.6)	4682.6 (-16.9)	5655.4 (+0.3)	4892.1 (-13.2)	61 (-1)	60 (-2)	62 (0)	60 (-2)	100 (-1)	98 (-3)	100 (-1)	96 (-5)	3.74	3.67	3.71	3.76
	EC	5845.1 (+3.7)	3355.6 (-40.5)	2921.6 (-48.2)	819.0 (-85.5)	60 (-2)	59 (-3)	59 (-3)	58 (-4)	98 (-3)	95 (-6)	94 (-7)	84 (-17)	3.69	3.78	3.69	3.54
19-June	MC	5060.1 (-10.2)	4854.7 (-13.9)	5170.9 (-8.3)	4756.0 (-15.6)	60 (-2)	59 (-3)	59 (-3)	59 (-3)	98 (-3)	97 (-4)	98 (-3)	96 (-5)	3.71	3.54	3.60	3.65
	EC	4929.1 (-12.6)	3653.5 (-35.2)	3220.9 (-42.9)	1364.3 (-75.8)	59 (-3)	59 (-3)	59 (-3)	58 (-4)	97 (-4)	96 (-5)	95 (-6)	90 (-11)	3.60	3.73	3.65	3.54
24-June	MC	3865.8 (-31.4)	3883.5 (-31.1)	4021.8 (-28.7)	3653.8 (-35.2)	59 (-3)	59 (-3)	59 (-3)	59 (-3)	98 (-3)	97 (-4)	98 (-3)	96 (-5)	3.43	3.31	3.37	3.38
	EC	3682.3 (-34.7)	2875.2 (-49.0)	2656.7 (-52.9)	1067.0 (-81.1)	59 (-3)	59 (-3)	58 (-4)	56 (-6)	97 (-4)	96 (-5)	94 (-7)	88 (-13)	3.39	3.57	3.53	3.36
29-June	MC	3136.8 (-44.3)	2951.8 (-47.6)	3260.0 (-42.2)	2863.2 (-49.2)	59 (-3)	58 (-4)	59 (-3)	59 (-3)	98 (-3)	96 (-5)	98 (-3)	96 (-5)	2.92	2.85	2.95	2.90
	EC	2941.0 (-47.8)	2014.2 (-64.3)	2035.6 (-63.9)	650.1 (-88.5)	59 (-3)	59 (-3)	57 (-5)	56 (-6)	97 (-4)	96 (-5)	93 (-8)	87 (-14)	2.98	3.14	3.07	3.01

%deviation from baseline valueDeviation from baseline in DAS

Table 4.114: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Amritsar, Punjab

DOS	Time period	BASELINE: Yield= 4-June (5636.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (101 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	4927.6 (-12.6)*	4865.4 (-13.7)	5061.8 (-10.2)	4487.5 (-20.4)	59 (-3)**	58 (-4)	58 (-4)	58 (-4)	96 (-5)**	95 (-6)	96 (-5)	95 (-6)	2.66	2.65	2.71	2.70
	EC	5065.9 (-10.1)	4268.5 (-24.3)	3778.6 (-33.0)	2564.9 (-54.5)	59 (-3)	56 (-6)	56 (-6)	55 (-7)	96 (-5)	92 (-9)	92 (-9)	89 (-12)	2.67	2.68	2.73	2.28
15-May	MC	4502.3 (-20.1)	4456.4 (-20.9)	4716.9 (-16.3)	4312.9 (-23.5)	58 (-4)	58 (-4)	58 (-4)	58 (-4)	96 (-5)	95 (-6)	95 (-6)	95 (-6)	2.70	2.71	2.80	2.72
	EC	4437.5 (-21.3)	4707.7 (-16.5)	4345.6 (-22.9)	2934.8 (-47.9)	58 (-4)	56 (-6)	57 (-5)	55 (-7)	96 (-5)	92 (-9)	92 (-9)	89 (-12)	2.72	2.70	2.83	2.38
20-May	MC	4454.3 (-21.0)	4245.5 (-24.7)	4642.5 (-17.6)	4034.0 (-28.4)	61 (-1)	61 (-1)	61 (-1)	61 (-1)	98 (-3)	98 (-3)	98 (-3)	97 (-4)	2.94	3.10	3.14	3.03
	EC	4269.9 (-24.2)	3314.3 (-41.2)	3384.0 (-40.0)	2087.7 (-63.0)	61 (-1)	60 (-2)	60 (-2)	57 (-5)	98 (-3)	96 (-5)	95 (-6)	89 (-12)	3.11	3.12	3.16	3.88
25-May	MC	5235.7 (-7.1)	4809.8 (-14.7)	5391.6 (-4.3)	4636.8 (-17.7)	62 (0)	61 (-1)	61 (-1)	61 (-1)	99 (-2)	99 (-2)	99 (-2)	98 (-3)	3.17	3.25	3.32	3.19
	EC	4983.4 (-11.6)	3653.2 (-35.2)	3526.1 (-37.4)	1899.9 (-66.3)	62 (0)	60 (-2)	60 (-2)	58 (-4)	99 (-2)	96 (-5)	96 (-5)	86 (-15)	3.27	3.32	3.41	3.14
30-May	MC	4774.2 (-15.3)	4376.0 (-22.4)	4974.6 (-11.8)	4389.1 (-22.1)	62 (0)	62 (0)	62 (0)	62 (0)	100 (-1)	99 (-2)	100 (-1)	99 (-2)	3.28	3.41	3.55	3.42
	EC	4601.8 (-18.4)	3615.4 (-35.9)	3617.6 (-35.8)	1446.1 (-74.3)	62 (0)	59 (-3)	59 (-3)	58 (-4)	100 (-1)	95 (-6)	95 (-6)	82 (-19)	3.41	3.59	3.63	3.35

DOS	Time period	BASELINE: Yield= 4-June (5636.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (62 DAS)				BASELINE: Maturity=4-June (101 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	5149.1 (-8.7)	4262.5 (-24.4)	4923.1 (-12.7)	4231.9 (-24.9)	63 (-1)	60 (-2)	61 (-1)	61 (-1)	101 (0)	98 (-3)	99 (-2)	98 (-3)	3.18	3.28	3.39	3.27
	EC	4419.0 (-21.6)	3181.5 (-43.6)	2751.3 (-51.2)	1987.8 (-64.7)	60 (-2)	60 (-2)	59 (-3)	58 (-4)	98 (-3)	96 (-5)	95 (-6)	93 (-8)	3.23	3.37	3.38	3.50
14-June	MC	5659.1 (+0.4)	5275.0 (-6.4)	5827.0 (-3.4)	5155.6 (-8.5)	62 (0)	61 (-1)	62 (0)	61 (-1)	100 (-1)	100 (-1)	100 (-1)	99 (-2)	3.21	3.35	3.44	3.31
	EC	5579.9 (-1.0)	4841.9 (-14.1)	3486.8 (-38.1)	1844.2 (-67.3)	62 (0)	59 (-3)	60 (-2)	58 (-4)	100 (-1)	96 (-5)	96 (-5)	93 (-8)	3.24	3.45	3.40	3.56
19-June	MC	5299.9 (-6.0)	5241.4 (-7.0)	5747.4 (+2.0)	5133.0 (-8.9)	59 (-3)	59 (-3)	59 (-3)	59 (-3)	99 (-2)	98 (-3)	98 (-3)	97 (-4)	3.09	3.19	3.34	3.14
	EC	5029.0 (-10.8)	3880.6 (-31.2)	3968.3 (-29.6)	2331.7 (-58.6)	59 (-3)	59 (-3)	59 (-3)	58 (-4)	98 (-3)	96 (-5)	95 (-6)	93 (-8)	2.99	3.19	3.28	3.44
24-June	MC	4398.9 (-22.0)	4534.3 (-19.6)	4801.4 (-14.8)	4233.0 (-24.9)	61 (-1)	60 (-2)	60 (-2)	60 (-2)	101 (0)	99 (-2)	100 (-1)	99 (-2)	2.88	3.04	3.10	2.92
	EC	3765.6 (-33.2)	3085.5 (-45.3)	3443.1 (-38.9)	2116.3 (-62.4)	60 (-2)	58 (-4)	58 (-4)	57 (-5)	100 (-1)	96 (-5)	95 (-6)	92 (-9)	2.73	2.84	3.04	3.13
29-June	MC	3611.2 (-35.9)	3830.7 (-32.4)	4169.7 (-26.0)	3521.6 (-37.5)	61 (-1)	58 (-4)	59 (-3)	59 (-3)	100 (-1)	98 (-3)	98 (-3)	97 (-4)	2.45	2.53	2.60	2.45
	EC	3288.6 (-41.7)	2478.0 (-56.0)	2739.8 (-51.4)	1681.6 (-70.2)	59 (-3)	58 (-4)	58 (-4)	56 (-6)	99 (-2)	95 (-6)	95 (-6)	91 (-10)	2.31	2.42	2.52	2.69

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.115: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Amritsar, Punjab

DOS	Time period	BASELINE: Yield = 4-June (5370.5 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (3.16)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	3513.2 (-34.6)*	3684.5 (-31.4)	3476.6 (-35.3)	3158.7 (-41.2)	54 (-4)**	54 (-4)	54 (-4)	54 (-4)	92 (-7)**	92 (-7)	92 (-7)	91 (-8)	2.70	2.62	2.77	2.74
	EC	3269.1 (-39.1)	1600.5 (-70.2)	1481.1 (-72.4)	103.0 (-98.1)	54 (-4)	54 (-4)	54 (-4)	51 (-7)	91 (-8)	86 (-13)	84 (-15)	67 (-32)	2.68	2.49	2.49	1.09
15-May	MC	4192.5 (-21.9)	4337.7 (-19.2)	3941.9 (-26.6)	3814.5 (-29.0)	54 (-4)	54 (-4)	54 (-4)	54 (-4)	92 (-7)	92 (-7)	92 (-7)	91 (-8)	2.56	2.52	2.59	2.59
	EC	4026.6 (-25.0)	2183.9 (-59.3)	1890.4 (-64.8)	6.4 (-99.9)	54 (-4)	53 (-5)	53 (-5)	51 (-7)	91 (-8)	85 (-14)	82 (-17)	65 (-34)	2.58	2.35	2.33	1.11
20-May	MC	3567.2 (-33.6)	3553.5 (-33.8)	3535.7 (-34.2)	3202.1 (-40.4)	56 (-2)	56 (-2)	56 (-2)	56 (-2)	94 (-5)	94 (-5)	94 (-5)	93 (-6)	2.75	2.71	2.85	2.71
	EC	3296.3 (-38.6)	2382.2 (-55.6)	1895.2 (-64.7)	361.4 (-93.3)	56 (-2)	56 (-2)	56 (-2)	53 (-5)	93 (-6)	91 (-8)	88 (-11)	76 (-23)	2.63	2.46	2.47	1.17
25-May	MC	3612.4 (-32.7)	3408.3 (-36.5)	3959.0 (-26.3)	3255.9 (-39.4)	57 (-1)	57 (-1)	57 (-1)	56 (-2)	94 (-5)	94 (-5)	95 (-4)	94 (-5)	2.98	2.94	3.04	2.94
	EC	2945.6 (-45.1)	1831.8 (-65.9)	1512.4 (-71.8)	322.4 (-94.0)	56 (-2)	56 (-2)	56 (-2)	53 (-5)	94 (-5)	87 (-12)	84 (-15)	71 (-28)	2.91	2.78	2.73	1.41
30-May	MC	4114.0 (-23.4)	3784.5 (-29.5)	4558.2 (-15.1)	3814.7 (-29.0)	57 (-1)	57 (-1)	57 (-1)	57 (-1)	96 (-3)	95 (-4)	96 (-3)	94 (-5)	3.40	3.41	3.46	3.32
	EC	3261.8 (-39.3)	1549.3 (-71.1)	1734.5 (-67.7)	563.8 (-89.5)	57 (-1)	56 (-2)	56 (-2)	53 (-5)	94 (-5)	82 (-17)	83 (-16)	76 (-23)	3.28	2.96	2.92	1.51

DOS	Time period	BASELINE: Yield = 4-June (5370.5 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (3.16)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	3837.2 (-28.6)	2954.1 (-45.0)	3931.8 (-26.8)	3069.6 (-42.8)	57 (-1)	56 (-2)	58 (0)	56 (-2)	95 (-4)	94 (-5)	97 (-2)	93 (-6)	3.58	3.55	3.61	3.52
	EC	2871.6 (-46.5)	583.2 (-89.1)	816.9 (-84.8)	319.4 (-94.0)	55 (-3)	54 (-4)	54 (-4)	53 (-5)	93 (-6)	72 (-27)	74 (-25)	71 (-28)	3.53	3.25	3.25	2.57
14-June	MC	3769.8 (-29.8)	3541.7 (-34.0)	4262.9 (-20.6)	3418.4 (-36.3)	58 (0)	57 (-1)	58 (0)	57 (-1)	96 (-3)	96 (-3)	97 (-2)	95 (-4)	3.44	3.37	3.41	3.50
	EC	3427.4 (-36.2)	2556.1 (-52.4)	2356.4 (-56.1)	133.0 (-97.5)	57 (-1)	54 (-4)	54 (-4)	54 (-4)	95 (-4)	91 (-8)	91 (-8)	69 (-30)	3.54	3.47	3.46	3.10
19-June	MC	4140.3 (-22.9)	4015.8 (-25.2)	4477.6 (-16.6)	3945.4 (-26.5)	57 (-1)	57 (-1)	57 (-1)	57 (-1)	97 (-2)	96 (-3)	97 (-2)	96 (-3)	3.37	3.29	3.36	3.45
	EC	3885.1 (-27.7)	2843.7 (-47.0)	2846.4 (-47.0)	218.6 (-95.9)	57 (-1)	55 (-3)	56 (-2)	54 (-4)	96 (-3)	92 (-7)	92 (-7)	71 (-28)	3.45	3.54	3.52	3.32
24-June	MC	3976.5 (-26.0)	3738.1 (-30.4)	4037.2 (-24.8)	3756.8 (-30.0)	55 (-3)	55 (-3)	55 (-3)	55 (-3)	95 (-4)	94 (-5)	96 (-3)	94 (-5)	3.36	3.20	3.39	3.48
	EC	4025.4 (-25.0)	2672.4 (-50.2)	2707.4 (-49.6)	995.0 (-81.5)	55 (-3)	54 (-4)	54 (-4)	52 (-6)	94 (-5)	91 (-8)	91 (-8)	84 (-15)	3.45	3.56	3.55	3.18
29-June	MC	3263.3 (-39.2)	3079.4 (-42.7)	3259.6 (-39.3)	2992.3 (-44.3)	54 (-4)	54 (-4)	55 (-3)	54 (-4)	94 (-5)	94 (-5)	95 (-4)	94 (-5)	3.36	2.82	3.07	3.17
	EC	3317.0 (-38.2)	2331.1 (-56.6)	2323.9 (-56.7)	900.8 (-83.2)	54 (-4)	54 (-4)	54 (-4)	52 (-6)	94 (-5)	92 (-7)	92 (-7)	84 (-15)	3.42	3.35	3.39	3.18

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.116: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Amritsar, Punjab

DOS	Time period	BASELINE: Yield = 4-June (5370.5 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (3.16)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	4390.6 (-18.2)*	3790.7 (-29.4)	3995.1 (-25.6)	3949.1 (-26.5)	54 (-4)**	54 (-4)	54 (-4)	54 (-4)	94 (-5)**	93 (-6)	93 (-6)	93 (-6)	2.67	2.66	2.59	2.64
	EC	3862.0 (-28.1)	3280.2 (-38.9)	2776.8 (-48.3)	951.6 (-82.3)	55 (-3)	54 (-4)	54 (-4)	52 (-6)	94 (-5)	93 (-6)	92 (-7)	78 (-21)	2.65	2.77	2.79	2.25
15-May	MC	4510.0 (-16.0)	4097.2 (-23.7)	4268.6 (-20.5)	4333.9 (-19.3)	54 (-4)	54 (-4)	54 (-4)	54 (-4)	93 (-6)	93 (-6)	93 (-6)	93 (-6)	2.58	2.61	2.50	2.57
	EC	3829.1 (-28.7)	3534.1 (-34.2)	3236.5 (-39.7)	1639.9 (-69.5)	54 (-4)	54 (-4)	54 (-4)	53 (-5)	93 (-6)	92 (-7)	91 (-8)	85 (-14)	2.61	2.67	2.63	2.37
20-May	MC	4109.8 (-23.5)	3632.7 (-32.4)	3720.7 (-30.7)	3822.6 (-28.8)	57 (-1)	56 (-2)	56 (-2)	56 (-2)	96 (-3)	95 (-4)	95 (-4)	95 (-4)	2.79	2.85	2.82	2.84
	EC	3659.6 (-31.9)	3276.0 (-39.0)	2517.5 (-53.1)	1160.9 (-78.3)	57 (-1)	56 (-2)	56 (-2)	55 (-3)	96 (-3)	95 (-4)	93 (-6)	83 (-16)	2.98	3.01	2.90	2.75
25-May	MC	4450.6 (-17.1)	4227.7 (-21.3)	4107.1 (-23.5)	4383.2 (-18.4)	57 (-1)	57 (-1)	57 (-1)	57 (-1)	97 (-2)	96 (-3)	96 (-3)	96 (-3)	2.98	3.04	3.00	3.07
	EC	4307.6 (-19.8)	3809.6 (-29.1)	2827.5 (-47.3)	1161.6 (-78.4)	57 (-1)	57 (-1)	57 (-1)	55 (-3)	97 (-2)	95 (-4)	94 (-5)	83 (-16)	3.08	3.14	3.14	2.94
30-May	MC	4906.7 (-8.6)	4817.9 (-10.3)	4587.1 (-14.6)	4989.3 (-7.1)	58 (0)	58 (0)	58 (0)	58 (0)	97 (-2)	97 (-2)	97 (-2)	97 (-2)	3.41	3.47	3.44	3.50
	EC	5331.6 (-0.7)	4626.4 (-13.9)	3544.4 (-34.0)	1509.0 (-71.9)	58 (0)	57 (-1)	57 (-1)	55 (-3)	98 (-1)	96 (-3)	95 (-4)	83 (-16)	3.45	3.52	3.53	3.15

DOS	Time period	BASELINE: Yield = 4-June (5370.5 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (3.16)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	4225.4 (-21.3)	4270.4 (-20.5)	4004.4 (-25.4)	4499.0 (-16.2)	58 (0)	58 (0)	58 (0)	58 (0)	98 (-1)	98 (-1)	98 (-1)	98 (-1)	3.49	3.58	3.60	3.68
	EC	4915.5 (-8.5)	5604.1 (+4.3)	3560.3 (-33.7)	966.7 (-82.0)	58 (0)	58 (0)	57 (-1)	54 (-4)	99 (0)	97 (-2)	95 (-4)	75 (-24)	3.56	3.59	3.66	3.32
14-June	MC	4904.1 (-8.7)	5070.8 (-5.6)	4775.3 (-11.1)	5178.1 (-3.6)	58 (0)	58 (0)	58 (0)	58 (0)	98 (-1)	98 (-1)	98 (-1)	98 (-1)	3.23	3.30	3.35	3.41
	EC	5921.7 (+10.3)	4740.5 (-11.7)	3454.7 (-35.7)	2511.7 (-53.2)	58 (0)	57 (-1)	57 (-1)	55 (-3)	99 (0)	97 (-2)	96 (-3)	90 (-9)	3.30	3.30	3.49	3.41
19-June	MC	5319.9 (-0.9)	5316.8 (-1.0)	5173.3 (-3.7)	5406.7 (+0.7)	58 (0)	58 (0)	58 (0)	58 (0)	99 (0)	98 (-1)	98 (-1)	98 (-1)	3.24	3.37	3.40	3.47
	EC	6078.7 (+13.2)	5239.5 (-2.4)	4041.6 (-24.7)	2465.9 (-54.1)	57 (-1)	57 (-1)	57 (-1)	55 (-3)	99 (0)	98 (-1)	96 (-3)	93 (-6)	3.30	3.32	3.49	3.46
24-June	MC	4697.5 (-12.5)	4716.1 (-12.2)	4572.4 (-14.9)	4741.9 (-11.7)	57 (-1)	56 (-2)	56 (-2)	56 (-2)	99 (0)	98 (-1)	98 (-1)	97 (-2)	3.30	3.37	3.43	3.46
	EC	5411.4 (+0.8)	4659.5 (-13.2)	3750.0 (-30.2)	2652.9 (-50.6)	57 (-1)	56 (-2)	55 (-3)	54 (-4)	99 (0)	98 (-1)	94 (-5)	92 (-7)	3.29	3.35	3.43	3.42
29-June	MC	3928.6 (-26.9)	3946.3 (-26.5)	3804.9 (-29.1)	3956.1 (-26.3)	57 (-1)	54 (-4)	54 (-4)	55 (-3)	98 (-1)	96 (-4)	96 (-3)	96 (-3)	2.95	3.00	3.04	3.04
	EC	4410.0 (-17.9)	3887.6 (-27.6)	2867.8 (-46.6)	1991.3 (-62.9)	56 (-2)	54 (-4)	54 (-4)	54 (-4)	99 (0)	96 (-4)	94 (-5)	92 (-7)	3.02	3.00	3.18	3.28

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.117: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Amritsar, Punjab

DOS	Time period	BASELINE: Yield = 4-June (5370.5 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (3.16)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	3969.4 (-26.1)*	3586.9 (-33.2)	3739.9 (-30.4)	3599.9 (-33.0)	54 (-4)**	54 (-4)	54 (-4)	54 (-4)	93 (-6)**	92 (-4)	93 (-6)	92 (-7)	2.76	2.81	2.65	2.73
	EC	3347.5 (-37.7)	2939.2 (-45.3)	2523.9 (-53.0)	198.3 (-96.3)	54 (-4)	54 (-4)	54 (-4)	52 (-6)	93 (-6)	89 (-7)	90 (-9)	69 (-30)	2.74	2.67	2.70	1.34
15-May	MC	4403.7 (-18.0)	3979.0 (-25.9)	4039.1 (-24.8)	4287.3 (-20.2)	54 (-4)	54 (-4)	54 (-4)	54 (-4)	93 (-6)	92 (-4)	93 (-6)	92 (-7)	2.62	2.69	2.55	2.55
	EC	3852.0 (-28.3)	3957.6 (-26.3)	3467.8 (-35.4)	109.4 (-98.0)	54 (-4)	53 (-5)	53 (-5)	51 (-7)	92 (-7)	90 (-6)	90 (-9)	66 (-33)	2.63	2.56	2.57	1.31
20-May	MC	3781.2 (-29.6)	3482.8 (-35.1)	3765.5 (-29.9)	3478.7 (-35.2)	56 (-2)	56 (-2)	57 (-1)	56 (-2)	95 (-4)	92 (-4)	95 (-4)	94 (-5)	2.86	2.88	2.83 (-)	2.69
	EC	3596.5 (-33.0)	3427.3 (-36.2)	2740.8 (-49.0)	1269.8 (-76.4)	56 (-2)	56 (-2)	56 (-2)	54 (-4)	94 (-5)	90 (-6)	92 (-7)	84 (-15)	2.88	2.59	2.85	1.58
25-May	MC	4516.9 (-15.9)	3732.8 (-30.5)	4257.1 (-20.7)	3636.5 (-32.3)	57 (-1)	57 (-1)	57 (-1)	57 (-1)	96 (-3)	92 (-4)	96 (-3)	94 (-5)	3.08	3.02	3.03	2.99
	EC	4022.6 (-25.1)	3491.4 (-35.0)	2800.7 (-47.9)	1149.2 (-78.6)	57 (-1)	56 (-2)	56 (-2)	54 (-4)	95 (-4)	90 (-6)	91 (-8)	80 (-19)	3.08	2.97	3.00	1.74
30-May	MC	5036.0 (-6.2)	4163.9 (-22.5)	4695.4 (-12.6)	4220.0 (-21.4)	58 (0)	58 (0)	58 (0)	57 (-1)	97 (-2)	93 (-3)	97 (-2)	95 (-4)	3.50	3.50	3.48	3.42
	EC	4623.4 (-13.9)	4162.4 (-22.5)	3280.3 (-38.9)	1321.3 (-75.4)	57 (-1)	57 (-1)	57 (-1)	54 (-4)	96 (-3)	91 (-5)	90 (-9)	82 (-17)	3.51	3.20	3.24	1.80

DOS	Time period	BASELINE: Yield = 4-June (5370.5 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (3.16)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	4240.0 (-21.0)	3573.9 (-33.4)	3840.5 (-28.5)	3233.9 (-39.8)	58 (0)	57 (-1)	58 (0)	56 (-2)	98 (-1)	93 (-3)	97 (-2)	94 (-5)	3.70	3.66	3.65	3.64
	EC	4477.3 (-16.6)	3076.3 (-42.7)	2145.9 (-60.0)	533.7 (-90.1)	57 (-1)	55 (-3)	55 (-3)	54 (-4)	96 (-3)	91 (-5)	87 (-12)	72 (-27)	3.64	3.40	3.31	2.79
14-June	MC	4609.4 (-14.2)	3723.8 (-30.7)	4374.7 (-18.5)	3692.6 (-31.2)	58 (0)	58 (0)	58 (0)	57 (-1)	98 (-1)	93 (-3)	97 (-2)	96 (-3)	3.43	3.44	3.42	3.55
	EC	4031.7 (-24.9)	2708.3 (-49.6)	2534.4 (-52.8)	946.3 (-82.4)	58 (0)	55 (-3)	55 (-3)	54 (-4)	97 (-2)	90 (-6)	92 (-7)	81 (-18)	3.45	3.53	3.39	3.19
19-June	MC	4520.8 (-15.8)	3968.7 (-26.1)	4498.4 (-16.2)	3996.2 (-25.6)	58 (0)	57 (-1)	58 (0)	57 (-1)	98 (-1)	94 (-2)	98 (-1)	96 (-3)	3.48	3.40	3.44	3.51
	EC	4121.7 (-23.2)	3042.6 (-43.3)	2765.2 (-48.5)	843.1 (-84.3)	57 (-1)	58 (0)	57 (-1)	54 (-4)	97 (-2)	91 (-5)	94 (-5)	86 (-13)	3.44	3.53	3.46	3.31
24-June	MC	4017.7 (-25.2)	3550.4 (-33.9)	3844.6 (-28.4)	3575.3 (-33.4)	56 (-2)	56 (-2)	56 (-2)	55 (-3)	96 (-3)	94 (-2)	96 (-3)	94 (-5)	3.50	3.39	3.46	3.47
	EC	3652.1 (-32.0)	2839.2 (-47.1)	2555 (-52.4)	1192.8 (-77.8)	55 (-3)	55 (-3)	55 (-3)	53 (-5)	95 (-4)	92 (-4)	92 (-7)	87 (-12)	3.41	3.55	3.48	3.18
29-June	MC	3011.1 (-43.9)	2874.7 (-46.5)	3155.2 (-41.2)	2802.1 (-47.8)	55 (-3)	54 (-4)	54 (-4)	54 (-4)	96 (-3)	95 (-1)	95 (-4)	94 (-5)	3.16	3.05	3.16	3.11
	EC	2877.0 (-46.4)	2046.9 (-61.9)	1898.1 (-64.7)	771.7 (-85.6)	54 (-4)	55 (-3)	54 (-4)	53 (-5)	94 (-5)	93 (-3)	92 (-7)	86 (-13)	3.17	3.39	3.31	3.09

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.118: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Amritsar, Punjab

DOS	Time period	BASELINE: Yield = 4-June (5370.5 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (3.16)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	4048.8 (-24.6)*	3980.7 (-25.9)	4023.6 (-25.1)	3556.2 (-33.8)	54 (-4)**	54 (-4)	54 (-4)	54 (-4)	94 (-5)**	93 (-6)	94 (-5)	93 (-6)	2.55	2.55	2.63	2.62
	EC	4085.2 (-23.9)	3639.5 (-32.2)	3259.2 (-39.3)	2102.9 (-60.8)	54 (-4)	54 (-4)	54 (-4)	52 (-6)	94 (-5)	92 (-7)	91 (-8)	87 (-12)	2.55	2.71	2.77	2.19
15-May	MC	3910.8 (-27.2)	3989.5 (-25.7)	4074.7 (-24.1)	3723.7 (-30.7)	54 (-4)	54 (-4)	54 (-4)	54 (-4)	94 (-5)	93 (-6)	93 (-6)	93 (-6)	2.55	2.55	2.62	2.61
	EC	4045.0 (-24.7)	4101.8 (-23.6)	3651.6 (-32.0)	2758.2 (-48.6)	54 (-4)	54 (-4)	54 (-4)	52 (-6)	93 (-6)	92 (-7)	91 (-8)	87 (-12)	2.56	2.59	2.70	2.14
20-May	MC	3540.9 (-34.1)	3575.3 (-33.4)	3759.1 (-30.0)	3374.9 (-37.2)	57 (-1)	57 (-1)	56 (-2)	56 (-2)	96 (-3)	95 (-4)	95 (-4)	95 (-4)	2.75	2.80	2.87	2.76
	EC	3562.4 (-33.7)	3145.0 (-41.4)	2942.3 (-45.2)	2330.0 (-56.6)	57 (-1)	56 (-2)	56 (-2)	54 (-4)	95 (-4)	94 (-5)	93 (-6)	89 (-10)	2.82	2.77	2.83	2.57
25-May	MC	3967.3 (-26.1)	3751.0 (-30.1)	4141.2 (-22.9)	3598.4 (-33.0)	57 (-1)	57 (-1)	57 (-1)	57 (-1)	97 (-2)	96 (-3)	96 (-3)	96 (-3)	2.85	2.90	2.97	2.82
	EC	3720.2 (-30.7)	3021.7 (-43.7)	2927.4 (-45.5)	1725.0 (-67.9)	57 (-1)	57 (-1)	57 (-1)	54 (-4)	97 (-2)	94 (-5)	94 (-5)	85 (-14)	2.94	2.96	2.99	2.81
30-May	MC	4254.8 (-20.8)	4009.8 (-25.3)	4520.2 (-15.8)	4022.7 (-25.1)	58 (0)	58 (0)	58 (0)	58 (0)	98 (-1)	97 (-2)	97 (-2)	97 (-2)	3.19	3.30	3.37	3.25
	EC	3973.2 (-26.0)	3214.9 (-40.1)	3287.7 (-38.8)	1669.4 (-68.9)	58 (0)	57 (-1)	57 (-1)	55 (-3)	97 (-2)	95 (-4)	94 (-5)	82 (-17)	3.34	3.38	3.46	3.08

DOS	Time period	BASELINE: Yield = 4-June (5370.5 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (58 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (3.16)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	4035.5 (-24.9)	3583.4 (-33.3)	3941.7 (-26.6)	4040.9 (-24.8)	58 (0)	58 (0)	58 (0)	58 (0)	99 (0)	98 (-1)	98 (-1)	97 (-2)	3.36	3.47	3.54	3.41
	EC	3804.6 (-29.1)	2609.3 (-51.4)	2597.5 (-51.6)	465.9 (-91.3)	58 (0)	56 (-2)	55 (-3)	54 (-4)	98 (-1)	93 (-6)	93 (-6)	74 (-25)	3.43	3.54	3.48	3.41
14-June	MC	4510.5 (-16.0)	4068.9 (-24.2)	4550.6 (-15.3)	4024.2 (-25.1)	58 (0)	58 (0)	58 (0)	58 (0)	98 (-1)	97 (-2)	98 (-1)	97 (-2)	2.97	3.12	3.20	3.08
	EC	4361.7 (-18.8)	3087.3 (-42.5)	2763.3 (-48.6)	1818.3 (-66.1)	58 (0)	57 (-1)	57 (-1)	55 (-3)	98 (-1)	95 (-4)	95 (-4)	91 (-8)	3.03	3.27	3.19	3.34
19-June	MC	4688.5 (-12.7)	4303.0 (-19.9)	4811.6 (-10.4)	4230.2 (-21.2)	57 (-1)	57 (-1)	57 (-1)	57 (-1)	98 (-1)	97 (-2)	98 (-1)	97 (-2)	2.95	3.04	3.16	2.99
	EC	4317.1 (-19.6)	3382.8 (-37.0)	3177.9 (-40.8)	2233.5 (-58.4)	57 (-1)	57 (-1)	57 (-1)	55 (-3)	98 (-1)	96 (-3)	95 (-4)	92 (-7)	2.88	3.12	3.07	3.27
24-June	MC	4202.1 (-21.8)	4152.4 (-22.7)	4504.5 (-16.1)	3879.9 (-27.8)	57 (-1)	57 (-1)	57 (-1)	57 (-1)	98 (-1)	97 (-2)	98 (-1)	97 (-2)	2.90	3.07	3.18	2.93
	EC	3801.9 (-29.2)	2964.7 (-44.8)	3055.5 (-43.1)	1918.3 (-64.3)	57 (-1)	55 (-3)	55 (-3)	54 (-4)	98 (-1)	93 (-6)	93 (-6)	91 (-8)	2.74	2.89	3.01	3.14
29-June	MC	3482.6 (-35.1)	3466.7 (-35.4)	3813.7 (-29.0)	3194.6 (-40.5)	56 (-2)	55 (-3)	56 (-2)	55 (-3)	98 (-1)	96 (-3)	97 (-2)	96 (-3)	2.63	2.70	2.82	2.57
	EC	2871.4 (-46.5)	2288.5 (-57.4)	2512.0 (-53.2)	1542.7 (-71.3)	56 (-2)	54 (-4)	54 (-4)	54 (-4)	97 (-2)	93 (-6)	93 (-6)	90 (-9)	2.39	2.49	2.65	2.81

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.119: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Patiala, Punjab

DOS	Time period	BASELINE: Yield= 4-June (5726.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	4545.5 (-20.6)*	4636.0 (-19.0)	4696.3 (-18.0)	4371.0 (-23.7)	57 (-3)**	56 (-4)	57 (-3)	56 (-4)	93 (-5)**	92 (-6)	94 (-4)	92 (-6)	2.70	2.72	2.61	2.65
	EC	3790.6 (-33.8)	778.4 (-86.4)	1501.4 (-73.8)	0.7 (-99.9)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	91 (-7)	75 (-23)	79 (-19)	68 (-30)	2.68	2.56	2.57	1.64
15-May	MC	4213.5 (-26.4)	4432.2 (-22.6)	4334.5 (-24.3)	4221.1 (-26.3)	58 (-2)	57 (-3)	58 (-2)	57 (-3)	94 (-4)	93 (-5)	95 (-3)	93 (-5)	2.86	2.84	2.79	2.77
	EC	3873.6 (-32.3)	2726.2 (-52.4)	2928.3 (-48.9)	484.2 (-91.5)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	91 (-7)	90 (-8)	90 (-8)	75 (-23)	2.82	2.42	2.42	1.79
20-May	MC	4005.1 (-30.1)	4025.8 (-29.7)	4272.0 (-25.4)	3739.4 (-34.7)	58 (-2)	57 (-3)	58 (-2)	57 (-3)	94 (-4)	94 (-4)	95 (-3)	93 (-5)	3.01	3.02	2.98	2.98
	EC	3332.9 (-41.8)	2379.9 (-58.4)	2537.4 (-55.7)	510.0 (-91.1)	58 (-2)	55 (-5)	55 (-5)	55 (-5)	93 (-5)	90 (-8)	90 (-8)	74 (-24)	3.08	2.69	2.75	1.99
25-May	MC	4725.1 (-17.5)	4688.3 (-18.1)	5198.3 (-9.2)	4294.6 (-25.0)	58 (-2)	57 (-3)	58 (-2)	57 (-3)	94 (-4)	94 (-4)	95 (-3)	93 (-5)	3.32	3.33	3.29	3.31
	EC	3807.5 (-33.5)	2211.4 (-61.4)	2375.4 (-58.5)	655.7 (-88.6)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	92 (-6)	85 (-13)	87 (-11)	75 (-23)	3.34	3.20	3.20	2.26
30-May	MC	4995.8 (-12.8)	5038.2 (-12.0)	5223.5 (-8.8)	4634.2 (-19.1)	57 (-3)	57 (-3)	58 (-2)	57 (-3)	94 (-4)	94 (-4)	95 (-3)	93 (-5)	3.61	3.64	3.57	3.62
	EC	4377.4 (-23.6)	1856.2 (-67.6)	2317.1 (-59.5)	853.9 (-85.1)	57 (-3)	56 (-4)	56 (-4)	55 (-5)	93 (-5)	80 (-18)	83 (-15)	78 (-20)	3.65	3.29	3.37	2.58

DOS	Time period	BASELINE: Yield= 4-June (5726.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	4472.7 (-21.9)	4323.2 (-24.5)	4876.0 (-14.9)	3973.2 (-30.6)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	95 (-3)	95 (-3)	95 (-3)	94 (-4)	3.63	3.64	3.53	3.61
	EC	3721.2 (-35.0)	1041.3 (-81.8)	1748.4 (-69.5)	420.4 (-92.7)	57 (-3)	56 (-4)	56 (-4)	55 (-5)	94 (-4)	77 (-21)	82 (-16)	73 (-25)	3.69	3.60	3.62	3.49
14-June	MC	5664.4 (-1.1)	5367.9 (-6.3)	6151.2 (+7.4)	4962.3 (-13.3)	58 (-2)	58 (-2)	59 (-1)	58 (-2)	95 (-3)	95 (-3)	96 (-2)	95 (-3)	3.80	3.79	3.76	3.74
	EC	4437.6 (-22.5)	2436.6 (-57.4)	2578.4 (-55.0)	582.6 (-89.8)	57 (-3)	56 (-4)	56 (-4)	55 (-5)	94 (-4)	91 (-7)	91 (-7)	75 (-23)	3.67	3.70	3.70	3.62
19-June	MC	5892.6 (+2.9)	5477.3 (-4.3)	5995.0 (+4.7)	5263.8 (-8.1)	59 (-1)	60 (0)	60 (0)	59 (-1)	97 (-1)	97 (-1)	98 (0)	96 (-2)	3.91	3.84	3.82	3.80
	EC	4982.9 (-13.0)	3196.3 (-44.2)	3361.8 (-41.3)	1744.7 (-69.5)	59 (-1)	56 (-4)	56 (-4)	55 (-5)	96 (-2)	92 (-6)	92 (-6)	88 (-10)	3.68	3.76	3.76	3.65
24-June	MC	4937.2 (-13.8)	4460.7 (-22.1)	4963.7 (-13.3)	4288.8 (-25.1)	59 (-1)	59 (-1)	60 (0)	59 (-1)	98 (0)	97 (-1)	98 (0)	97 (-1)	3.43	3.38	3.37	3.57
	EC	4121.7 (-28.0)	3182.9 (-44.4)	3178.9 (-44.5)	1743.0 (-69.6)	59 (-1)	56 (-4)	56 (-4)	55 (-5)	96 (-2)	92 (-6)	93 (-5)	88 (-10)	3.26	3.51	3.50	3.57
29-June	MC	4204.9 (-26.6)	3721.1 (-35.0)	4145.6 (-27.6)	3598.7 (-37.1)	59 (-1)	59 (-1)	59 (-1)	59 (-1)	97 (-1)	97 (-1)	98 (0)	97 (-1)	3.00	2.90	2.95	2.85
	EC	3412.0 (-40.4)	2530.7 (-55.8)	2597.3 (-54.6)	1484.9 (-74.1)	58 (-2)	56 (-4)	56 (-4)	55 (-5)	96 (-2)	92 (-6)	92 (-6)	88 (-10)	2.65	2.97	2.96	3.20

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.120: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Patiala, Punjab

DOS	Time period	BASELINE: Yield= 4-June (5726.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	4634.8 (-19.1)*	4556.0 (-20.4)	4712.8 (-17.7)	4177.7 (-27.0)	58 (-2)**	58 (-2)	58 (-2)	58 (-2)	95 (-3)**	95 (-6)	95 (-3)	94 (-4)	2.67	2.75	2.70	2.68
	EC	4224.8 (-26.2)	4030.9 (-29.6)	3592.4 (-37.3)	1505.5 (-73.7)	58 (-2)	58 (-2)	57 (-3)	55 (-5)	95 (-3)	95 (-6)	93 (-3)	86 (-12)	2.60	2.75	2.69	2.43
15-May	MC	4488.5 (-21.6)	4441.7 (-22.4)	4460.7 (-22.1)	4226.3 (-26.2)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	95 (-3)	95 (-6)	95 (-3)	95 (-3)	2.91	2.97	2.96	2.93
	EC	4094.8 (-28.5)	3836.8 (-33.0)	3294.8 (-42.5)	1499.2 (-73.8)	58 (-2)	58 (-2)	58 (-2)	55 (-5)	95 (-3)	95 (-6)	94 (-4)	84 (-14)	2.85	2.98	2.89	2.43
20-May	MC	4731.8 (-17.4)	4775.2 (-16.6)	4766.9 (-16.8)	4674.9 (-18.4)	59 (-1)	58 (-2)	58 (-2)	58 (-2)	96 (-2)	98 (-3)	96 (-2)	95 (-3)	3.06	3.11	3.14	3.11
	EC	4324.3 (-24.5)	3891.7 (-32.0)	3172.8 (-44.6)	1096.1 (-80.8)	58 (-2)	58 (-2)	58 (-2)	55 (-5)	96 (-2)	97 (-4)	94 (-4)	81 (-17)	3.12	3.14	3.07	2.80
25-May	MC	5710.7 (-0.3)	6023.8 (+5.2)	5673.6 (-0.9)	5987.2 (+4.5)	59 (-1)	59 (-1)	59 (-1)	59 (-1)	97 (-1)	99 (-2)	97 (-1)	96 (-2)	3.32	3.35	3.37	3.33
	EC	5630.4 (-1.7)	4932.0 (-13.9)	3972.2 (-30.6)	1791.5 (-68.7)	59 (-1)	59 (-1)	59 (-1)	56 (-4)	97 (-1)	98 (-3)	94 (-4)	84 (-14)	3.30	3.38	3.28	3.10
30-May	MC	5770.4 (+0.8)	6098.0 (+6.48)	5756.8 (+0.5)	6231.9 (+8.8)	60 (0)	58 (-2)	59 (-1)	57 (-3)	98 (0)	99 (-2)	97 (-1)	95 (-3)	3.61	3.61	3.63	3.57
	EC	5705.3 (-0.4)	5115.3 (-10.7)	4162.6 (-27.3)	1648.8 (-71.2)	60 (0)	57 (-3)	57 (-3)	56 (-4)	97 (-1)	99 (-2)	93 (-5)	80 (-18)	3.54	3.62	3.53	3.33

DOS	Time period	BASELINE: Yield= 4-June (5726.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	6109.9 (+6.7)	6476.1 (+13.1)	6134.6 (+7.1)	6553.7 (-14.4)	59 (-1)	58 (-2)	58 (-2)	58 (-2)	98 (0)	98 (-3)	97 (-1)	97 (-1)	3.57	3.65	3.63	3.64
	EC	6385.0 (+11.5)	5148.2 (-10.1)	4072.2 (-28.9)	2781.1 (-51.4)	60 (0)	58 (-2)	57 (-3)	56 (-4)	99 (1)	98 (-3)	94 (-4)	91 (-7)	3.58	3.71	3.53	3.67
14-June	MC	6856.3 (+19.7)	7158.9 (+25.0)	6996.3 (+22.2)	7009.5 (+22.4)	60 (0)	60 (0)	60 (0)	59 (-1)	98 (0)	100 (-1)	98 (0)	98 (0)	3.78	3.90	3.63	3.81
	EC	6798.9 (+18.7)	6399.4 (+11.7)	5392.3 (-5.8)	3190.2 (-44.3)	59 (-1)	59 (-1)	57 (-3)	56 (-4)	99 (1)	100 (-1)	95 (-3)	91 (-7)	3.75	3.88	3.64	3.79
19-June	MC	6660.7 (+16.3)	6716.3 (+17.3)	6570.6 (+14.7)	6499.4 (+13.5)	60 (0)	59 (-1)	60 (0)	59 (-1)	99 (1)	99 (-2)	99 (1)	99 (1)	3.86	3.98	3.89	3.84
	EC	6680.1 (+16.6)	6056.2 (+5.7)	5002.9 (-12.6)	3209.3 (-44.0)	59 (-1)	59 (-1)	59 (-1)	56 (-4)	99 (1)	98 (-3)	96 (-2)	92 (-6)	3.86	3.97	3.91	3.79
24-June	MC	5455.0 (-4.7)	5362.1 (-6.4)	5327.2 (-7.0)	5323.7 (-7.0)	59 (-1)	60 (0)	60 (0)	60 (0)	99 (1)	99 (-2)	99 (1)	99 (1)	3.34	3.41	3.38	3.31
	EC	5765.9 (+0.7)	4714.3 (-17.9)	4025.5 (-29.7)	2669.8 (-53.4)	59 (-1)	59 (-1)	59 (-1)	56 (-4)	100 (2)	98 (-3)	97 (-1)	92 (-6)	3.49	3.48	3.52	3.54
29-June	MC	4352.2 (-22.8)	4583.6 (-20.0)	4463.3 (-22.1)	4393.5 (-23.3)	59 (-1)	60 (0)	59 (-1)	60 (0)	99 (1)	99 (-2)	99 (1)	99 (1)	2.92	3.04	3.00	2.89
	EC	4552.7 (-19.2)	3869.3 (-32.4)	3290.7 (-42.5)	2079.1 (-63.7)	59 (-1)	59 (-1)	59 (-1)	56 (-4)	100 (2)	98 (-3)	97 (-1)	92 (-6)	3.10	3.04	3.03	2.90

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.121: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Patiala, Punjab

DOS	Time period	BASELINE: Yield= 4-June (5726.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	4832.8 (-15.6)*	4650.6 (-19.4)	4839.3 (-15.5)	4950.3 (-13.6)	57 (-3)**	56 (-4)	56 (-4)	56 (-4)	94 (-4)**	93 (-5)	93 (-5)	92 (-6)	2.74	2.77	2.70	2.61
	EC	4491.9 (-21.6)	3673.2 (-35.9)	3358.8 (-41.3)	5.2 (-99.9)	56 (-4)	55 (-5)	56 (-4)	55 (-5)	93 (-5)	91 (-7)	91 (-7)	69 (-29)	2.71	2.74	2.70	1.89
15-May	MC	4610.7 (-19.5)	4613.4 (-19.4)	4414.7 (-22.9)	4761.7 (-16.9)	58 (-2)	57 (-3)	57 (-3)	56 (-4)	95 (-3)	93 (-5)	94 (-4)	93 (-5)	2.94	2.88	2.89	2.76
	EC	4114.0 (-28.2)	3911.7 (-31.7)	3784.1 (-33.9)	1261.2 (-78.0)	58 (-2)	56 (-4)	56 (-4)	55 (-5)	95 (-3)	91 (-7)	91 (-7)	83 (-15)	2.86	2.67	2.67	1.03
20-May	MC	4948.0 (-13.6)	4196.7 (-26.7)	4507.7 (-21.3)	4323.3 (-24.5)	58 (-2)	58 (-2)	58 (-2)	57 (-3)	96 (-2)	95 (-3)	95 (-3)	94 (-4)	3.11	3.01	3.06	2.97
	EC	4233.8 (-26.1)	3333.7 (-41.8)	3455.8 (-39.7)	1223.9 (-78.6)	58 (-2)	56 (-4)	56 (-4)	55 (-5)	95 (-3)	91 (-7)	91 (-7)	81 (-17)	3.06	2.90	2.89	2.28
25-May	MC	6166.1 (+7.7)	4814.6 (-15.9)	5607.5 (-2.1)	5128.6 (-10.4)	59 (-1)	57 (-3)	58 (-2)	57 (-3)	97 (-1)	94 (-4)	96 (-2)	94 (-4)	3.39	3.32	3.37	3.33
	EC	5538.4 (-3.3)	3869.4 (-32.4)	3670.7 (-35.9)	1674.5 (-70.8)	59 (-1)	56 (-4)	56 (-4)	55 (-5)	96 (-2)	91 (-7)	92 (-6)	85 (-13)	3.35	3.31	3.27	2.51
30-May	MC	5928.5 (+3.5)	4981.7 (-13.0)	5822.1 (+1.7)	5548.1 (-3.1)	59 (-1)	58 (-2)	57 (-3)	57 (-3)	98 (0)	94 (-4)	95 (-3)	94 (-4)	3.66	3.62	3.61	3.62
	EC	5695.7 (-0.5)	4040.6 (-29.4)	4161.9 (-27.3)	1497.6 (-73.8)	57 (-3)	56 (-4)	56 (-4)	56 (-4)	95 (-3)	91 (-7)	92 (-6)	80 (-18)	3.61	3.56	3.55	2.67

DOS	Time period	BASELINE: Yield= 4-June (5726.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	5899.9 (+3.0)	4378.8 (-23.5)	5390.0 (-5.9)	4761.1 (-16.9)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	97 (-1)	95 (-3)	96 (-2)	95 (-3)	3.60	3.62	3.65	3.64
	EC	5147.7 (-10.1)	2939.6 (-48.7)	3317.3 (-42.1)	204.0 (-96.4)	58 (-2)	57 (-3)	57 (-3)	56 (-4)	95 (-3)	93 (-5)	93 (-5)	71 (-27)	3.63	3.72	3.67	3.41
14-June	MC	6832.9 (+19.3)	5630.4 (-1.7)	6628.5 (+15.7)	5811.4 (+1.5)	60 (0)	58 (-2)	59 (-1)	58 (-2)	98 (0)	96 (-2)	97 (-1)	95 (-3)	3.84	3.82	3.85	3.83
	EC	6461.1 (+12.8)	3417.5 (-40.3)	3297.1 (-42.4)	1196.3 (-79.1)	60 (0)	57 (-3)	57 (-3)	56 (-4)	98 (0)	93 (-5)	93 (-5)	86 (-12)	3.83	3.72	3.73	3.52
19-June	MC	6303.5 (+10.1)	5515.1 (-3.7)	6176.8 (+7.9)	5462.9 (-4.6)	60 (0)	60 (0)	60 (0)	60 (0)	98 (0)	97 (-1)	98 (0)	97 (-1)	3.93	3.94	3.95	3.90
	EC	5971.0 (+4.3)	4036.6 (-29.5)	3772.0 (-42.4)	1653.4 (-71.1)	60 (0)	57 (-3)	57 (-3)	56 (-4)	98 (0)	93 (-5)	93 (-5)	89 (-9)	3.91	3.76	3.74	3.48
24-June	MC	4979.0 (-13.0)	4564.1 (-20.3)	4990.2 (-12.9)	4333.7 (-24.3)	60 (0)	59 (0)	60 (0)	60 (0)	99 (1)	97 (-1)	98 (0)	97 (-1)	3.37	3.41	3.38	3.44
	EC	4704.5 (-17.8)	3004.2 (-47.5)	2837.1 (-50.4)	1434.6 (-74.9)	60 (0)	59 (0)	59 (-1)	56 (-4)	98 (0)	95 (-3)	95 (-3)	88 (-10)	3.43	3.40	3.31	3.45
29-June	MC	4140.3 (-27.7)	3841.1 (-32.9)	4180.5 (-27.0)	3504.1 (-38.8)	60 (0)	59 (-1)	59 (-1)	59 (-1)	98 (0)	97 (-1)	98 (0)	97 (-1)	2.95	2.95	2.91	3.03
	EC	3814.1 (-33.4)	2506.2 (-56.2)	2355.0 (-58.9)	955.1 (-83.3)	59 (-1)	58 (-2)	58 (-2)	56 (-4)	98 (0)	94 (-4)	94 (-4)	87 (-11)	3.05	2.75	2.76	2.96

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.122: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Patiala, Punjab

DOS	Time period	BASELINE: Yield= 4-June (5726.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	4696.8 (-18.0)*	5045.7 (-11.9)	5097.5 (-11.0)	4605.4 (-19.6)	58 (-2)**	56 (-4)	57 (-3)	56 (-4)	95 (-3)**	93 (-5)	94 (-4)	92 (-6)	2.70	2.78	2.62	2.73
	EC	4912.2 (-14.2)	4910.6 (-14.2)	4406.7 (-23.0)	1507.3 (-73.7)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	93 (-5)	91 (-7)	91 (-7)	86 (-12)	2.71	2.69	2.67	1.95
15-May	MC	4579.2 (-20.0)	4538.9 (-20.7)	4638.7 (-19.0)	4278.0 (-25.3)	58 (-2)	58 (-2)	58 (-2)	57 (-3)	95 (-3)	95 (-3)	95 (-3)	94 (-4)	2.90	2.88	2.80	2.82
	EC	4318.6 (-24.6)	4477.0 (-21.8)	4408.4 (-23.0)	1780.8 (-68.9)	58 (-2)	56 (-4)	56 (-4)	55 (-5)	95 (-3)	92 (-6)	91 (-7)	85 (-13)	2.89	2.65	2.68	2.10
20-May	MC	4911.7 (-14.2)	4537.3 (-20.8)	4720.9 (-17.6)	4137.6 (-27.7)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	96 (-2)	95 (-3)	96 (-2)	94 (-4)	3.06	3.09	3.03	3.01
	EC	4682.9 (-18.2)	3574.3 (-37.6)	3573.6 (-37.6)	1586.6 (-72.3)	58 (-2)	56 (-4)	56 (-4)	55 (-5)	96 (-2)	92 (-6)	91 (-7)	82 (-16)	3.09	2.92	2.93	2.34
25-May	MC	6024.2 (-5.2)	5542.7 (-3.2)	5814.8 (+3.3)	5095.6 (-11.0)	59 (-1)	59 (-1)	59 (-1)	58 (-2)	97 (-1)	96 (-2)	96 (-2)	95 (-3)	3.32	3.34	3.34	3.28
	EC	5752.3 (+0.4)	4464.3 (-22.0)	4185.6 (-26.9)	1981.7 (-65.4)	59 (-1)	56 (-4)	56 (-4)	55 (-5)	96 (-2)	92 (-6)	92 (-6)	84 (-14)	3.33	3.34	3.31	2.62
30-May	MC	6037.3 (+5.4)	5652.4 (-1.3)	5844.5 (+2.06)	5336.5 (-6.8)	58 (-2)	58 (-2)	58 (-2)	57 (-3)	96 (-2)	95 (-3)	96 (-2)	94 (-4)	3.57	3.62	3.60	3.56
	EC	5845.5 (+2.1)	4769.8 (-16.7)	4582.9 (-20.0)	1672.1 (-70.8)	57 (-3)	57 (-3)	57 (-3)	56 (-4)	95 (-3)	93 (-5)	92 (-6)	79 (-19)	3.59	3.62	3.61	2.97

DOS	Time period	BASELINE: Yield= 4-June (5726.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.19)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	6220.5 (+8.6)	5305.1 (-7.4)	5662.4 (-1.1)	5078.2 (-11.3)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	97 (-1)	96 (-2)	96 (-2)	95 (-3)	3.55	3.57	3.54	3.55
	EC	5644.4 (-1.4)	4018.1 (-29.8)	3609.8 (-37.0)	2361.1 (-58.8)	58 (-2)	57 (-3)	57 (-3)	56 (-4)	96 (-2)	94 (-4)	94 (-4)	90 (-8)	3.51	3.60	3.62	3.61
14-June	MC	6863.2 (+19.8)	6414.2 (+12.0)	6622.0 (+15.6)	6558.9 (+14.5)	60 (0)	59 (-1)	59 (-1)	58 (-2)	99 (1)	97 (-1)	98 (0)	96 (-2)	3.77	3.78	3.77	3.77
	EC	6773.3 (+18.3)	6281.4 (+9.7)	4847.9 (-15.3)	2425.1 (-57.6)	60 (0)	57 (-3)	57 (-3)	56 (-4)	98 (0)	94 (-4)	94 (-4)	91 (-7)	3.77	3.71	3.63	3.72
19-June	MC	6636.6 (+15.9)	6101.6 (+6.5)	6388.0 (+11.5)	6040.6 (+5.5)	60 (0)	60 (0)	60 (0)	60 (0)	99 (1)	98 (0)	99 (1)	98 (0)	3.88	3.86	3.83	3.89
	EC	6598.5 (+15.2)	4648.6 (-18.8)	4441.5 (-22.4)	2943.5 (-48.6)	59 (-1)	59 (-1)	58 (-2)	56 (-4)	99 (1)	96 (-2)	95 (-3)	91 (-7)	3.85	3.69	3.66	3.82
24-June	MC	5258.7 (-8.17)	4846.5 (-15.4)	5227.2 (-8.7)	4800.9 (-16.2)	60 (0)	60 (0)	60 (0)	60 (0)	99 (1)	98 (0)	99 (1)	98 (0)	3.31	3.36	3.35	2.37
	EC	5208.5 (-9.0)	3606.1 (-37.0)	3465.2 (-39.5)	2323.4 (-59.4)	60 (0)	59 (-1)	59 (-1)	56 (-4)	99 (1)	96 (-2)	95 (-3)	91 (-7)	3.33	3.25	3.22	3.59
29-June	MC	4499.3 (-21.4)	3928.8 (-31.4)	4329.4 (-24.4)	3886.6 (-32.1)	60 (0)	59 (-1)	59 (-1)	59 (-1)	99 (1)	98 (0)	99 (1)	98 (0)	2.88	2.89	2.97	2.81
	EC	4317.5 (-24.6)	2781.5 (-51.4)	2734.9 (-52.2)	1767.5 (-69.1)	59 (-1)	59 (-1)	59 (-1)	56 (-4)	98 (0)	96 (-2)	96 (-2)	91 (-7)	2.86	2.54	2.60	2.94

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.123: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Patiala, Punjab

DOS	Time period	BASELINE: Yield = 4-June (5751.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.06)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	3766.4 (-34.5)*	3805.6 (-33.8)	3906.0 (-32.1)	3645.7 (-36.6)	54 (-2)**	54 (-2)	54 (-2)	54 (-2)	92 (-4)**	92 (-4)	92 (-4)	91 (-5)	2.63	2.64	2.53	2.65
	EC	3099.6 (-46.1)	644.3 (-88.8)	1146.3 (-80.1)	15.9 (-99.7)	54 (-2)	51 (-5)	51 (-5)	51 (-5)	91 (-5)	73 (-23)	77 (-19)	65 (-31)	2.67	2.52	2.53	1.63
15-May	MC	3899.0 (-32.2)	3981.2 (-30.8)	3983.8 (-30.7)	3736.2 (-35.0)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	92 (-4)	92 (-4)	92 (-4)	2.65	2.64	2.58	2.59
	EC	3355.5 (-41.7)	923.5 (-83.9)	1677.4 (-70.8)	436.3 (-92.4)	54 (-2)	51 (-5)	52 (-4)	51 (-5)	91 (-5)	72 (-24)	79 (-17)	73 (-23)	2.60	2.35	2.38	1.54
20-May	MC	3543.2 (-38.4)	3612.7 (-37.2)	3628.4 (-36.9)	3365.9 (-41.5)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	92 (-4)	92 (-4)	92 (-4)	2.89	2.89	2.86	2.82
	EC	2967.0 (-48.4)	2427.4 (-57.8)	2457.7 (-57.3)	499.4 (-91.3)	54 (-2)	53 (-3)	53 (-3)	51 (-5)	91 (-5)	89 (-7)	89 (-7)	74 (-22)	2.86	2.49	2.53	1.79
25-May	MC	3798.6 (-33.9)	3861.2 (-32.9)	4064.4 (-29.3)	3543.8 (-38.4)	54 (-2)	54 (-2)	55 (-1)	54 (-2)	93 (-3)	93 (-3)	93 (-3)	92 (-4)	2.97	3.02	2.91	2.99
	EC	3156.6 (-45.1)	2021.7 (-64.8)	2131.2 (-62.9)	372.9 (-93.5)	54 (-2)	53 (-3)	53 (-3)	51 (-5)	92 (-4)	85 (-11)	87 (-9)	69 (-27)	3.04	2.83	2.88	2.00
30-May	MC	4500.6 (-21.7)	4588.8 (-20.2)	4700.8 (-18.3)	4181.5 (-27.3)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	93 (-3)	93 (-3)	94 (-2)	93 (-3)	3.38	3.41	3.32	3.38
	EC	3969.7 (-31.0)	1954.6 (-66.0)	2254.2 (-60.8)	880.6 (-84.7)	55 (-1)	52 (-4)	53 (-3)	51 (-5)	93 (-3)	80 (-16)	83 (-13)	78 (-18)	3.42	3.04	3.11	2.18

DOS	Time period	BASELINE: Yield = 4-June (5751.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.06)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	3748.3 (-34.8)	3664.6 (-36.3)	3999.6 (-30.4)	3408.3 (-40.7)	54 (-2)	54 (-2)	55 (-1)	54 (-2)	93 (-3)	92 (-4)	94 (-2)	92 (-4)	3.75	3.75	3.71	3.72
	EC	3163.1 (-45.0)	658.5 (-88.5)	1314.8 (-77.1)	428.3 (-92.5)	53 (-3)	52 (-4)	52 (-4)	52 (-4)	91 (-5)	70 (-26)	76 (-20)	68 (-28)	3.73	3.37	3.44	3.16
14-June	MC	4377.2 (-23.9)	4145.8 (-27.9)	4649.9 (-19.1)	3829.7 (-33.4)	56 (0)	56 (0)	56 (0)	56 (0)	95 (-1)	94 (-2)	95 (-1)	94 (-2)	3.60	3.59	3.51	3.55
	EC	3514.3 (-38.9)	2516.8 (-56.2)	2463.2 (-57.2)	608.1 (-89.4)	55 (-1)	52 (-4)	53 (-3)	52 (-4)	94 (-2)	89 (-7)	89 (-7)	72 (-24)	3.55	3.47	3.50	3.39
19-June	MC	5144.9 (-10.5)	4796.1 (-16.6)	5268.5 (-8.4)	4527.3 (-21.3)	56 (0)	56 (0)	56 (0)	55 (-1)	95 (-1)	95 (-1)	96 (0)	94 (-2)	3.70	3.66	3.60	3.59
	EC	4290.4 (-25.4)	2405.7 (-58.2)	2742.0 (-52.3)	968.1 (-83.2)	55 (-1)	53 (-3)	53 (-3)	52 (-4)	94 (-2)	90 (-6)	90 (-6)	76 (-20)	3.51	3.52	3.53	3.41
24-June	MC	4695.5 (-18.3)	4288.4 (-25.4)	4742.7 (-17.5)	4120.0 (-28.4)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-1)	95 (-1)	96 (0)	94 (-2)	3.69	3.61	3.61	3.54
	EC	3869.7 (-32.7)	2893.2 (-49.7)	2949.7 (-48.7)	1657.7 (-71.2)	55 (-1)	54 (-2)	54 (-2)	52 (-4)	94 (-2)	92 (-4)	92 (-4)	87 (-9)	3.37	3.50	3.51	3.40
29-June	MC	3904.2 (-32.1)	3489.0 (-39.3)	3902.8 (-32.1)	3335.0 (-42.0)	55 (-1)	55 (-1)	55 (-1)	54 (-2)	95 (-1)	94 (-2)	95 (-1)	94 (-2)	3.92	3.17	3.20	3.11
	EC	3064.7 (-46.7)	2196.9 (-61.8)	2266.2 (-60.6)	1467.2 (-74.5)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	94 (-2)	92 (-4)	92 (-4)	86 (-10)	2.85	3.24	3.22	3.14

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.124: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Patiala, Punjab

DOS	Time period	BASELINE: Yield = 4-June (5751.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.06)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	3892.8 (-32.3)*	3981.0 (-30.8)	4141.1 (-28.0)	3524.3 (-38.7)	54 (-2)**	54 (-2)	54 (-2)	54 (-2)	93 (-3)**	92 (-4)	92 (-4)	92 (-4)	2.53	2.67	2.63	2.55
	EC	3603.4 (-37.3)	3369.4 (-41.4)	3032.6 (-47.3)	215.2 (-96.2)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	93 (-3)	92 (-4)	91 (-5)	67 (-29)	2.50	2.64	2.58	2.40
15-May	MC	3743.8 (-34.9)	3825.4 (-33.5)	3905.0 (-32.1)	3559.7 (-38.1)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	93 (-3)	93 (-3)	93 (-3)	92 (-4)	2.66	2.77	2.75	2.69
	EC	3450.8 (-40.0)	3303.2 (-42.6)	3024.0 (-47.4)	1250.9 (-78.2)	54 (-2)	54 (-2)	54 (-2)	53 (-6)	93 (-3)	92 (-4)	91 (-5)	83 (-13)	2.62	2.76	2.67	2.33
20-May	MC	3402.3 (-40.8)	3342.9 (-41.9)	3345.5 (-41.8)	3256.5 (-43.4)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	93 (-3)	93 (-3)	93 (-3)	93 (-3)	2.92	3.00	3.01	2.99
	EC	3194.9 (-44.4)	2883.1 (-49.9)	2552.7 (-55.6)	1126.2 (-80.4)	54 (-2)	54 (-2)	54 (-2)	53 (-3)	93 (-3)	92 (-4)	92 (-4)	81 (-15)	2.88	3.01	2.91	2.64
25-May	MC	4268.3 (-25.8)	4594.4 (-20.1)	4440.0 (-22.8)	4596.5 (-20.1)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	94 (-2)	94 (-2)	94 (-2)	94 (-2)	3.02	3.02	3.05	3.06
	EC	4037.5 (-29.8)	3716.9 (-35.4)	3038.5 (-47.2)	1324.5 (-77.0)	55 (-1)	55 (-1)	55 (-1)	53 (-3)	94 (-2)	93 (-3)	92 (-4)	81 (-15)	2.98	3.05	2.98	2.81
30-May	MC	4987.7 (-13.3)	5309.6 (-7.7)	5090.6 (-11.5)	5386.5 (-6.3)	56 (0)	55 (-1)	56 (0)	55 (-1)	95 (-1)	95 (-1)	95 (-1)	95 (-1)	3.36	3.40	3.42	3.38
	EC	4966.8 (-13.6)	4348.1 (-24.4)	3609.0 (-37.2)	1680.6 (-70.8)	56 (0)	55 (-1)	55 (-1)	52 (-4)	95 (-1)	94 (-2)	93 (-3)	80 (-16)	3.27	3.45	3.34	3.08

DOS	Time period	BASELINE: Yield = 4-June (5751.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.06)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	4864.6 (-15.4)	5148.5 (-10.5)	4948.9 (-13.9)	5360.5 (-6.8)	56 (0)	56 (0)	56 (0)	56 (0)	96 (0)	96 (0)	96 (0)	96 (0)	3.70	3.77	3.77	3.71
	EC	5839.5 (+1.5)	4113.6 (-28.5)	3787.0 (-34.1)	982.1 (-82.9)	56 (0)	55 (-1)	54 (-2)	52 (-4)	96 (0)	95 (-1)	93 (-3)	72 (-24)	3.68	3.79	3.68	3.48
14-June	MC	5629.1 (-2.1)	5995.3 (+4.2)	5801.4 (+0.9)	6111.5 (+6.3)	56 (0)	56 (0)	56 (0)	56 (0)	96 (0)	96 (0)	96 (0)	96 (0)	3.43	3.55	3.50	3.48
	EC	5854.1 (+1.8)	4990.2 (-13.2)	4029.0 (-29.9)	2570.3 (-55.3)	56 (0)	55 (-1)	55 (-1)	53 (-3)	96 (0)	95 (-1)	94 (-2)	90 (-6)	3.43	3.55	3.50	3.54
19-June	MC	6023.0 (+4.7)	6227.4 (+8.3)	6032.8 (+4.9)	6114.5 (+6.3)	56 (0)	56 (0)	56 (0)	56 (0)	96 (0)	96 (0)	96 (0)	96 (0)	3.59	3.72	3.68	3.65
	EC	6463.2 (+12.4)	5447.3 (-5.3)	4543.6 (-21.0)	3007.4 (-47.7)	55 (-1)	55 (-1)	55 (-1)	54 (-2)	97 (1)	95 (-1)	94 (-2)	91 (-5)	3.64	3.73	3.68	3.62
24-June	MC	5052.5 (-12.1)	4961.7 (-13.7)	4940.2 (-14.1)	4814.9 (-16.3)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	97 (1)	97 (1)	96 (0)	97 (1)	3.64	3.74	3.68	3.57
	EC	5324.2 (-7.4)	4489.8 (-21.9)	3869.8 (-32.7)	2565.2 (-55.4)	56 (0)	55 (-1)	55 (-1)	54 (-2)	98 (2)	95 (-1)	94 (-2)	91 (-5)	3.74	3.76	3.63	3.58
29-June	MC	4263.1 (-25.9)	4334.5 (-24.6)	4313.8 (-25.0)	4185.2 (-27.2)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	96 (0)	97 (1)	96 (0)	97 (1)	3.28	3.37	3.30	3.17
	EC	4814.9 (-16.3)	3644.8 (-36.6)	3040.2 (-47.1)	1857.4 (-67.7)	55 (-1)	55 (-1)	54 (-2)	53 (-3)	97 (1)	95 (-1)	94 (-2)	91 (-5)	3.42	3.39	3.30	3.04

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.125: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Patiala, Punjab

DOS	Time period	BASELINE: Yield = 4-June (5751.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.06)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	4136.9 (-28.1)*	3823.7 (-33.5)	4091.9 (-28.8)	4133.1 (-28.1)	54 (-2)**	54 (-2)	54 (-2)	53 (-3)	93 (-3)**	92 (-4)	92 (-4)	91 (-5)	2.72	2.69	2.58	2.56
	EC	3643.8 (-36.6)	2886.1 (-49.8)	2816.7 (-51.0)	58.5 (-99.0)	54 (-2)	52 (-4)	52 (-4)	51 (-5)	92 (-4)	89 (-7)	90 (-6)	66 (-30)	2.62	2.74	2.65	1.80
15-May	MC	3997.5 (-30.5)	3859.9 (-32.9)	3852.3 (-33.0)	4346.3 (-24.4)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	93 (-3)	92 (-4)	93 (-3)	92 (-4)	2.76	2.67	2.70	2.59
	EC	3726.3 (-35.2)	3690.4 (-35.8)	3639.5 (-36.7)	8.1 (-99.9)	54 (-2)	53 (-3)	53 (-3)	51 (-5)	92 (-4)	90 (-6)	90 (-6)	65 (-31)	2.63	2.59	2.57	1.81
20-May	MC	3587.0 (-37.6)	3552.9 (-38.2)	3369.1 (-41.4)	3809.8 (-33.8)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	93 (-3)	93 (-3)	93 (-3)	93 (-3)	2.96	2.89	2.93	2.84
	EC	3515.9 (-38.9)	3163.1 (-45.0)	3246.5 (-43.5)	1133.2 (-80.3)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	92 (-4)	91 (-5)	91 (-5)	80 (-16)	2.90	2.72	2.78	2.04
25-May	MC	4604.6 (-19.9)	3903.9 (-32.1)	4300.8 (-25.2)	4283.7 (-25.5)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	94 (-2)	93 (-3)	94 (-2)	93 (-3)	3.02	2.97	3.02	3.03
	EC	4132.8 (-28.1)	3241.8 (-43.6)	3361.4 (-41.5)	1070.1 (-81.4)	55 (-1)	54 (-2)	54 (-2)	52 (-4)	93 (-3)	91 (-5)	92 (-4)	76 (-20)	2.97	3.01	2.99	2.28
30-May	MC	5392.4 (-6.2)	4542.6 (-21.0)	4992.6 (-13.2)	4991.0 (-13.2)	56 (0)	55 (-1)	56 (0)	55 (-1)	95 (-1)	94 (-2)	95 (-1)	94 (-2)	3.44	3.38	3.40	3.39
	EC	5075.5 (-11.7)	3865.3 (-32.8)	4152.3 (-27.8)	1586.5 (-72.4)	55 (-1)	54 (-2)	55 (-1)	52 (-4)	94 (-2)	91 (-5)	92 (-4)	80 (-16)	3.37	3.35	3.33	2.35

DOS	Time period	BASELINE: Yield = 4-June (5751.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.06)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	4745.9 (-17.5)	3700.2 (-35.7)	4499.6 (-21.8)	3994.9 (-30.5)	56 (0)	55 (-1)	56 (0)	54 (-2)	96 (0)	93 (-3)	95 (-1)	93 (-3)	3.78	3.75	3.78	3.73
	EC	5628.5 (-2.1)	2790.0 (-51.5)	3229.0 (-43.9)	714.8 (-87.6)	56 (0)	53 (-3)	53 (-3)	52 (-4)	95 (-1)	90 (-6)	91 (-5)	70 (-26)	3.76	3.58	3.59	3.10
14-June	MC	5345.4 (-7.0)	4202.9 (-26.9)	5159.1 (-10.3)	4426.8 (-23.0)	56 (0)	56 (0)	56 (0)	56 (0)	96 (0)	94 (-2)	95 (-1)	95 (-1)	3.50	3.59	3.55	3.60
	EC	4954.5 (-13.9)	2736.0 (-52.4)	3053.1 (-46.9)	1347.2 (-76.6)	56 (0)	55 (-1)	55 (-1)	52 (-4)	95 (-1)	92 (-4)	92 (-4)	84 (-12)	3.56	3.56	3.54	3.30
19-June	MC	5773.4 (+0.4)	4851.6 (-15.6)	5573.7 (-3.1)	4993.2 (-13.2)	56 (0)	56 (0)	56 (0)	56 (0)	96 (0)	95 (-1)	96 (0)	95 (-1)	3.65	3.70	3.69	3.70
	EC	5515.8 (-4.9)	3260.6 (-43.3)	3688.4 (-35.9)	1125.3 (-80.4)	56 (0)	55 (-1)	55 (-1)	53 (-3)	95 (-1)	93 (-3)	93 (-3)	84 (-12)	3.66	3.56	3.60	3.34
24-June	MC	4796.0 (-16.6)	4308 (-25.1)	4646.2 (-19.2)	4258.4 (-26.0)	56 (0)	55 (-1)	55 (-1)	55 (-1)	96 (0)	95 (-1)	96 (0)	95 (-1)	3.69	3.69	3.70	3.72
	EC	4610.1 (-19.8)	2936.2 (-48.9)	3145.6 (-45.3)	1402.7 (-75.6)	55 (-1)	55 (-1)	55 (-1)	53 (-3)	96 (0)	93 (-3)	93 (-3)	87 (-9)	3.69	3.48	3.53	3.26
29-June	MC	3899.0 (-32.2)	3614.0 (-37.1)	3920.6 (-31.8)	3379.3 (-41.2)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	96 (0)	94 (-2)	96 (0)	94 (-2)	3.24	3.26	3.27	3.29
	EC	3668.1 (-36.2)	2257.5 (-60.7)	2458.7 (-57.2)	998.3 (-82.6)	55 (-1)	54 (-2)	55 (-1)	52 (-4)	95 (-1)	92 (-4)	93 (-3)	86 (-10)	3.27	3.00	3.12	3.03

*%deviation from baseline value**Deviation from baseline in DAS

Table 4.126: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Patiala, Punjab

DOS	Time period	BASELINE: Yield = 4-June (5751.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.06)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	3925.4 (-31.7)*	4021.9 (-30.1)	4439.5 (-22.8)	3674.0 (-36.1)	54 (-2)**	54 (-2)	54 (-2)	54 (-2)	93 (-3)**	92 (-4)	93 (-3)	92 (-4)	2.58	2.64	2.57	2.60
	EC	4060.0 (-29.4)	3613.7 (-37.2)	3280.4 (-43.0)	96.2 (-98.3)	54 (-2)	53 (-3)	52 (-4)	51 (-5)	92 (-4)	90 (-6)	90 (-6)	66 (-30)	2.56	2.69	2.68	1.90
15-May	MC	3820.7 (-33.6)	4023.5 (-30.0)	4311.9 (-25.0)	3666.1 (-36.2)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	93 (-3)	92 (-4)	93 (-3)	92 (-4)	2.66	2.65	2.59	2.58
	EC	3792.6 (-34.0)	3879.1 (-32.5)	3800.6 (-33.9)	1743.2 (-69.7)	54 (-2)	54 (-2)	54 (-2)	51 (-5)	93 (-3)	91 (-5)	91 (-5)	83 (-13)	2.64	2.59	2.55	1.87
20-May	MC	3467.4 (-39.7)	3551.3 (-38.2)	3815.2 (-33.7)	3304.1 (-42.5)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	93 (-3)	93 (-3)	93 (-3)	92 (-4)	2.93	2.88	2.84	2.82
	EC	3320.1 (-42.3)	3521.8 (-38.8)	3479.4 (-39.5)	1705.6 (-70.3)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	93 (-3)	92 (-4)	91 (-5)	82 (-14)	2.93	2.83	2.80	2.08
25-May	MC	4593.6 (-20.1)	4315.2 (-25.0)	4485.3 (-22.0)	3999.3 (-30.4)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	94 (-2)	94 (-2)	94 (-2)	93 (-3)	3.00	2.99	2.96	2.96
	EC	4313.8 (-25.0)	3735.4 (-35.0)	3557.0 (-38.1)	1508.0 (-73.8)	55 (-1)	54 (-2)	54 (-2)	52 (-4)	94 (-2)	92 (-4)	92 (-4)	78 (-18)	3.00	3.02	3.02	2.25
30-May	MC	5255.1 (-8.6)	4920.3 (-14.4)	5190.7 (-9.74)	4564.9 (-20.6)	56 (0)	56 (0)	56 (0)	55 (-1)	95 (-1)	95 (-1)	95 (-1)	94 (-2)	3.54	3.39	3.34	3.35
	EC	5077.1 (-11.7)	4593.9 (-20.1)	4286.8 (-25.4)	1771.8 (-69.2)	56 (0)	53 (-3)	54 (-2)	52 (-4)	95 (-1)	91 (-5)	92 (-4)	79 (-17)	3.56	3.37	3.35	2.58

DOS	Time period	BASELINE: Yield = 4-June (5751.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.06)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	5006.2 (-13.0)	5044.1 (-12.3)	4509.3 (-21.6)	4424.5 (-23.1)	56 (0)	55 (-1)	55 (-1)	54 (-2)	96 (0)	94 (-2)	95 (-1)	94 (-2)	3.73	3.74	3.73	3.68
	EC	4522.6 (-21.4)	3343.2 (-41.9)	3624.4 (-37.0)	513.6 (-91.1)	56 (0)	53 (-3)	53 (-3)	52 (-4)	96 (0)	92 (-4)	91 (-5)	71 (-25)	3.72	3.69	3.66	3.36
14-June	MC	5674.3 (-1.3)	4963.4 (-13.7)	5235.4 (-9.0)	4804.5 (-16.5)	56 (0)	56 (0)	56 (0)	56 (0)	96 (0)	96 (0)	96 (0)	95 (-1)	3.45	3.51	3.50	3.47
	EC	5429.0 (-5.60)	3801.0 (-33.9)	3480.4 (-39.5)	2448.4 (-57.4)	56 (0)	56 (0)	55 (-1)	52 (-4)	96 (0)	94 (-2)	93 (-3)	88 (-8)	3.45	3.48	3.46	3.45
19-June	MC	6046.2 (+5.1)	5433.0 (-5.5)	5738.3 (-0.2)	5364.9 (-6.7)	56 (0)	56 (0)	56 (0)	56 (0)	97 (1)	96 (0)	96 (0)	95 (-1)	3.58	3.65	3.69	3.64
	EC	5822.2 (+1.2)	4257.4 (-26.0)	3915.5 (-31.9)	2762.8 (-52.0)	56 (0)	55 (-1)	55 (-1)	53 (-3)	96 (0)	94 (-2)	94 (-2)	89 (-7)	3.56	3.57	3.44	3.54
24-June	MC	4975.9 (-13.5)	4633.2 (-19.4)	5084.5 (-11.6)	4506.8 (-21.6)	56 (0)	55 (-1)	56 (0)	55 (-1)	97 (1)	96 (0)	96 (0)	96 (0)	3.60	3.63	3.62	3.61
	EC	4865.3 (-15.4)	3403.3 (-40.8)	3338.4 (-41.9)	2334.6 (-59.4)	55 (-1)	55 (-1)	55 (-1)	53 (-3)	96 (0)	94 (-2)	94 (-2)	90 (-6)	3.62	3.37	3.35	3.55
29-June	MC	4245.2 (-26.2)	3724.0 (-35.2)	4114.4 (-28.4)	3699.3 (-35.7)	55 (-1)	55 (-3)	55 (-1)	55 (-1)	96 (0)	96 (-3)	96 (0)	95 (-1)	3.24	3.20	3.20	3.19
	EC	4063.3 (-29.3)	2767.9 (-51.9)	2603.1 (-54.7)	1733.0 (-69.9)	55 (-1)	54 (-4)	55 (-1)	53 (-3)	96 (0)	93 (-6)	93 (-3)	90 (-6)	3.20	2.89	2.85	3.09

*%deviation from baseline value

**Deviation from baseline in DAS

Agroclimatic zone IV (Bathinda)

The PMH1 (Table 4.127, 4.128, 4.129 and 4.130) and PMH2 (Table 4.131, 4.132, 4.133 and 4.134) cultivar at Bathinda observed no increase in yield. The four GCM models under the four RCPs for the optimized sowing window taken in consideration observed that none of the sowing dates were showing an increase in yield at this zone. The anthesis period for PMH1 (Table 4.127, 4.128, 4.129 and 4.130) shortened by 2-3 days during mid-century and 4-5 days during end-century while the maturity by 3-5 days and 3-25 days during mid and end-century. The CSIRO-Mk-3-6-0 model showed that the shortening of maturity was very high during mid-century under RCP4.5. Similar results for anthesis and maturity were observed for PMH2 (Table 4.131, 4.132, 4.133 and 4.134) where the shortening of anthesis was by 2-3 days during mid-century and 1-5 days during the end-century. The maturity shortened by 4-7 days during mid-century and 5-25 days during end-century. The LAI for both the cultivars was higher for all the dates of sowing except the early sowing dates 10th May to 25th May.

Agroclimatic zone V (Abohar and Faridkot)

Abohar observed no increase in yield during the considered sowing window under future scenarios for both the cultivars PMH1 (Table 4.135, 4.136, 4.137 and 4.138) and PMH2 (Table 4.139, 4.140, 4.141 and 4.142). The four GCMs predicted a major decline under RCP8.5 during the end-century. The anthesis period for PMH1 (Table 4.135, 4.136, 4.137 and 4.138) shortened by 2-5 days and 4-6 days while the maturity shortened by 5-12 days and 5-28 days during mid and end-century, respectively. The maximum shortening was observed during the early dates of sowing. The IPSL-CM5A-MR model showed maximum shortening under RCP4.5 and RCP8.5. Similar results for anthesis and maturity were observed for PMH2 (Table 4.139, 4.140, 4.141 and 4.142) where the shortening of anthesis was by 1-3 days during mid-century and 2-5 days during the end-century. The maturity shortened by 6-9 days during mid-century and 4-28 days during end-century. The LAI for both the cultivars was higher for all the dates of sowing except the early sowing dates 10th May to 20th May.

The PMH1 cultivar at Faridkot observed a yield increase on early dates of sowing. The CSIRO-Mk-3-6-0 model (Table 4.143) observed the yield to increase significantly on 10th, 15th and 25th May during the mid-century ranging 1.2% to 23.8% under the four scenarios. The FIO-ESM (Table 4.144) model too observed yield increment from 5th May to 14th June with significant increase obtained on 5th, 10th, 15th, 25th and 30th May under most of the RCPs. The increase in yield as projected by FIO-ESM ranged 3.5% to 27.7% during the mid-century and 1.9% to 22.0% during the end-century. Most of the increment was observed under RCP6.0

during the end-century with 10th May showing a good response during both the centuries. IPSL-CM5A-MR model (Table 4.145) too observed yield increase from baseline on 5th, 10th, 15th and 30th May during the mid-century ranging 1.5% to 28.2%. Significant increase was observed on 10th, 15th and 30th May under all the four scenarios during the mid-century. The end-century observed the increment only under RCP2.6 ranging 5.4% to 17.0% on 5th, 15th, 25th and 30th May. IPSL-CM5A-MR also observed the yield increment on 5th, 10th, 15th, 25th and 30th May under most of the scenarios ranging 0.9% to 24.8%. The end-century observed the increase from baseline only under RCP2.6 on 10th (19.7%), 25th May (6.2%) and 30th May (5.7%). Ensemble model (Table 4.146) too showed 5th, 10th, 15th and 30th May as dates when yield would increase during the mid-century in the range 5.1% to 28.2%. The end-century observed the increase in yield only under RCP2.6. The anthesis days for PMH1 (Table 4.143, 4.144, 4.145, 4.146) cultivar at Faridkot observed shortening by 0-2 days during mid-century and 1-4 days during end-century on an average and maturity observed the shortening by 2-4 days and 4-25 days on an average as predicted by the four GCMs under four RCPs. The LAI for the early dates of sowing that were best for the location was lower.

The PMH2 cultivar at Faridkot observed a yield increase on early dates of sowing. The CSIRO-Mk-3-6-0 model (Table 4.147) observed the yield to increase slightly on 10th, 15th and 30th May during the mid-century ranging 0.2% to 12.6% under the four scenarios. The end-century observed no yield increase except on 15th May under RCP2.6. The FIO-ESM (Table 4.148) model too observed yield increment on 10th, 15th and 30th May under most of the RCPs. The increase in yield as projected by FIO-ESM ranged 3.9% to 16.5% during the mid-century and 1.2% to 4.2% during the end-century under the four RCPs. Similarly IPSL-CM5A-MR model (Table 4.149) too observed yield increase from baseline on 10th, 15th, 25th and 30th May during the mid-century ranging 1.6% to 15.7%. The end-century observed the increment only under RCP2.6 on 15th (4.0%) and 30th May (4.6%). Ensemble model (Table 4.150) too showed 10th, 15th and 30th May as dates when yield would increase during the mid-century in the range 1.6% to 16.3%. The end-century observed the increase in yield only under RCP2.6 on 10th May (9.6%), 15th May (13%) and 30th May (6.6%). The anthesis days for PMH2 (Table 4.147, 4.148, 4.149, 4.150) cultivar at Faridkot observed shortening by 2-3 days during mid-century and 2-4 days during end-century on an average and maturity observed the shortening by 2-5 days and 3-25 days on an average as predicted by the four GCMs under four RCPs. The LAI for the early dates of sowing that were best for the location was lower.

Kumar *et al* (2011) showed similar results where analysis of maize crop under increase rainfall and number of rainy days indicated yield increment in most of the districts. Under the above study too the regions experiencing good rainfall (<1000mm) like agroclimatic zone II and III during the *kharif* season showed yield increment while IV and V (Abohar) depicted yield decline with rainfall (<500mm) during the respective season. Patidar *et al* (2020) in Madhya Pradesh observed similar decline in maize grain yield with increase in when selected sowing date was 30th June but a shift in sowing dates to 7th July and 14th July the region observed the reduction to be lower thus suggesting these dates to help in mitigating the temperature affect on the maize yield. Also, the study showed sowing after 21st June was not found to mitigate the affect of temperature. Similar results were observed in other crops like rice, wheat and soybean where delayed sowing helped in offsetting the temperature effects as it coincided with the peak of seasonal rainfall. This helped in reduced exposure of silking-tasseling stage to dry conditions (Jalota *et al* 2012; Balvanshi and Tiwari, 2019).

Table 4.127: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Bathinda, Punjab

DOS	Time period	BASELINE: Yield= 4-June (3244.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (1.95)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	2276.7 (-29.8)*	1725.4 (-46.8)	2098.5 (-35.3)	1841.1 (-43.2)	55 (-5)**	55 (-5)	56 (-4)	55 (-5)	91 (-7)**	87 (-11)	92 (-6)	90 (-8)	1.55	1.35	1.58	1.56
	EC	1908.3 (-41.2)	1.4 (-100.0)	267.7 (-91.8)	0 (-100)	55 (-5)	55 (-5)	55 (-5)	55 (-5)	90 (-8)	69 (-29)	73 (-25)	68 (-30)	1.65	0.72	1.46	0.72
15-May	MC	2191.1 (-32.4)	2070.0 (-36.2)	2475.7 (-23.9)	2226.2 (-31.4)	56 (-4)	56 (-4)	56 (-4)	56 (-4)	91 (-7)	90 (-8)	92 (-6)	91 (-7)	1.58	1.27	1.59	1.59
	EC	1950.4 (-39.9)	251.6 (-92.2)	1268.9 (-60.9)	75.3 (-97.7)	55 (-5)	55 (-5)	55 (-5)	55 (-5)	90 (-8)	78 (-20)	86 (-12)	71 (-27)	1.66	0.69	1.42	0.64
20-May	MC	2114.9 (-34.8)	1712.6 (-47.2)	2475.3 (-23.7)	2149.6 (-33.7)	57 (-3)	56 (-4)	58 (-2)	56 (-4)	93 (-5)	90 (-8)	93 (-5)	92 (-6)	1.65	1.41	1.70	1.66
	EC	1806.2 (-44.3)	228.3 (-93.0)	1471.6 (-54.6)	100.4 (-96.9)	55 (-5)	55 (-5)	55 (-5)	55 (-5)	90 (-8)	73 (-25)	85 (-13)	72 (-26)	1.66	0.78	1.49	0.75
25-May	MC	2207.8 (-31.9)	1376.8 (-57.6)	2561.2 (-21.0)	2073.9 (-36.1)	56 (-4)	56 (-4)	57 (-3)	56 (-4)	91 (-7)	85 (-13)	93 (-5)	90 (-8)	1.78	1.62	1.81	1.83
	EC	1710.0 (-47.3)	49.1 (-98.5)	985.7 (-69.6)	3.6 (-99.9)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	90 (-8)	70 (-28)	81 (-17)	68 (-30)	1.86	0.91	1.73	0.86
30-May	MC	2523.8 (-22.2)	1002.1 (-69.1)	2838.6 (-12.5)	2256.0 (-30.4)	56 (-4)	56 (-4)	57 (-3)	56 (-4)	92 (-6)	85 (-13)	93 (-5)	90 (-8)	1.97	1.86	2.01	2.02
	EC	1903.7 (-41.3)	447.1 (-86.2)	1032.2 (-68.2)	337.8 (-89.6)	56 (-4)	55 (-5)	56 (-4)	55 (-5)	89 (-9)	70 (-28)	81 (-17)	76 (-22)	2.05	1.13	1.95	1.05

DOS	Time period	BASELINE: Yield= 4-June (3244.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (1.95)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	2649.7 (-18.3)	1062.6 (-67.2)	3194.0 (-1.5)	2204.1 (-32.1)	57 (-3)	57 (-3)	57 (-3)	57 (-3)	93 (-5)	75 (-23)	94 (-4)	89 (-9)	2.10	2.11	2.10	2.12
	EC	1961.9 (-39.5)	38.8 (-98.8)	66.6 (-98.0)	120.3 (-96.3)	57 (-3)	56 (-4)	56 (-4)	55 (-5)	88 (-10)	75 (-23)	71 (-27)	70 (-28)	2.16	1.91	2.13	1.79
14-June	MC	1948.4 (-39.9)	1166.0 (-64.0)	2129.9 (-34.3)	1923.3 (-40.7)	57 (-3)	57 (-3)	58 (-2)	57 (-3)	93 (-5)	84 (-14)	94 (-4)	93 (-5)	2.09	2.14	2.08	2.09
	EC	2347.1 (-27.7)	2.4 (-99.9)	1516.6 (-53.2)	135.7 (-95.8)	57 (-3)	56 (-4)	56 (-4)	55 (-5)	92 (-6)	70 (-28)	90 (-8)	71 (-27)	2.14	2.18	2.16	2.11
19-June	MC	1980.5 (-39.0)	1346.2 (-58.5)	2079.7 (-35.9)	2113.0 (-34.9)	57 (-3)	57 (-3)	57 (-3)	57 (-3)	94 (-4)	92 (-6)	94 (-4)	93 (-5)	2.10	2.17	2.08	2.11
	EC	1804.6 (-44.4)	582.3 (-82.0)	1951.4 (-39.8)	562.3 (-82.7)	56 (-4)	56 (-4)	56 (-4)	55 (-5)	93 (-5)	69 (-29)	91 (-7)	84 (-14)	2.18	2.27	2.22	2.17
24-June	MC	1565.1 (-51.8)	891.9 (-72.5)	1620.7 (-50.0)	1463.9 (-54.9)	59 (-1)	57 (-3)	59 (-1)	58 (-2)	96 (-2)	92 (-6)	97 (-1)	95 (-3)	1.97	2.03	1.95	1.98
	EC	1522.1 (-53.1)	494.2 (-84.8)	999.0 (-69.2)	379.7 (-88.3)	58 (-2)	56 (-4)	56 (-4)	55 (-5)	95 (-3)	90 (-8)	91 (-7)	85 (-13)	2.03	2.13	2.08	2.07
29-June	MC	1293.8 (-60.1)	697.9 (-78.5)	1362.0 (-58.0)	1196.3 (-63.1)	58 (-2)	57 (-3)	59 (-1)	58 (-2)	96 (-2)	94 (-4)	97 (-1)	95 (-3)	1.83	1.90	1.81	1.85
	EC	1180.0 (-63.6)	404.4 (-87.5)	739.4 (-77.2)	291.4 (-91.0)	56 (-4)	55 (-5)	56 (-4)	55 (-5)	94 (-4)	90 (-8)	91 (-7)	84 (-14)	1.89	1.93	1.92	1.85

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.128: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Bathinda, Punjab

DOS	Time period	BASELINE: Yield= 4-June (3244.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (1.95)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	2246.4 (-30.8)*	2088.6 (-35.6)	2356.7 (-27.3)	2139.5 (-34.0)	58 (-2)**	56 (-4)	58 (-2)	57 (-3)	94 (-4)**	92 (-6)	94 (-4)	92 (-6)	1.59	1.66	1.62	1.61
	EC	2003.4 (-38.2)	1664.0 (-48.7)	1718.3 (-47.0)	1.3 (-100.0)	58 (-2)	56 (-4)	56 (-4)	55 (-5)	94 (-4)	92 (-6)	91 (-7)	69 (-29)	1.56	1.64	1.62	1.34
15-May	MC	2112.3 (-34.9)	2173.4 (-33.0)	2156.6 (-33.5)	2106.7 (-35.1)	58 (-2)	57 (-3)	58 (-2)	58 (-2)	94 (-4)	93 (-5)	94 (-4)	93 (-5)	1.64	1.67	1.67	1.67
	EC	1925.9 (-40.6)	1886.1 (-41.9)	1828.5 (-43.6)	312.5 (-90.4)	58 (-2)	57 (-3)	56 (-4)	55 (-5)	94 (-4)	91 (-7)	91 (-7)	77 (-21)	1.61	1.67	1.67	1.36
20-May	MC	2424.5 (-25.3)	2216.8 (-31.7)	2373.1 (-26.9)	2286.9 (-29.5)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	94 (-4)	94 (-4)	94 (-4)	94 (-4)	1.76	1.77	1.82	1.83
	EC	2266.8 (-30.1)	1921.1 (-40.8)	1548.5 (-52.3)	247.9 (-92.4)	58 (-2)	58 (-2)	57 (-3)	55 (-5)	94 (-4)	94 (-4)	91 (-7)	73 (-25)	1.74	1.77	1.78	1.45
25-May	MC	2772.9 (-14.5)	2687.5 (-17.1)	2819.9 (-13.1)	2817.5 (-13.1)	59 (-1)	57 (-3)	58 (-2)	57 (-3)	95 (-3)	93 (-5)	94 (-4)	93 (-5)	1.81	1.85	1.88	1.90
	EC	2639.9 (-18.6)	2118.0 (-34.7)	1801.9 (-44.4)	420.5 (-87.0)	59 (-1)	56 (-4)	56 (-4)	55 (-5)	95 (-3)	92 (-6)	90 (-8)	76 (-22)	1.78	1.82	1.90	1.70
30-May	MC	3065.0 (-5.5)	3178.7 (-2.0)	3097.6 (-4.5)	3322.5 (+2.4)	58 (-2)	57 (-3)	57 (-3)	57 (-3)	95 (-3)	94 (-4)	94 (-4)	93 (-5)	2.03	2.06	2.10	2.13
	EC	2875.1 (-11.4)	2778.8 (-14.3)	2089.4 (-35.6)	634.3 (-80.4)	59 (-1)	57 (-3)	57 (-3)	55 (-5)	96 (-1)	93 (-5)	90 (-8)	79 (-19)	1.99	2.05	2.12	1.84

DOS	Time period	BASELINE: Yield= 4-June (3244.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (1.95)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	2466.0 (-24.0)	2574.4 (-20.6)	2465.0 (-24.0)	2659.5 (-18.0)	58 (-2)	57 (-3)	58 (-2)	57 (-3)	95 (-3)	95 (-3)	95 (-3)	95 (-3)	2.11	2.15	2.13	2.16
	EC	2613.8 (-19.4)	2968.4 (-8.5)	1643.0 (-49.3)	757.9 (-76.6)	57 (-3)	57 (-3)	57 (-3)	55 (-5)	95 (-3)	94 (-4)	93 (-5)	77 (-21)	2.09	2.13	2.16	2.09
14-June	MC	2784.9 (-14.1)	2868.2 (-11.6)	2681.0 (-17.3)	2778.1 (-14.4)	58 (-2)	57 (-3)	57 (-3)	57 (-3)	95 (-3)	95 (-3)	95 (-3)	95 (-3)	2.11	2.13	2.08	2.09
	EC	3302.4 (+1.8)	2317.4 (-28.6)	1841.1 (-43.2)	941.7 (-71.0)	59 (-1)	57 (-3)	57 (-3)	56 (-4)	98 (0)	94 (-4)	93 (-5)	83 (-15)	2.05	2.09	2.16	2.15
19-June	MC	2476.4 (+23.7)	2584.1 (-20.3)	2471.0 (-23.8)	2657.7 (-18.1)	59 (-1)	59 (-1)	59 (-1)	59 (-1)	98 (0)	98 (0)	98 (-0)	97 (-1)	2.09	2.16	2.11	2.15
	EC	2608.1 (-19.6)	2210.6 (-31.9)	1871.6 (-42.3)	1567.5 (-51.7)	59 (-1)	59 (-1)	58 (-2)	56 (-4)	98 (0)	96 (-2)	95 (-3)	91 (-7)	2.04	2.12	2.24	2.33
24-June	MC	1776.8 (-45.2)	1937.6 (-40.3)	1792.0 (-44.8)	1866.7 (-42.5)	59 (-1)	59 (-1)	59 (-1)	59 (-1)	98 (0)	98 (0)	98 (0)	98 (0)	2.00	2.10	2.07	2.13
	EC	1996.5 (-38.5)	1667.6 (-48.6)	1408.3 (-56.6)	1134.9 (-65.0)	59 (-1)	59 (-1)	58 (-2)	56 (-4)	98 (0)	97 (-1)	96 (-2)	91 (-7)	2.04	2.09	2.17	2.33
29-June	MC	1709.6 (-47.3)	1788.0 (-44.9)	1711.7 (-47.2)	1673.9 (-48.4)	59 (-1)	59 (-1)	59 (-1)	59 (-1)	98 (0)	98 (0)	98 (0)	98 (-1)	1.91	1.99	2.00	2.04
	EC	1905.8 (-41.2)	1433.2 (-55.8)	1235.0 (-61.9)	935.9 (-71.1)	59 (-1)	58 (-2)	58 (-2)	55 (-5)	99 (1)	97 (-1)	96 (-2)	91 (-7)	1.95	1.99	2.07	2.13

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.129: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and leaf area index of PMH1 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Bathinda, Punjab

DOS	Time period	BASELINE: Yield= 4-June (3244.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (1.95)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	1852.6 (-42.9)*	2208.1 (-31.9)	2181.4 (-32.8)	2338.4 (-27.9)	56 (-4)**	56 (-4)	56 (-4)	56 (-4)	92 (-6)**	91 (-7)	92 (-6)	90 (-8)	1.66	1.61	1.62	1.60
	EC	1639.3 (-49.5)	32.8 (-99.0)	36.4 (-98.9)	0.4 (-100)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	92 (-6)	70 (-28)	69 (-29)	69 (-29)	1.64	1.59	1.59	0.72
15-May	MC	2275.5 (-29.9)	2215.6 (-31.7)	2211.1 (-31.8)	2322.5 (-28.4)	57 (-3)	56 (-4)	56 (-4)	56 (-4)	93 (-5)	91 (-7)	92 (-6)	91 (-7)	1.66	1.61	1.62	1.63
	EC	2056.5 (-36.6)	2190.5 (-32.5)	1679.2 (-48.2)	209.6 (-93.5)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	91 (-7)	90 (-8)	90 (-8)	78 (-20)	1.64	1.56	1.61	0.72
20-May	MC	2480.5 (-23.5)	2072.6 (-36.1)	2271.4 (-30.0)	2193.4 (-32.4)	58 (-2)	57 (-3)	57 (-3)	56 (-4)	94 (-4)	92 (-6)	93 (-5)	91 (-7)	1.70	1.67	1.69	1.69
	EC	2110.8 (-34.9)	2558.2 (-21.1)	2131.8 (-34.3)	196.7 (-93.9)	58 (-2)	55 (-5)	55 (-5)	55 (-5)	93 (-5)	90 (-8)	90 (-8)	73 (-25)	1.71	1.55	1.60	0.86
25-May	MC	2840.5 (-12.4)	2121.9 (-34.6)	2524.4 (-22.2)	2165.4 (-33.2)	57 (-3)	56 (-4)	56 (-4)	56 (-4)	94 (-4)	92 (-6)	92 (-6)	91 (-7)	1.76	1.78	1.76	1.82
	EC	2232.6 (-31.2)	1962.2 (-39.5)	1655.3 (-49.0)	264.3 (-91.9)	56 (-4)	55 (-5)	56 (-4)	55 (-5)	92 (-6)	90 (-8)	89 (-9)	74 (-24)	1.75	1.68	1.77	1.01
30-May	MC	3281.8 (+1.2)	2454.0 (-24.3)	3017.0 (-7.0)	2524.8 (-22.2)	57 (-3)	57 (-3)	57 (-3)	56 (-4)	94 (-4)	92 (-6)	93 (-5)	92 (-6)	1.98	1.99	2.00	2.06
	EC	2712.2 (-16.4)	2197.8 (-32.2)	1827.1 (-43.7)	859.3 (-73.5)	57 (-3)	55 (-5)	56 (-4)	56 (-4)	93 (-5)	91 (-7)	88 (-10)	81 (-17)	1.96	1.99	2.04	1.21

DOS	Time period	BASELINE: Yield= 4-June (3244.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (1.95)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	2252.8 (-30.6)	2622.2 (-19.2)	2465.0 (-24.0)	2850.3 (-12.1)	58 (-2)	57 (-3)	57 (-3)	57 (-3)	95 (-3)	93 (-5)	94 (-4)	93 (-5)	2.09	2.10	2.11	2.15
	EC	2564.6 (-20.9)	1701.6 (-47.6)	1550.7 (-52.2)	68.1 (-97.9)	57 (-3)	56 (-4)	56 (-4)	56 (-4)	93 (-5)	92 (-6)	85 (-13)	71 (-27)	2.09	2.12	2.16	1.92
14-June	MC	2449.5 (-24.5)	1755.8 (-45.9)	2234.4 (-31.1)	1850.3 (-43.0)	58 (-2)	57 (-3)	57 (-3)	57 (-3)	95 (-3)	93 (-5)	94 (-4)	93 (-5)	2.07	2.04	2.09	2.11
	EC	2082.5 (-35.8)	1965.3 (-39.4)	2225.5 (-31.4)	895.4 (-72.4)	57 (-3)	56 (-4)	56 (-4)	56 (-4)	94 (-4)	92 (-6)	92 (-6)	90 (-8)	2.07	2.16	2.17	2.16
19-June	MC	2215.0 (-31.7)	1755.6 (-45.9)	2144.0 (-33.9)	1869.0 (-42.4)	58 (-2)	57 (-3)	58 (-2)	57 (-3)	96 (-2)	94 (-4)	96 (-2)	93 (-5)	2.07	2.05	2.12	2.13
	EC	2060.6 (-36.5)	1450.5 (-55.3)	1821.5 (-43.9)	1045.7 (-67.8)	57 (-3)	57 (-3)	56 (-4)	56 (-4)	94 (-4)	92 (-6)	92 (-6)	90 (-8)	2.09	2.22	2.23	2.22
24-June	MC	1563.7 (-51.8)	1400.1 (-56.8)	1606.0 (-50.5)	1557.3 (-52.0)	59 (-1)	59 (-1)	59 (-1)	59 (-1)	98 (0)	96 (-2)	97 (-1)	96 (-2)	1.96	1.92	2.01	1.99
	EC	1474.0 (-54.6)	1195.1 (-63.2)	1206.3 (-62.8)	506.6 (-84.4)	59 (-1)	57 (-3)	57 (-3)	56 (-4)	96 (-2)	92 (-6)	92 (-6)	90 (-8)	1.96	2.09	2.09	2.15
29-June	MC	1357.4 (-58.2)	1130.2 (-65.2)	1352.2 (-58.3)	1220.4 (-62.4)	59 (-1)	58 (-2)	59 (-1)	58 (-2)	98 (0)	96 (-2)	97 (-1)	95 (-3)	1.82	1.81	1.88	1.88
	EC	1224.7 (-62.2)	838.2 (-48.3)	820.8 (-74.7)	399.0 (-87.7)	58 (-2)	57 (-3)	57 (-3)	56 (-4)	96 (-2)	93 (-5)	92 (-6)	89 (-9)	1.84	1.97	1.90	1.90

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.130: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Bathinda, Punjab

DOS	Time period	BASELINE: Yield=4-June (3244.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (1.95)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	1770.3 (-45.4)*	1849.0 (-43.0)	1845.0 (-43.1)	1829.0 (-43.6)	56 (-4)**	56 (-4)	57 (-3)	56 (-4)	92 (-6)**	92 (-6)	93 (-5)	91 (-7)	1.56	1.65	1.56	1.62
	EC	1871.3 (-42.3)	2178.8 (-32.8)	1927.8 (-40.6)	1.7 (-100)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	92 (-6)	90 (-8)	88 (-10)	69 (-29)	1.68	1.60	1.62	0.79
15-May	MC	2083.3 (-35.8)	2226.8 (-31.4)	2036.0 (-37.2)	2091.1 (-35.5)	57 (-3)	56 (-4)	57 (-3)	56 (-4)	93 (-5)	92 (-6)	93 (-5)	91 (-7)	1.57	1.68	1.56	1.66
	EC	2198.2 (-32.2)	1974.5 (-39.1)	1836.6 (-43.4)	492.9 (-84.8)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	92 (-6)	90 (-8)	90 (-8)	78 (-20)	1.67	1.60	1.61	0.84
20-May	MC	2231.8 (-31.2)	2203.8 (-32.1)	2266.4 (-30.1)	2043.2 (-37.0)	58 (-2)	57 (-3)	58 (-2)	57 (-3)	94 (-4)	93 (-5)	94 (-4)	92 (-6)	1.65	1.74	1.65	1.71
	EC	2133.2 (-34.2)	1660.0 (-48.8)	1684.0 (-48.1)	455.4 (-86.0)	58 (-2)	56 (-4)	55 (-5)	55 (-5)	94 (-4)	91 (-7)	90 (-8)	76 (-22)	1.75	1.64	1.60	0.97
25-May	MC	2555.7 (-21.2)	2420.0 (-25.4)	2607.1 (-19.6)	2228.2 (-31.3)	57 (-3)	56 (-4)	58 (-2)	56 (-4)	93 (-5)	92 (-6)	94 (-4)	92 (-6)	1.71	1.78	1.69	1.76
	EC	2253.3 (-30.5)	1890.0 (-41.7)	1741.0 (-46.3)	712.2 (-78.0)	56 (-4)	56 (-4)	56 (-4)	55 (-5)	92 (-6)	91 (-7)	90 (-8)	80 (-18)	1.78	1.86	1.77	1.19
30-May	MC	2925.5 (-9.8)	2890.0 (-10.9)	2946.5 (-9.2)	2668.7 (-17.7)	57 (-3)	57 (-3)	57 (-3)	57 (-3)	94 (-4)	93 (-5)	94 (-4)	93 (-5)	1.94	2.01	1.91	1.98
	EC	2766.7 (-14.7)	2400.2 (-26.0)	1940.2 (-40.2)	733.5 (-77.4)	57 (-3)	56 (-4)	56 (-4)	55 (-5)	93 (-5)	91 (-7)	89 (-9)	79 (-19)	2.02	2.08	2.00	1.44

DOS	Time period	BASELINE: Yield=4-June (3244.0 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (1.95)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	2162.9 (-33.3)	2218.0 (-31.6)	2206.3 (-32.0)	2470.7 (-23.8)	58 (-2)	57 (-3)	58 (-2)	57 (-3)	95 (-3)	94 (-4)	95 (-3)	94 (-4)	2.03	2.13	2.02	2.11
	EC	2003.9 (-38.2)	1637.0 (-49.5)	2447.9 (-24.5)	637.3 (-80.3)	57 (-3)	57 (-3)	57 (-3)	55 (-5)	94 (-4)	92 (-6)	92 (-6)	79 (-19)	2.08	2.15	2.13	2.09
14-June	MC	2433.6 (-25.0)	2283.4 (-29.6)	2474.0 (-23.7)	2185.5 (-32.6)	58 (-2)	57 (-3)	58 (-2)	57 (-3)	95 (-3)	94 (-4)	95 (-3)	94 (-4)	2.01	2.11	2.02	2.10
	EC	2242.4 (-30.9)	1740.6 (-46.3)	1545.4 (-52.4)	748.5 (-76.9)	57 (-3)	57 (-3)	57 (-3)	56 (-4)	94 (-4)	92 (-6)	92 (-6)	84 (-14)	2.06	2.15	2.09	2.25
19-June	MC	2148.3 (-33.8)	2195.2 (-32.3)	2258.1 (-30.4)	2200.4 (-32.2)	59 (-1)	58 (-2)	59 (-1)	58 (-2)	97 (-1)	95 (-3)	97 (-1)	95 (-3)	1.93	2.11	2.00	2.11
	EC	2154.8 (-33.6)	1769.7 (-45.4)	1632.6 (-49.7)	1136.0 (-65.0)	59 (-1)	57 (-3)	57 (-3)	56 (-4)	97 (-1)	93 (-5)	93 (-5)	90 (-8)	1.97	2.19	2.11	2.32
24-June	MC	1568.2 (-51.7)	1555.9 (-52.0)	1635.3 (-49.6)	1592.5 (-50.9)	59 (-1)	59 (-1)	59 (-1)	59 (-1)	97 (-1)	97 (-1)	98 (0)	97 (-1)	1.81	1.98	1.91	1.99
	EC	1625.9 (-49.9)	1370.3 (-57.8)	1332.8 (-58.9)	848.8 (-73.8)	59 (-1)	57 (-3)	57 (-3)	56 (-4)	97 (-1)	93 (-5)	94 (-4)	90 (-8)	1.85	2.10	2.00	2.24
29-June	MC	1495.2 (-53.9)	1366.5 (-57.9)	1558.2 (-52.0)	1375.2 (-57.6)	59 (-1)	58 (-2)	59 (-1)	58 (-2)	97 (-1)	97 (-1)	98 (0)	96 (-2)	1.43	1.86	1.81	1.85
	EC	1404.8 (-56.7)	1043.5 (-67.8)	1069.7 (-67.0)	560.3 (-82.7)	58 (-2)	56 (-4)	57 (-3)	55 (-5)	97 (-1)	93 (-5)	93 (-5)	90 (-8)	1.44	1.93	1.88	1.99

***deviation from baseline value

***Deviation from baseline in DAS

Table 4.131: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Bathinda, Punjab

DOS	Time period	BASELINE: Yield=4-June (3214.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (1.93)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	1488.9 (-53.7)*	1420.7 (-55.8)	1800.7 (-44.0)	1375.3 (-57.2)	54 (-2)**	52 (-4)	54 (-2)	53 (-3)	91 (-5)**	85 (-11)	91 (-5)	89 (-7)	1.60	1.37	1.59	1.56
	EC	1125.6 (-65.0)	69.1 (-97.9)	338.5 (-89.5)	17.8 (-99.4)	54 (-2)	51 (-5)	51 (-5)	51 (-5)	90 (-6)	68 (-28)	72 (-24)	65 (-31)	1.70	0.69	1.44	0.72
15-May	MC	1689.2 (-47.4)	1449.8 (-54.9)	1916.7 (-40.4)	1656.1 (-48.5)	54 (-2)	53 (-3)	54 (-2)	53 (-3)	91 (-5)	85 (-11)	91 (-5)	89 (-7)	1.55	1.18	1.56	1.55
	EC	1423.0 (-55.7)	0 (-100)	284.7 (-91.1)	0 (-100)	54 (-2)	51 (-5)	51 (-5)	51 (-5)	90 (-6)	65 (-31)	69 (-27)	65 (-31)	1.66	0.59	1.31	0.58
20-May	MC	1528.1 (-52.5)	1465.4 (-54.4)	1727.5 (-46.3)	1545.2 (-51.9)	54 (-2)	53 (-3)	54 (-2)	54 (-2)	91 (-5)	89 (-7)	92 (-4)	91 (-5)	1.58	1.25	1.66	1.54
	EC	1311.5 (-59.2)	209.7 (-93.5)	1095.0 (-65.9)	65.4 (-98.0)	54 (-2)	52 (-4)	52 (-4)	51 (-5)	90 (-6)	73 (-23)	84 (-12)	68 (-28)	1.59	0.65	1.27	0.64
25-May	MC	1860.0 (-42.1)	1340.4 (-58.3)	2062.7 (-35.8)	1767.7 (-45.0)	54 (-2)	53 (-3)	54 (-2)	54 (-2)	91 (-5)	85 (-11)	92 (-4)	90 (-6)	1.57	1.42	1.59	1.59
	EC	1479.5 (-54.0)	203.6 (-93.7)	934.8 (-70.9)	87.5 (-97.3)	54 (-2)	52 (-4)	52 (-4)	51 (-5)	89 (-7)	69 (-27)	81 (-15)	68 (-28)	1.75	0.86	1.49	0.80
30-May	MC	2045.9 (-36.4)	957.8 (-70.2)	2350.7 (-26.9)	1870.7 (-41.8)	54 (-2)	53 (-3)	55 (-1)	54 (-2)	92 (-4)	80 (-16)	93 (-3)	90 (-6)	1.78	1.61	1.82	1.79
	EC	1546.7 (-51.9)	412.7 (-87.2)	939.3 (-70.8)	244.9 (-92.4)	54 (-2)	52 (-4)	52 (-4)	51 (-5)	89 (-7)	80 (-16)	81 (-15)	71 (-25)	1.85	0.92	1.63	0.90

DOS	Time period	BASELINE: Yield=4-June (3214.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (1.93)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	1625.3 (-49.4)	279.1 (-91.3)	1765.2 (-45.1)	1330.5 (-58.6)	53 (-3)	53 (-3)	53 (-3)	53 (-3)	91 (-5)	70 (-26)	91 (-5)	87 (-9)	2.16	2.10	2.18	2.20
	EC	1221.7 (-62.0)	215.7 (-93.3)	254.7 (-92.1)	182.3 (-94.3)	53 (-3)	52 (-4)	52 (-4)	51 (-5)	86 (-10)	70 (-26)	71 (-25)	70 (-26)	2.26	1.64	2.13	1.56
14-June	MC	2254.5 (-29.9)	1287.0 (-60.0)	1906.2 (-40.7)	2036.9 (-36.6)	53 (-3)	53 (-3)	54 (-2)	53 (-3)	92 (-4)	90 (-6)	93 (-3)	91 (-5)	2.10	2.13	2.08	2.11
	EC	2310.3 (-28.1)	0 (-100)	348.7 (-89.1)	2.7 (-99.9)	53 (-3)	52 (-4)	52 (-4)	51 (-5)	90 (-6)	66 (-30)	71 (-25)	65 (-31)	2.16	1.96	2.16	1.89
19-June	MC	2765.6 (-14.0)	1322.3 (-58.9)	2887.6 (-10.2)	2369.3 (-26.3)	55 (-1)	54 (-2)	55 (-1)	54 (-2)	94 (-2)	90 (-6)	94 (-2)	92 (-4)	2.04	2.11	2.02	2.06
	EC	3014.1 (-6.2)	1.9 (-99.9)	1174.3 (-63.5)	133.6 (-95.8)	55 (-1)	52 (-4)	52 (-4)	51 (-5)	93 (-3)	66 (-30)	89 (-7)	68 (-28)	2.11	2.16	2.16	2.05
24-June	MC	1438.1 (-55.3)	845.4 (-73.7)	1470.4 (-54.3)	1319.9 (-58.9)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	94 (-2)	92 (-4)	95 (-1)	93 (-3)	2.12	2.18	2.09	2.13
	EC	1360.7 (-57.7)	561.3 (-82.5)	976.9 (-69.6)	626.0 (-80.5)	55 (-1)	52 (-4)	54 (-2)	51 (-5)	93 (-3)	88 (-8)	91 (-5)	81 (-15)	2.21	2.22	2.24	2.04
29-June	MC	1146.8 (-64.3)	651.0 (-79.8)	1198.6 (-62.7)	1065.2 (-66.9)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	94 (-2)	92 (-4)	94 (-2)	93 (-3)	1.99	2.08	1.97	2.01
	EC	1065.9 (-66.8)	569.1 (-82.3)	734.5 (-77.1)	595.0 (-81.5)	54 (-2)	53 (-3)	54 (-2)	51 (-5)	93 (-3)	89 (-7)	91 (-5)	82 (-14)	2.07	2.17	2.11	2.06

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.132: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Bathinda, Punjab

DOS	Time period	BASELINE: Yield = 4-June (3214.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (1.93)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	1674.4 (-47.9)*	2306.6 (-28.2)	1784.0 (-44.5)	2158.1 (-32.9)	54 (-2)**	54 (-2)	54 (-2)	54 (-2)	92 (-4)**	92 (-4)	92 (-4)	91 (-5)	1.59	1.66	1.60	1.57
	EC	1523.7 (-52.6)	1575.8 (-51.0)	2140.6 (-33.4)	39.5 (-98.8)	54 (-2)	54 (-2)	54 (-2)	51 (-5)	92 (-4)	91 (-5)	91 (-5)	66 (-30)	1.56	1.63	1.65	1.35
15-May	MC	1727.7 (-46.3)	1736.4 (-46.0)	1807.9 (-43.8)	1720.6 (-47.1)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	92 (-4)	92 (-4)	91 (-5)	1.62	1.66	1.63	1.62
	EC	1542.9 (-52.0)	1470.4 (-54.3)	1441.4 (-55.2)	188.7 (-94.1)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	92 (-4)	91 (-5)	91 (-5)	70 (-26)	1.58	1.63	1.61	1.23
20-May	MC	1703.2 (-47.0)	1691.7 (-47.4)	1747.4 (-45.6)	1701.1 (-47.1)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	92 (-4)	92 (-4)	92 (-4)	1.78	1.78	1.79	1.80
	EC	1535.5 (-52.2)	1417.3 (-55.9)	1320.6 (-58.9)	257.4 (-92.0)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	92 (-4)	91 (-5)	91 (-5)	73 (-23)	1.76	1.78	1.73	1.28
25-May	MC	2334.6 (-27.4)	2275.4 (-29.2)	2366.4 (-26.4)	2366.4 (-26.4)	55 (-1)	54 (-2)	55 (-1)	54 (-2)	93 (-3)	92 (-4)	93 (-3)	92 (-4)	1.66	1.68	1.70	1.70
	EC	2211.3 (-31.2)	1823.3 (-43.3)	1525.8 (-52.5)	284.1 (-91.2)	55 (-1)	54 (-2)	54 (-2)	52 (-4)	93 (-3)	92 (-4)	90 (-6)	71 (-25)	1.64	1.67	1.69	1.50
30-May	MC	2798.4 (-13.0)	2838.9 (-11.7)	2791.9 (-13.1)	2934.4 (-8.7)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	94 (-2)	93 (-3)	94 (-2)	93 (-3)	1.91	1.94	1.97	1.98
	EC	2750.7 (-14.4)	2384.4 (-25.8)	1867.5 (-41.9)	658.6 (-79.5)	55 (-1)	55 (-1)	55 (-1)	52 (-4)	94 (-2)	93 (-3)	90 (-6)	79 (-17)	1.84	1.93	1.99	1.60

DOS	Time period	BASELINE: Yield = 4-June (3214.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (1.93)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	1974.8 (-38.6)	2146.0 (-33.2)	2254.4 (-29.9)	2425.0 (-24.6)	56 (0)	53 (-3)	54 (-2)	53 (-3)	95 (-1)	92 (-4)	93 (-3)	92 (-4)	2.17	2.23	2.23	2.28
	EC	2069.0 (-35.6)	1843.0 (-42.7)	1353.1 (-57.9)	274.0 (-91.5)	55 (-1)	53 (-3)	53 (-3)	52 (-4)	95 (-1)	91 (-5)	87 (-9)	69 (-27)	2.14	2.22	2.30	2.04
14-June	MC	2308.7 (-28.2)	2448.2 (-23.8)	2288.6 (-28.8)	2393.0 (-25.6)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-1)	95 (-1)	95 (-1)	95 (-1)	2.09	2.11	2.09	2.11
	EC	2390.1 (-25.7)	1914.8 (-40.4)	1588.1 (-50.6)	843.9 (-73.7)	55 (-1)	55 (-1)	55 (-1)	52 (-4)	95 (-1)	94 (-2)	93 (-3)	80 (-16)	2.05	2.10	2.13	2.04
19-June	MC	2175.2 (-32.3)	2381.2 (-25.9)	2211.3 (-31.2)	2270.7 (-29.4)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-1)	95 (-1)	95 (-1)	95 (-1)	2.05	2.10	2.03	2.06
	EC	2386.0 (-25.8)	1923.9 (-40.1)	1683.1 (-67.6)	772.9 (-76.0)	55 (-1)	55 (-1)	55 (-1)	52 (-4)	96 (0)	94 (-2)	93 (-3)	82 (-14)	1.99	2.05	2.15	2.15
24-June	MC	1762.7 (-45.2)	1894.0 (-41.1)	1761.8 (-45.2)	1822.1 (-43.3)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-1)	95 (-1)	96 (0)	95 (-1)	2.13	2.20	2.16	2.20
	EC	1930.7 (-39.9)	1583.1 (-50.8)	1386.8 (-56.9)	1060.4 (-67.0)	55 (-1)	55 (-1)	55 (-1)	53 (-3)	96 (0)	94 (-2)	93 (-3)	90 (-6)	2.12	2.19	2.30	2.28
29-June	MC	1436.3 (-55.3)	1580.9 (-50.8)	1445.0 (-55.0)	1512.8 (-52.9)	54 (-2)	55 (-1)	54 (-2)	55 (-1)	95 (-1)	95 (-1)	95 (-1)	96 (0)	2.02	2.16	2.12	2.22
	EC	1554.6 (-51.6)	1207.9 (-62.4)	1071.6 (-66.7)	740.1 (-77.0)	54 (-2)	54 (-2)	54 (-2)	53 (-3)	96 (0)	94 (-2)	93 (-3)	90 (-6)	2.04	2.16	2.25	2.24

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.133: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Bathinda, Punjab

DOS	Time period	BASELINE: Yield=4-June (3214.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (1.93)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	1582.0 (-50.8)*	1504.3 (-53.2)	1549.2 (-51.8)	1480.1 (-54.0)	54 (-2)**	53 (-3)	54 (-2)	53 (-3)	92 (-4)**	91 (-5)	92 (-4)	89 (-7)	1.71	1.63	1.63	1.62
	EC	1388.6 (-56.8)	195.8 (-93.9)	139.2 (-95.7)	43.5 (-98.7)	54 (-2)	52 (-4)	52 (-4)	51 (-5)	91 (-5)	69 (-27)	68 (-28)	66 (-30)	1.69	1.56	1.59	0.69
15-May	MC	1777.6 (-44.7)	1709.1 (-46.8)	1717.1 (-46.6)	1983.7 (-38.3)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	91 (-5)	91 (-5)	90 (-6)	1.65	1.59	1.62	1.58
	EC	1745.8 (-45.7)	28.7 (-99.1)	96.8 (-97.0)	0 (-100)	54 (-2)	51 (-5)	52 (-4)	51 (-5)	91 (-5)	65 (-31)	66 (-30)	65 (-31)	1.63	1.55	1.48	0.63
20-May	MC	1484.6 (-53.8)	1494.3 (-53.5)	1658.7 (-48.4)	1571.8 (-51.1)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	91 (-5)	92 (-4)	91 (-5)	1.71	1.68	1.71	1.59
	EC	2392.3 (-25.6)	1491.7 (-53.6)	1600.1 (-50.2)	182.8 (-94.3)	54 (-2)	53 (-3)	52 (-4)	52 (-4)	91 (-5)	89 (-7)	88 (-8)	73 (-23)	1.73	1.35	1.37	0.76
25-May	MC	1902.1 (-40.8)	1795.5 (-44.1)	2150.4 (-33.1)	1818.8 (-43.4)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	92 (-4)	92 (-4)	91 (-5)	1.63	1.59	1.62	1.62
	EC	2722.9 (-15.3)	1822.1 (-43.3)	1519.6 (-57.7)	146.3 (-95.4)	54 (-2)	53 (-3)	53 (-3)	52 (-4)	92 (-4)	90 (-6)	88 (-8)	68 (-28)	1.63	1.57	1.53	0.93
30-May	MC	2203.1 (-31.5)	2006.2 (-37.6)	2539.7 (-21.0)	2008.2 (-37.5)	55 (-1)	55 (-1)	55 (-1)	54 (-2)	93 (-3)	92 (-4)	93 (-3)	92 (-4)	1.86	1.80	1.84	1.84
	EC	1948.9 (-39.4)	1825.7 (-43.2)	1573.8 (-51.0)	814.7 (-74.7)	55 (-1)	53 (-3)	53 (-3)	52 (-4)	92 (-4)	90 (-6)	87 (-9)	81 (-15)	1.83	1.66	1.76	1.00

DOS	Time period	BASELINE: Yield=4-June (3214.6 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (1.93)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
09-June	MC	1661.6 (-48.3)	1581.4 (-50.8)	1884.3 (-41.4)	1613.5 (-49.8)	53 (-3)	53 (-3)	53 (-3)	53 (-3)	92 (-4)	91 (-5)	92 (-4)	90 (-6)	2.15	2.16	2.18	2.24
	EC	1982.1 (-38.3)	1346.0 (-58.1)	1082.4 (-66.3)	297.2 (-90.8)	53 (-3)	52 (-4)	52 (-4)	52 (-4)	91 (-5)	89 (-7)	83 (-13)	71 (-25)	2.15	2.12	2.23	1.67
14-June	MC	1646.5 (-48.8)	1929.9 (-40.0)	1986.8 (-38.2)	2548.3 (-20.7)	56 (0)	54 (-2)	55 (-1)	53 (-3)	95 (-1)	92 (-4)	94 (-2)	91 (-5)	2.08	2.07	2.10	2.13
	EC	1919.9 (-40.3)	2046.5 (-36.3)	2038.1 (-36.6)	233.9 (-92.7)	55 (-1)	53 (-3)	52 (-4)	52 (-4)	93 (-3)	90 (-6)	89 (-7)	73 (-23)	2.09	2.15	2.18	1.95
19-June	MC	1943.7 (-39.5)	2771.4 (-13.8)	2394.1 (-25.5)	2974.8 (-7.5)	56 (0)	55 (-1)	55 (-1)	55 (-1)	95 (-1)	93 (-3)	94 (-2)	93 (-3)	2.02	2.00	2.05	2.08
	EC	1570.4 (-51.1)	1159.9 (-63.9)	1582.4 (-50.8)	731.7 (-77.2)	55 (-1)	53 (-3)	53 (-3)	53 (-3)	94 (-2)	90 (-6)	90 (-6)	88 (-8)	2.02	2.15	2.17	2.11
24-June	MC	1417.4 (-55.9)	1257.7 (-60.9)	1506.5 (-53.1)	1345.9 (+58.1)	56 (0)	55 (-1)	55 (-1)	55 (-1)	95 (-1)	93 (-3)	95 (-1)	93 (-3)	2.09	2.07	2.13	2.16
	EC	1181.2 (-63.2)	1075.1 (-66.5)	1077.1 (-66.5)	771.1 (-76.0)	55 (-1)	55 (-1)	55 (-1)	53 (-3)	94 (-2)	92 (-4)	92 (-4)	89 (-7)	2.10	2.24	2.25	2.14
29-June	MC	1089.0 (-66.1)	1018.8 (-68.3)	1200.5 (-62.7)	1086.0 (-66.2)	55 (-1)	52 (-4)	55 (-1)	54 (-2)	95 (-1)	93 (-3)	95 (-1)	93 (-3)	1.97	1.95	2.03	2.04
	EC	4458.8 (-20.1)	817.9 (-74.6)	768.3 (-76.1)	326.7 (-89.8)	54 (-2)	52 (-4)	54 (-2)	52 (-4)	94 (-2)	92 (-4)	92 (-4)	89 (-7)	2.00	2.14	2.12	2.12

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.134: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Bathinda, Punjab

DOS	Time period	BASELINE: Yield=4-June (5584.2 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (102 DAS)				BASELINE: LAI=4-June (3.81)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
10-May	MC	1585.9 (-50.7)*	1581.4 (-50.8)	1521.1 (-52.7)	1483.6 (-53.9)	54 (-2)**	54 (-2)	54 (-2)	53 (-3)	92 (-4)**	91 (-5)	92 (-4)	91 (-5)	1.57	1.70	1.54	1.70
	EC	1550.9 (-51.8)	1360.2 (-57.7)	1094.7 (-66.0)	25.8 (-99.2)	54 (-2)	52 (-4)	52 (-4)	51 (-5)	91 (-5)	88 (-8)	87 (-9)	65 (-31)	1.69	1.68	1.70	0.79
15-May	MC	1645.3 (-48.8)	1727.0 (-46.3)	1644.9 (-48.8)	1634.1 (-49.2)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	91 (-5)	92 (-4)	91 (-5)	1.55	1.66	1.55	1.64
	EC	1682.2 (-47.7)	1638.6 (-49.0)	1947.9 (-39.4)	404.0 (-87.4)	54 (-2)	53 (-3)	53 (-3)	51 (-5)	91 (-5)	89 (-7)	88 (-8)	76 (-20)	1.65	1.42	1.54	0.72
20-May	MC	1587.8 (-50.6)	2086.3 (-35.1)	1585.8 (-50.7)	1532.6 (-52.3)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	91 (-5)	92 (-4)	91 (-5)	1.62	1.64	1.64	1.61
	EC	1597.8 (-50.3)	1618.6 (-49.7)	1379.1 (-57.1)	451.6 (-86.0)	54 (-2)	54 (-2)	53 (-3)	51 (-5)	92 (-4)	90 (-6)	90 (-6)	75 (-21)	1.69	1.46	1.42	0.84
25-May	MC	2150.4 (-33.1)	2415.9 (-24.9)	2210.4 (-31.2)	1913.7 (-40.5)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	92 (-4)	92 (-4)	92 (-4)	1.56	1.64	1.55	1.63
	EC	1980.5 (-38.4)	1751.5 (-45.5)	1500.1 (-53.3)	328.1 (-89.8)	54 (-2)	53 (-3)	53 (-3)	51 (-5)	92 (-4)	90 (-6)	89 (-7)	71 (-25)	1.66	1.60	1.56	1.03
30-May	MC	2469.8 (-23.2)	2045.9 (-36.4)	2538.3 (-21.0)	2214.0 (-31.1)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	93 (-3)	93 (-3)	93 (-3)	93 (-3)	1.80	1.87	1.79	1.84
	EC	2341.5 (-27.2)	1546.7 (-51.9)	1579.4 (-50.9)	765.7 (-76.2)	55 (-1)	52 (-4)	53 (-3)	52 (-4)	93 (-3)	89 (-7)	89 (-7)	79 (-17)	1.89	1.82	1.79	1.20
09-June	MC	1820.8 (-43.4)	1756.2 (-45.4)	1876.2 (-41.6)	1696.6 (-47.2)	53 (-3)	53 (-3)	53 (-3)	53 (-3)	92 (-4)	91 (-5)	92 (-4)	91 (-5)	2.09	2.19	2.06	2.18

DOS	Time period	BASELINE: Yield=4-June (5584.2 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (102 DAS)				BASELINE: LAI=4-June (3.81)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
	EC	1761.1 (-45.2)	1421.2 (-55.8)	1180.7 (-63.3)	259.7 (-91.9)	53 (-3)	53 (-3)	53 (-3)	52 (-4)	92 (-4)	90 (-6)	86 (-10)	69 (-27)	2.17	2.30	2.22	1.90
14-June	MC	1899.6 (-40.9)	1778.9 (-44.7)	1952.1 (-39.3)	1660.2 (-48.3)	55 (-1)	54 (-2)	55 (-1)	54 (-2)	94 (-2)	93 (-3)	95 (-1)	93 (-3)	2.03	2.12	2.02	2.11
	EC	1834.5 (-42.9)	1300.3 (-59.6)	1070.1 (-66.7)	834.4 (-74.0)	55 (-1)	53 (-3)	53 (-3)	52 (-4)	94 (-2)	90 (-6)	90 (-6)	82 (-14)	2.10	2.16	2.13	2.09
19-June	MC	1898.1 (-41.0)	1830.3 (-43.1)	1958.2 (-39.1)	1785.9 (-44.4)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-1)	94 (-2)	95 (-1)	94 (-2)	1.97	2.07	1.97	2.05
	EC	1866.3 (-41.9)	2359.2 (-26.6)	1204.8 (-62.5)	814.4 (-74.7)	55 (-1)	54 (-2)	54 (-2)	52 (-4)	95 (-1)	91 (-5)	91 (-5)	86 (-10)	2.03	2.13	2.06	2.20
24-June	MC	1554.5 (-51.6)	1511.5 (-53.0)	1629.8 (-49.3)	1510.6 (-53.0)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-1)	94 (-2)	95 (-1)	94 (-2)	2.05	2.14	2.05	2.14
	EC	1541.1 (-52.1)	1204.8 (-62.5)	1132.9 (-64.8)	663.6 (-79.3)	55 (-1)	55 (-1)	55 (-1)	53 (-3)	95 (-1)	93 (-3)	93 (-3)	89 (-7)	2.10	2.22	2.12	2.26
29-June	MC	1279.0 (-60.2)	1195.5 (-62.8)	1311.6 (-59.2)	1157.4 (-64.0)	54 (-2)	54 (-2)	55 (-1)	54 (-2)	95 (-1)	94 (-2)	95 (-1)	94 (-2)	1.91	1.98	1.90	2.00
	EC	1181.2 (-63.2)	864.6 (-73.1)	854.3 (-73.4)	484.3 (-84.9)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	94 (-2)	93 (-3)	92 (-4)	89 (-7)	1.93	2.11	2.06	2.20

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.135: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Abohar, Punjab

DOS	Time period	BASELINE: Yield=4-June (3310.1 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (1.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	1712.1 (-48.3)*	1699.0 (-48.7)	1934.3 (-41.6)	1446.5 (-56.3)	55 (-5)**	55 (-5)	56 (-4)	55 (-5)	90 (-9)**	94 (-4)	94 (-4)	87 (-12)	1.57	1.59	1.56	1.63
	EC	1027.2 (-69.0)	7.3 (-100.0)	27.9 (-99.1)	5.2 (-99.8)	55 (-5)	55 (-5)	55 (-5)	55 (-5)	90 (-9)	89 (-9)	90 (-8)	68 (-31)	1.62	1.62	1.59	1.12
10-May	MC	1964.3 (-40.7)	1971.9 (-40.4)	2020.4 (-39.0)	1867.3 (-43.6)	56 (-4)	55 (-5)	57 (-3)	55 (-5)	91 (-8)	93 (-5)	95 (-3)	90 (-9)	1.62	1.62	1.59	1.63
	EC	1513.3 (-54.3)	621.3 (-81.2)	1036.7 (-68.7)	64.0 (-98.1)	55 (-5)	55 (-5)	55 (-5)	54 (-6)	90 (-9)	90 (-8)	90 (-8)	71 (-28)	1.63	1.63	1.61	1.00
15-May	MC	2069.5 (-37.5)	2082.8 (-37.1)	2220.3 (-32.9)	1985.7 (-40.0)	57 (-3)	56 (-4)	57 (-3)	56 (-4)	93 (-6)	93 (-5)	94 (-4)	91 (-8)	1.70	1.68	1.66	1.67
	EC	2035.4 (-38.5)	672.0 (-79.7)	1161.4 (-64.9)	86.3 (-97.4)	55 (-5)	55 (-5)	55 (-5)	54 (-6)	90 (-9)	90 (-8)	90 (-8)	73 (-26)	1.69	1.60	1.64	1.10
20-May	MC	2065.6 (-37.6)	2010.9 (-39.2)	2248.5 (-32.1)	1820.9 (-45.0)	57 (-3)	56 (-4)	58 (-2)	56 (-4)	92 (-7)	94 (-4)	95 (-3)	90 (-9)	1.80	1.78	1.74	1.79
	EC	1331.0 (-59.8)	377.9 (-88.6)	730.0 (-77.9)	19.9 (-99.4)	55 (-5)	55 (-5)	55 (-5)	55 (-5)	86 (-13)	90 (-8)	90 (-8)	68 (-31)	1.79	1.66	1.67	1.18
25-May	MC	2407.2 (-27.3)	2322.1 (-29.8)	2583.4 (-22.0)	2016.7 (-39.1)	56 (-4)	56 (-4)	57 (-3)	56 (-4)	92 (-7)	94 (-4)	95 (-3)	88 (-11)	1.99	1.99	1.95	1.99
	EC	1295.2 (-60.9)	1153.2 (-65.2)	1132.5 (-65.8)	186.0 (-94.4)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	81 (-18)	86 (-12)	87 (-11)	73 (-26)	1.99	2.02	1.98	1.36

DOS	Time period	BASELINE: Yield=4-June (3310.1 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (1.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	1962.3 (-40.7)	1846.4 (-44.2)	2164.0 (-34.6)	1512.4 (-54.3)	57 (-3)	57 (-3)	57 (-3)	56 (-4)	92 (-7)	95 (-3)	96 (-2)	86 (-13)	2.16	2.16	2.13	2.16
	EC	686.6 (-79.2)	523.1 (-84.2)	527.8 (-84.0)	89.4 (-97.3)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	76 (-23)	81 (-17)	83 (-15)	71 (-28)	2.17	2.18	2.13	1.59
09-June	MC	2040.4 (-38.3)	1959.6 (-40.8)	1951.0 (-41.0)	2019.5 (-39.0)	57 (-3)	57 (-3)	57 (-3)	57 (-3)	93 (-6)	94 (-4)	95 (-3)	92 (-7)	2.08	2.09	2.06	2.09
	EC	2394.9 (-27.6)	1294.3 (-60.9)	1342.2 (-59.4)	33.9 (-99.0)	56 (-4)	56 (-4)	56 (-4)	55 (-5)	92 (-7)	71 (-27)	75 (-23)	69 (-30)	2.10	2.16	2.13	2.11
14-June	MC	1829.1 (-44.7)	1852.9 (-44.0)	2006.1 (-39.4)	2154.0 (-34.9)	57 (-3)	57 (-3)	59 (-1)	56 (-4)	93 (-6)	95 (-3)	97 (-1)	93 (-6)	2.12	2.14	2.09	2.13
	EC	2748.0 (-17.0)	1226.2 (-63.0)	1495.6 (-54.8)	235.0 (-92.9)	56 (-4)	56 (-4)	56 (-4)	55 (-5)	92 (-7)	91 (-7)	91 (-7)	75 (-24)	2.15	2.31	2.23	2.20
19-June	MC	1511.8 (-54.3)	1352.4 (-59.1)	1583.8 (-52.1)	1401.8 (-57.6)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	96 (-3)	96 (-2)	97 (-1)	95 (-4)	2.03	2.04	2.01	1.93
	EC	1370.9 (-58.6)	1088.6 (-67.1)	1081.7 (-67.3)	365.0 (-89.0)	58 (-2)	56 (-4)	56 (-4)	55 (-5)	95 (-4)	91 (-7)	91 (-7)	82 (-17)	2.07	2.20	2.14	2.03
24-June	MC	1281.7 (-61.3)	1128.6 (-65.9)	1402.8 (-57.6)	1159.6 (-65.0)	58 (-2)	57 (-3)	58 (-2)	57 (-3)	96 (-3)	97 (-1)	98 (0)	95 (-4)	1.92	1.92	1.91	1.55
	EC	1077.2 (-67.4)	832.4 (-74.9)	850.8 (-74.3)	251.7 (-92.4)	56 (-4)	56 (-4)	55 (-5)	55 (-5)	93 (-6)	93 (-5)	93 (-5)	81 (-18)	1.96	2.05	2.03	1.74

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.136: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Abohar, Punjab

DOS	Time period	BASELINE: Yield=4-June (3310.1 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (1.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	1919.0 (-42.0)*	1522.7 (-54.0)	1861.9 (-43.8)	2074.9 (-37.3)	58 (-2)**	57 (-3)	58 (-2)	57 (-3)	94 (-5)	95 (-3)	93 (-6)	92 (-7)	1.59	1.65	1.58	1.57
	EC	1657.7 (-49.9)	1267.1 (-61.7)	1444.9 (-56.3)	0 (-100)	58 (-2)	56 (-4)	55 (-5)	55 (-5)	94 (-5)	94 (-4)	89 (-10)	69 (-30)	1.47	1.65	1.62	1.59
10-May	MC	1960.0 (-40.8)	1777.6 (-46.3)	1829.2 (-44.7)	1720.5 (-48.0)	58 (-2)	57 (-3)	58 (-2)	57 (-3)	94 (-5)	95 (-3)	93 (-6)	93 (-6)	1.61	1.61	1.59	1.60
	EC	1677.5 (-49.3)	1514.5 (-54.2)	1443.4 (-56.4)	138.2 (-95.8)	58 (-2)	58 (-2)	56 (-4)	55 (-5)	93 (-6)	95 (-3)	91 (-8)	74 (-25)	1.55	1.61	1.64	1.60
15-May	MC	2156.7 (-34.8)	1979.2 (-40.2)	1996.9 (-39.7)	1951.2 (-41.0)	58 (-2)	58 (-2)	58 (-2)	58 (-2)	94 (-5)	95 (-3)	93 (-6)	93 (-6)	1.73	1.69	1.72	1.73
	EC	1876.0 (-43.3)	1758.4 (-46.9)	1372.0 (-58.5)	141.4 (-95.7)	58 (-2)	58 (-2)	57 (-3)	55 (-5)	94 (-5)	94 (-4)	91 (-8)	72 (-27)	1.68	1.71	1.75	1.64
20-May	MC	2679.3 (-19.0)	2450.1 (-26.0)	2432.9 (-26.5)	2424.3 (-26.8)	59 (-1)	58 (-2)	58 (-2)	57 (-3)	95 (-4)	95 (-3)	94 (-5)	93 (-6)	1.80	1.75	1.81	1.81
	EC	2300.6 (-30.5)	1947.5 (-41.2)	1421.3 (-57.1)	30.9 (-99.1)	58 (-2)	57 (-3)	56 (-4)	55 (-5)	94 (-5)	95 (-3)	88 (-11)	69 (-30)	1.74	1.74	1.83	1.81
25-May	MC	2975.1 (-10.1)	2907.6 (-12.2)	2800.5 (-15.4)	3045.3 (-8.0)	59 (-1)	58 (-2)	58 (-2)	57 (-3)	96 (-3)	96 (-2)	94 (-5)	93 (-6)	2.01	1.96	2.01	2.03
	EC	2562.2 (-22.6)	2424.2 (-26.8)	1643.0 (-50.4)	462.1 (-86.0)	59 (-1)	57 (-3)	56 (-4)	55 (-5)	95 (-4)	96 (-2)	86 (-13)	78 (-21)	1.95	1.97	2.03	2.07

DOS	Time period	BASELINE: Yield=4-June (3310.1 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (1.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	2816.3 (-14.9)	2931.7 (-11.4)	2777.2 (-16.1)	2949.8 (-10.9)	57 (-3)	57 (-3)	57 (-3)	57 (-3)	94 (-5)	97 (-1)	94 (-5)	93 (-6)	2.10	2.09	2.12	2.15
	EC	2532.6 (-23.5)	2326.6 (-29.7)	1318.8 (-60.1)	324.8 (-90.2)	58 (-2)	56 (-4)	56 (-4)	55 (-5)	95 (-4)	96 (-2)	84 (-15)	75 (-24)	2.06	2.09	2.16	2.14
09-June	MC	3435.9 (+3.8)	2887.8 (-12.8)	2831.6 (-14.4)	3052.3 (-7.8)	59 (-1)	57 (-3)	59 (-1)	59 (-1)	97 (-2)	97 (-1)	94 (-5)	95 (-4)	2.03	2.08	2.05	2.09
	EC	2601.6 (-21.4)	2202.9 (-33.4)	1726.1 (-47.9)	968.4 (-70.7)	59 (-1)	57 (-3)	57 (-3)	55 (-5)	97 (-2)	95 (-3)	92 (-7)	83 (-16)	2.00	2.03	2.08	2.18
14-June	MC	2804.3 (-15.3)	2646.3 (-20.0)	2626.3 (-20.7)	2948.0 (-10.9)	59 (-1)	59 (-1)	58 (-2)	59 (-1)	97 (-2)	98 (0)	97 (-2)	97 (-2)	2.05	2.15	2.09	2.16
	EC	2172.5 (-34.4)	2148.7 (-35.1)	1948.7 (-41.1)	1631.1 (-50.7)	58 (-2)	58 (-2)	58 (-2)	55 (-5)	97 (-2)	97 (-1)	94 (-5)	90 (-9)	2.01	2.06	2.16	2.41
19-June	MC	2135.2 (-35.5)	2081.0 (-37.1)	2039.1 (-38.4)	2230.1 (-32.6)	59 (-1)	59 (-1)	58 (-2)	59 (-1)	98 (-1)	98 (0)	98 (-1)	98 (-1)	2.03	2.17	2.09	2.17
	EC	1805.2 (-45.5)	1669.3 (-49.6)	1593.7 (-51.9)	1091.7 (-67.0)	58 (-2)	58 (-2)	57 (-3)	55 (-5)	98 (-1)	97 (-1)	95 (-4)	91 (-8)	2.05	2.08	2.16	2.46
24-June	MC	1989.1 (-39.9)	1956.4 (-40.9)	1901.2 (-42.6)	2035.0 (-38.5)	59 (-1)	59 (-1)	58 (-2)	59 (-1)	98 (-1)	99 (1)	98 (-1)	98 (-1)	2.02	2.09	2.06	2.11
	EC	1468.3 (-55.6)	1407.4 (-57.5)	1302.7 (-60.6)	773.0 (-76.6)	58 (-2)	58 (-2)	57 (-3)	55 (-5)	98 (-1)	97 (-1)	95 (-4)	91 (-8)	2.01	2.01	2.11	2.16

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.137: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Abohar, Punjab

DOS	Time period	BASELINE: Yield=4-June (3310.1 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (1.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	2248.6 (-32.1)*	2006.6 (-39.4)	2074.7 (-37.3)	1964.6 (-40.6)	56 (-4)**	56 (-4)	56 (-4)	55 (-5)	92 (-7)**	91 (-8)	92 (-7)	90 (-9)	1.64	1.60	1.64	1.61
	EC	2423.0 (-26.8)	15.0 (-99.5)	19.2 (-99.4)	2.0 (-100)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	91 (-8)	69 (-30)	69 (-30)	69 (-30)	1.65	1.57	1.68	1.24
10-May	MC	2168.8 (-34.5)	1911.1 (-42.3)	1988.6 (-39.9)	1789.8 (-45.9)	57 (-3)	56 (-4)	56 (-4)	55 (-5)	93 (-6)	91 (-8)	93 (-6)	90 (-9)	1.66	1.62	1.70	1.62
	EC	1902.7 (-42.5)	1626.5 (-50.9)	1536.5 (-53.6)	385.8 (-88.3)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	92 (-7)	89 (-10)	89 (-10)	79 (-20)	1.67	1.61	1.69	1.28
15-May	MC	2463.2 (-25.6)	1884.6 (-43.1)	2198.9 (-33.6)	1846.1 (-44.2)	57 (-3)	57 (-3)	58 (-2)	56 (-4)	93 (-6)	92 (-7)	93 (-6)	91 (-8)	1.75	1.68	1.77	1.67
	EC	2058.9 (-37.8)	1459.2 (-55.9)	1886.3 (-43.0)	388.1 (-88.3)	58 (-2)	55 (-5)	55 (-5)	55 (-5)	93 (-6)	89 (-10)	88 (-11)	75 (-24)	1.72	1.63	1.81	1.40
20-May	MC	2756.4 (-16.7)	1984.0 (-40.1)	2376.2 (-28.2)	1934.5 (-41.5)	58 (-2)	57 (-3)	57 (-3)	56 (-4)	94 (-5)	92 (-7)	93 (-6)	91 (-8)	1.82	1.76	1.98	1.79
	EC	2107.7 (-36.3)	1611.2 (-51.3)	1711.3 (-48.3)	361.8 (-89.1)	58 (-2)	55 (-5)	55 (-5)	55 (-5)	93 (-6)	90 (-9)	86 (-13)	74 (-25)	1.80	1.62	2.04	1.60
25-May	MC	3011.1 (-9.0)	2262.3 (-31.7)	2903.1 (-12.3)	2397.4 (-27.6)	58 (-2)	57 (-3)	56 (-4)	56 (-4)	95 (-4)	92 (-7)	93 (-6)	92 (-7)	2.04	1.95	2.13	1.96
	EC	2511.9 (-24.1)	1857.3 (-43.9)	1634.2 (-50.6)	865.0 (-73.9)	57 (-3)	55 (-5)	55 (-5)	55 (-5)	93 (-6)	91 (-8)	85 (-14)	81 (-18)	2.02	1.95	2.21	1.78

DOS	Time period	BASELINE: Yield=4-June (3310.1 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (1.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	2871.4 (-13.2)	1894.0 (-42.8)	2478.2 (-25.1)	2146.8 (-35.1)	57 (-3)	57 (-3)	57 (-3)	56 (-4)	94 (-5)	92 (-7)	93 (-6)	92 (-7)	2.15	2.12	2.06	2.13
	EC	2230.1 (-32.6)	1785.9 (-46.0)	1437.1 (-56.6)	489.9 (-85.2)	57 (-3)	55 (-5)	56 (-4)	56 (-4)	92 (-7)	91 (-8)	83 (-16)	76 (-23)	2.16	2.11	2.15	1.93
09-June	MC	2517.3 (-24.0)	1867.2 (-43.6)	2322.4 (-29.8)	2100.9 (-36.5)	57 (-3)	57 (-3)	57 (-3)	56 (-4)	95 (-4)	93 (-6)	94 (-5)	93 (-6)	2.07	2.06	2.11	2.05
	EC	2323.9 (-29.8)	1625.1 (-50.9)	2172.2 (-34.4)	956.4 (-71.1)	57 (-3)	56 (-4)	56 (-4)	56 (-4)	93 (-6)	91 (-8)	91 (-8)	90 (-9)	2.06	2.10	2.24	2.18
14-June	MC	2529.5 (-23.6)	1745.1 (-47.3)	2412.7 (-27.1)	1710.4 (-48.3)	58 (-2)	57 (-3)	58 (-2)	56 (-4)	96 (-3)	94 (-5)	95 (-4)	93 (-6)	2.12	2.09	2.04	2.09
	EC	2288.9 (-30.9)	2053.5 (-38.0)	1767.8 (-46.6)	1097.7 (-66.8)	56 (-4)	56 (-4)	56 (-4)	56 (-4)	93 (-6)	92 (-7)	92 (-7)	90 (-9)	2.11	2.17	2.15	2.30
19-June	MC	1751.5 (-47.1)	1430.2 (-56.8)	1786.7 (-46.0)	1372.6 (-58.5)	59 (-1)	58 (-2)	59 (-1)	58 (-2)	97 (-2)	96 (-3)	97 (-2)	96 (-3)	2.05	2.01	2.11	2.00
	EC	1773.0 (-46.4)	1095.6 (-66.9)	1177.9 (-64.4)	562.9 (-83.0)	58 (-2)	56 (-4)	56 (-4)	56 (-4)	96 (-3)	92 (-7)	92 (-7)	90 (-9)	2.04	2.08	2.24	2.24
24-June	MC	1533.9 (-53.7)	1192.5 (-64.0)	1577.8 (-52.3)	1114.5 (-66.3)	59 (-1)	58 (-2)	59 (-1)	57 (-3)	98 (-1)	96 (-3)	97 (-2)	95 (-4)	2.00	1.91	2.04	1.93
	EC	1438.8 (-56.5)	808.4 (-75.6)	851.5 (-74.3)	347.3 (-89.5)	58 (-2)	57 (-3)	56 (-4)	56 (-4)	96 (-3)	92 (-7)	92 (-7)	90 (-9)	1.98	2.01	2.15	2.03

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.138: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Abohar, Punjab

DOS	Time period	BASELINE: Yield=4-June (3310.1 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (1.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	1752.0 (-47.1)	1896.4 (-42.7)	1710.6 (-48.3)	1827.9 (-44.78)	57 (-3)**	56 (-4)	57 (-3)	56 (-4)	93 (-6)**	91 (-8)	93 (-6)	90 (-9)	1.57	1.53	1.53	1.60
	EC	1312.3 (-60.3)	803.2 (-75.7)	696.5 (-79.0)	0 (-100)	55 (-5)	55 (-5)	55 (-5)	55 (-5)	91 (-8)	77 (-22)	77 (-22)	68 (-31)	1.64	1.67	1.66	1.17
10-May	MC	1810.5 (-45.3)	1769.0 (-46.6)	1803.9 (-45.5)	1697.2 (-48.7)	57 (-3)	56 (-4)	57 (-3)	57 (-3)	93 (-6)	92 (-7)	93 (-6)	91 (-8)	1.59	1.60	1.59	1.62
	EC	1728.8 (-47.8)	1863.0 (-43.7)	1758.4 (-46.9)	245.3 (-92.6)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	92 (-7)	90 (-9)	90 (-9)	74 (-25)	1.63	1.66	1.65	1.16
15-May	MC	2056.8 (-37.9)	1922.5 (-41.9)	2055.0 (-37.9)	1787.9 (-46.0)	58 (-2)	57 (-3)	58 (-2)	56 (-4)	93 (-6)	93 (-6)	93 (-6)	92 (-7)	1.69	1.67	1.66	1.68
	EC	1894.7 (-42.8)	1466.7 (-55.7)	1377.0 (-58.4)	222.4 (-93.3)	58 (-2)	55 (-5)	55 (-5)	55 (-5)	93 (-6)	90 (-9)	90 (-9)	72 (-27)	1.67	1.70	1.66	1.28
20-May	MC	2271.0 (-31.4)	2045.5 (-38.2)	2249.5 (-32.0)	1933.8 (-41.6)	58 (-2)	56 (-4)	57 (-3)	56 (-4)	94 (-5)	92 (-7)	93 (-6)	92 (-7)	1.70	1.70	1.69	1.73
	EC	1968.3 (-40.5)	1493.4 (-54.9)	1430.8 (-56.8)	472.2 (-85.7)	56 (-4)	55 (-5)	55 (-5)	55 (-5)	92 (-7)	88 (-11)	87 (-12)	77 (-22)	1.69	1.86	1.84	1.53
25-May	MC	2711.8 (-18.1)	2630.7 (-20.5)	2763.8 (-16.5)	2397.8 (-27.6)	58 (-2)	56 (-4)	57 (-3)	56 (-4)	94 (-5)	93 (-6)	94 (-5)	92 (-7)	1.93	1.93	1.92	1.93
	EC	2401.6 (-27.4)	1614.5 (-51.2)	1503.1 (-54.6)	666.5 (-79.9)	56 (-4)	56 (-4)	56 (-4)	55 (-5)	92 (-7)	86 (-13)	85 (-14)	79 (-20)	1.92	2.00	1.96	1.75

DOS	Time period	BASELINE: Yield=4-June (3310.1 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (60 DAS)				BASELINE: Maturity=4-June (99 DAS)				BASELINE: LAI=4-June (1.89)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	2456.8 (-25.8)	2279.2 (-31.1)	2494.4 (-24.6)	2107.6 (-36.3)	57 (-3)	57 (-3)	57 (-3)	56 (-4)	93 (-6)	93 (-6)	93 (-6)	92 (-7)	2.03	2.06	2.04	2.05
	EC	2222.6 (-32.9)	1135.0 (-65.7)	1058.3 (-68.0)	397.0 (-88.0)	57 (-3)	56 (-4)	56 (-4)	55 (-5)	93 (-6)	83 (-16)	83 (-16)	74 (-25)	2.02	2.15	2.12	1.97
09-June	MC	2306.7 (-30.3)	2089.4 (-36.9)	2370.6 (-28.4)	1987.6 (-40.0)	57 (-3)	57 (-3)	57 (-3)	57 (-3)	94 (-5)	94 (-5)	94 (-5)	93 (-6)	2.07	2.08	2.07	2.09
	EC	2115.3 (-36.1)	1475.2 (-55.4)	1358.7 (-59.0)	849.9 (-74.3)	57 (-3)	56 (-4)	56 (-4)	55 (-5)	94 (-5)	92 (-7)	92 (-7)	84 (-15)	2.06	2.12	2.05	2.15
14-June	MC	2056.8 (-37.9)	1941.6 (-41.3)	2123.1 (-35.9)	1972.3 (-40.4)	59 (-1)	58 (-2)	59 (-1)	58 (-2)	97 (-2)	95 (-4)	97 (-2)	95 (-4)	2.10	2.11	2.09	2.08
	EC	1948.3 (-41.1)	1712.0 (-48.3)	1519.0 (-54.1)	1301.0 (-60.7)	59 (-1)	56 (-4)	56 (-4)	55 (-5)	96 (-3)	92 (-7)	92 (-7)	90 (-9)	2.10	2.18	2.09	2.24
19-June	MC	1562.2 (-52.8)	1441.4 (-56.4)	1588.8 (-52.0)	1494.9 (-54.8)	59 (-1)	59 (-1)	59 (-1)	58 (-2)	97 (-2)	97 (-2)	97 (-2)	96 (-3)	2.00	2.01	2.00	2.03
	EC	1499.5 (-54.7)	1447.0 (-56.3)	1859.4 (-43.8)	902.8 (-72.7)	58 (-2)	56 (-4)	57 (-3)	55 (-5)	97 (-2)	93 (-6)	91 (-8)	90 (-9)	2.02	2.12	1.96	2.28
24-June	MC	1458.2 (-55.9)	1333.3 (-59.7)	1497.7 (-54.8)	1332.6 (-59.7)	58 (-2)	58 (-2)	59 (-1)	57 (-3)	97 (-2)	97 (-2)	98 (-1)	96 (-3)	1.92	1.93	1.93	1.93
	EC	1359.0 (-58.9)	1158.8 (-65.0)	1014.0 (-69.4)	630.7 (-80.9)	58 (-2)	56 (-4)	56 (-4)	55 (-5)	97 (-2)	93 (-6)	92 (-7)	90 (-9)	1.93	2.00	1.92	2.08

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.139: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Abohar, Punjab

DOS	Time period	BASELINE: Yield =4-June (3244.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (97 DAS)				BASELINE: LAI=4-June (1.98)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	1355.3 (-58.2)*	1314.4 (-59.5)	1514.7 (-53.3)	1123.0 (-65.4)	53 (-3)**	53 (-3)	54 (-2)	53 (-3)	90 (-7)**	90 (-7)	91 (-6)	87 (-10)	1.59	1.61	1.58	1.66
	EC	999.6 (-69.2)	144.7 (-95.5)	157.1 (-95.1)	30.6 (-99.0)	53 (-3)	51 (-5)	52 (-4)	51 (-5)	90 (-7)	69 (-28)	69 (-28)	66 (-31)	1.65	1.56	1.60	1.07
10-May	MC	1462.2 (-54.9)	1470.5 (-54.7)	1610.9 (-50.3)	1348.1 (-58.4)	53 (-3)	53 (-3)	53 (-3)	53 (-3)	90 (-7)	90 (-7)	91 (-6)	89 (-8)	1.58	1.58	1.57	1.61
	EC	1085.4 (-66.5)	138.3 (-95.7)	54.1 (-98.3)	0 (-100)	53 (-3)	51 (-5)	52 (-4)	51 (-5)	90 (-7)	67 (-30)	66 (-31)	65 (-32)	1.60	1.63	1.60	0.98
15-May	MC	1452.3 (-55.2)	1460.1 (-55.0)	1530.5 (-52.8)	1358.5 (-58.1)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	91 (-6)	91 (-6)	91 (-6)	90 (-7)	1.73	1.71	1.69	1.69
	EC	1167.7 (-64.0)	536.9 (-83.4)	699.9 (-78.4)	53 (-98.4)	54 (-2)	52 (-4)	52 (-4)	51 (-5)	90 (-7)	79 (-18)	83 (-14)	67 (-30)	1.72	1.42	1.54	0.92
20-May	MC	1700.6 (-47.6)	1689.0 (-47.9)	1830.5 (-43.6)	1540.8 (-52.5)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	91 (-6)	90 (-7)	91 (-6)	89 (-8)	1.66	1.66	1.63	1.67
	EC	1187.8 (-63.4)	554.2 (-82.9)	859.4 (-73.5)	76.7 (-97.6)	54 (-2)	51 (-5)	52 (-4)	51 (-5)	86 (-11)	74 (-23)	80 (-17)	68 (-29)	1.64	1.49	1.55	1.06
25-May	MC	1965.1 (-39.4)	1889.7 (-41.8)	2176.2 (-32.9)	1651.7 (-49.1)	54 (-2)	54 (-2)	55 (-1)	54 (-2)	92 (-5)	90 (-7)	92 (-5)	88 (-9)	1.80	1.78	1.76	1.79
	EC	1060.2 (-67.3)	832.0 (-74.3)	773.9 (-76.1)	5.0 (-99.8)	54 (-2)	52 (-4)	52 (-4)	51 (-5)	81 (-16)	79 (-18)	77 (-20)	65 (-32)	1.79	1.72	1.70	1.22

DOS	Time period	BASELINE: Yield =4-June (3244.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (97 DAS)				BASELINE: LAI=4-June (1.98)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	1973.3 (-39.2)	1851.5 (-42.9)	2092.6 (-35.5)	1584.0 (-51.2)	54 (-2)	53 (-3)	54 (-2)	53 (-3)	91 (-6)	88 (-9)	92 (-5)	86 (-11)	2.09	2.08	2.05	2.09
	EC	883.8 (-72.8)	687.4 (-78.8)	684.7 (-78.9)	129.6 (-96.0)	52 (-4)	52 (-4)	52 (-4)	51 (-5)	76 (-21)	77 (-20)	77 (-20)	69 (-28)	2.09	1.98	1.97	1.40
09-June	MC	2050.7 (-36.8)	2067.4 (-36.3)	1864.6 (-42.5)	1579.6 (-51.3)	54 (-2)	54 (-2)	55 (-1)	53 (-3)	92 (-5)	91 (-6)	93 (-4)	86 (-11)	2.12	2.12	2.09	2.12
	EC	789.2 (-75.7)	44.0 (-98.6)	51.3 (-98.4)	50.4 (-98.4)	52 (-4)	52 (-4)	52 (-4)	51 (-5)	74 (-23)	67 (-30)	67 (-30)	66 (-31)	2.14	2.14	2.13	1.92
14-June	MC	2978.8 (-8.2)	2742.0 (-15.5)	3069.5 (-5.4)	2282.9 (-29.6)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	93 (-4)	93 (-4)	94 (-3)	92 (-5)	2.02	2.05	2.00	2.04
	EC	1193.5 (-63.2)	1296.7 (-60.0)	1341.0 (-58.7)	32.0 (-99.0)	55 (-1)	52 (-4)	52 (-4)	51 (-5)	92 (-5)	88 (-9)	88 (-9)	66 (-31)	2.06	2.14	2.11	2.05
19-June	MC	1363.6 (-58.0)	1237.0 (-61.9)	1440.4 (-55.6)	1284.0 (-60.4)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	94 (-3)	94 (-3)	94 (-3)	93 (-4)	2.16	2.17	2.12	2.17
	EC	1268.9 (-60.9)	1359.1 (-58.1)	1155.9 (-64.4)	386.7 (-88.1)	54 (-2)	53 (-3)	53 (-3)	51 (-5)	93 (-4)	89 (-8)	90 (-7)	77 (-20)	2.23	2.29	2.24	2.06
24-June	MC	1112.2 (-65.7)	1010.1 (-68.9)	1190.9 (-63.3)	1038.4 (-68.0)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	94 (-3)	94 (-3)	94 (-3)	93 (-4)	2.08	2.09	2.05	2.17
	EC	1023.7 (-68.4)	752.8 (-76.8)	780.9 (-75.9)	264.9 (-91.8)	54 (-2)	53 (-3)	53 (-3)	51 (-5)	93 (-4)	90 (-7)	90 (-7)	80 (-17)	2.12	2.25	2.20	2.06

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.140: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Abohar, Punjab

DOS	Time period	BASELINE: Yield =4-June (3244.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (97 DAS)				BASELINE: LAI=4-June (1.98)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	1476.9 (-54.5)*	1746.8 (-46.1)	1866.0 (-42.5)	1830.7 (-43.6)	54 (-2)**	54 (-2)	53 (-3)	53 (-3)	92 (-5)**	91 (-6)	91 (-6)	91 (-6)	1.53	1.58	1.52	1.51
	EC	1304.2 (-59.8)	1168.0 (-64.0)	1059.7 (-67.3)	34.4 (-98.9)	54 (-2)	54 (-2)	53 (-3)	51 (-5)	92 (-5)	91 (-6)	89 (-8)	66 (-31)	1.51	1.55	1.56	1.63
10-May	MC	1600.8 (-50.7)	1485.7 (-54.2)	1505.0 (-53.6)	1407.9 (-56.6)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	91 (-6)	91 (-6)	91 (-6)	91 (-6)	1.58	1.63	1.56	1.57
	EC	1400.2 (-56.8)	1319.8 (-59.3)	1759.1 (-45.8)	94.0 (-97.1)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	91 (-6)	91 (-6)	90 (-7)	79 (-18)	1.52	1.59	1.61	1.50
15-May	MC	1564.5 (-51.8)	1435.9 (-55.7)	1487.5 (-54.1)	1462.6 (-54.9)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-5)	91 (-6)	91 (-6)	91 (-6)	1.76	1.70	1.75	1.75
	EC	1398.8 (-56.9)	1214.2 (-62.6)	1040.0 (-67.9)	135.8 (-95.8)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	91 (-6)	91 (-6)	90 (-7)	72 (-25)	1.68	1.72	1.78	1.51
20-May	MC	2018.0 (-37.8)	1903.0 (-41.3)	1897.5 (-41.5)	1901.3 (-41.4)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-5)	92 (-5)	92 (-5)	92 (-5)	1.67	1.63	1.65	1.66
	EC	1701.9 (-47.5)	1484.1 (-54.2)	1174.7 (-63.8)	67.3 (-97.9)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	92 (-5)	91 (-6)	88 (-9)	67 (-30)	1.62	1.65	1.68	1.63
25-May	MC	2674.3 (-17.6)	2572.1 (-20.7)	2539.8 (-21.7)	2600.8 (-19.8)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	93 (-4)	93 (-4)	93 (-4)	93 (-4)	1.84	1.81	1.86	1.88
	EC	2389.5 (-26.3)	2077.1 (-36.0)	1368.3 (-57.8)	421.5 (-87.0)	55 (-1)	55 (-1)	54 (-2)	52 (-4)	93 (-4)	92 (-5)	86 (-11)	78 (-19)	1.77	1.81	1.89	1.79

DOS	Time period	BASELINE: Yield =4-June (3244.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (97 DAS)				BASELINE: LAI=4-June (1.98)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	2456.4 (-24.3)	2528.1 (-22.1)	2415.0 (-25.6)	2566.0 (-20.9)	55 (-1)	55 (-1)	54 (-2)	53 (-3)	94 (-3)	93 (-4)	93 (-4)	92 (-5)	2.04	2.04	2.07	2.10
	EC	2310.8 (-28.8)	2070.0 (-36.2)	1287.6 (-60.3)	326.4 (-89.9)	55 (-1)	55 (-1)	52 (-4)	52 (-4)	93 (-4)	92 (-5)	83 (-14)	73 (-24)	2.00	2.03	2.10	2.07
09-June	MC	2397.8 (-26.1)	2445.5 (-24.6)	2412.7 (-25.6)	2534.7 (-21.9)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	94 (-3)	94 (-3)	94 (-3)	94 (-3)	2.08	2.07	2.09	2.12
	EC	2072.8 (-36.1)	1855.2 (-42.8)	2500.0 (-22.9)	657.4 (-79.7)	54 (-2)	55 (-1)	54 (-2)	52 (-4)	94 (-3)	93 (-4)	91 (-6)	74 (-23)	2.03	2.08	2.12	2.07
14-June	MC	2411.3 (-25.7)	2460.2 (-24.2)	2404.6 (-25.9)	2544.6 (-21.6)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-2)	95 (-2)	95 (-2)	95 (-2)	1.98	2.06	2.00	2.06
	EC	2239.6 (-31.0)	2143.2 (-33.9)	2716.7 (-16.3)	789.6 (-75.7)	55 (-1)	55 (-1)	55 (-1)	52 (-4)	95 (-2)	94 (-3)	93 (-4)	81 (-16)	1.92	2.00	2.04	2.19
19-June	MC	2000.9 (-38.3)	2016.9 (-37.8)	1957.8 (-39.7)	2090.5 (-35.6)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-2)	95 (-2)	95 (-2)	95 (-2)	2.14	2.21	2.18	2.25
	EC	1619.5 (-50.1)	1554.2 (-52.1)	1438.1 (-55.7)	1143.6 (-64.8)	55 (-1)	54 (-2)	54 (-2)	53 (-3)	96 (-1)	94 (-3)	93 (-4)	90 (-7)	2.08	2.15	2.23	2.29
24-June	MC	1682.8 (-48.1)	1699.8 (-47.6)	1560.3 (-51.9)	1697.1 (-47.7)	54 (-2)	54 (-2)	54 (-2)	55 (-1)	96 (-1)	96 (-1)	95 (-2)	96 (-1)	2.10	2.24	2.14	2.24
	EC	1445.1 (-55.4)	1235.8 (-61.9)	1178.9 (-63.7)	862.7 (-73.4)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	96 (-1)	94 (-3)	93 (-4)	89 (-8)	2.10	2.15	2.25	2.38

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.141: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Abohar, Punjab

DOS	Time period	BASELINE: Yield =4-June (3244.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (97 DAS)				BASELINE: LAI=4-June (1.98)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	1462.2 (-54.9)*	1329.4 (-59.0)	1412.8 (-56.4)	1131.5 (-65.1)	53 (-3)**	54 (-2)	54 (-2)	53 (-3)	91 (-6)**	90 (-7)	91 (-6)	89 (-8)	1.58	1.63	1.61	1.64
	EC	1290.5 (-60.2)	167.5 (-94.8)	131.2 (-96.0)	74.7 (-97.7)	54 (-2)	51 (-5)	52 (-4)	51 (-5)	91 (-6)	69 (-28)	68 (-29)	67 (-30)	1.59	1.60	1.75	1.18
10-May	MC	1697.6 (-47.7)	1480.3 (-54.4)	1558.0 (-52.0)	1396.7 (-56.9)	53 (-3)	54 (-2)	54 (-2)	54 (-2)	91 (-6)	91 (-6)	91 (-6)	90 (-7)	1.59	1.60	1.62	1.60
	EC	1465.4 (-54.8)	19.3 (-99.4)	402.8 (-87.6)	0 (-100)	54 (-2)	53 (-3)	51 (-5)	51 (-5)	91 (-6)	67 (-30)	71 (-26)	65 (-32)	1.58	1.60	1.68	1.13
15-May	MC	1636.8 (-49.5)	1382.4 (-57.4)	1527.2 (-52.9)	1300.6 (-59.9)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	91 (-6)	91 (-6)	91 (-6)	90 (-7)	1.73	1.71	1.73	1.70
	EC	1346.4 (-58.5)	1013.9 (-68.7)	1367.7 (-57.8)	363.7 (-88.8)	54 (-2)	53 (-3)	52 (-4)	51 (-5)	91 (-6)	89 (-8)	88 (-9)	75 (-22)	1.71	1.64	1.66	1.21
20-May	MC	2125.4 (-34.5)	1603.2 (-50.6)	1903.6 (-41.3)	1631.2 (-49.7)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-5)	91 (-6)	92 (-5)	91 (-6)	1.63	1.62	1.66	1.66
	EC	1623.0 (-50.0)	1436.6 (-55.7)	1214.5 (-62.6)	279.0 (-91.4)	54 (-2)	53 (-3)	53 (-3)	52 (-4)	91 (-6)	89 (-8)	88 (-9)	70 (-27)	1.62	1.58	1.67	1.42
25-May	MC	2720.8 (-16.1)	1878.8 (-42.1)	2428.0 (-25.2)	1910.7 (-41.1)	55 (-1)	55 (-1)	55 (-1)	54 (-2)	93 (-4)	92 (-5)	92 (-5)	91 (-6)	1.82	1.77	1.81	1.78
	EC	2057.6 (-36.6)	1595.0 (-50.8)	1614.6 (-50.2)	810.1 (-75.0)	55 (-1)	53 (-3)	53 (-3)	52 (-4)	92 (-5)	90 (-7)	86 (-11)	81 (-16)	1.79	1.71	1.79	1.53

DOS	Time period	BASELINE: Yield =4-June (3244.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (97 DAS)				BASELINE: LAI=4-June (1.98)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	2532.7 (-21.9)	1829.2 (-43.6)	2288.5 (-29.5)	1924.8 (-40.7)	55 (-1)	54 (-2)	54 (-2)	54 (-2)	94 (-3)	91 (-6)	92 (-5)	91 (-6)	2.06	2.04	2.06	2.06
	EC	1985.4 (-38.8)	1550.6 (-52.2)	1476.2 (-54.5)	651.7 (-79.9)	55 (-1)	52 (-4)	52 (-4)	52 (-4)	92 (-5)	89 (-8)	84 (-13)	76 (-21)	2.06	1.93	2.11	1.78
09-June	MC	2042.2 (-37.0)	1629.3 (-49.8)	1923.9 (-40.7)	2099.8 (-35.3)	55 (-1)	55 (-1)	55 (-1)	53 (-3)	94 (-3)	92 (-5)	91 (-6)	91 (-6)	2.18	2.10	2.11	2.09
	EC	1718.1 (-47.0)	1888.6 (-41.8)	1404.3 (-56.7)	159.9 (-95.1)	55 (-1)	52 (-4)	52 (-4)	52 (-4)	93 (-4)	89 (-8)	82 (-15)	71 (-26)	2.19	2.14	2.18	2.05
14-June	MC	2126.0 (-34.6)	2942.8 (-9.3)	2755.8 (-15.0)	2630.2 (-18.9)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-2)	93 (-4)	94 (-3)	93 (-4)	2.07	2.01	2.01	2.01
	EC	3202.1 (-1.3)	1458.6 (-55.0)	1160.9 (-64.2)	799.3 (-75.4)	55 (-1)	53 (-3)	53 (-3)	52 (-4)	93 (-4)	90 (-7)	81 (-16)	88 (-9)	2.07	2.08	2.15	2.15
19-June	MC	1613.0 (-50.3)	1321.4 (-59.3)	1660.4 (-48.8)	1287.1 (-60.3)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-2)	93 (-4)	94 (-3)	93 (-4)	1.98	2.14	2.17	2.14
	EC	1590.1 (-51.0)	1006.8 (-69.0)	1045.6 (-67.8)	804.8 (-75.2)	55 (-1)	54 (-2)	55 (-1)	53 (-3)	94 (-3)	91 (-6)	90 (-7)	89 (-8)	1.96	2.20	2.29	2.25
24-June	MC	1273.1 (-60.8)	1040.3 (-67.9)	1371.0 (-57.7)	980.4 (-69.8)	55 (-1)	54 (-2)	55 (-1)	54 (-2)	95 (-2)	93 (-4)	94 (-3)	93 (-4)	2.15	2.05	2.10	2.06
	EC	1242.9 (-61.7)	785.7 (-75.8)	767.6 (-76.3)	386.7 (-88.1)	54 (-2)	55 (-1)	54 (-2)	53 (-3)	94 (-3)	92 (-5)	92 (-5)	89 (-8)	2.14	2.15	2.21	2.24

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.142: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Abohar, Punjab

DOS	Time period	BASELINE: Yield =4-June (3244.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (97 DAS)				BASELINE: LAI=4-June (1.98)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	1314.2 (-59.5)*	1290.1 (-60.2)	1300.8 (-59.9)	1118.8 (-65.5)	53 (-3)**	53 (-3)	53 (-3)	53 (-3)	91 (-6)**	91 (-6)	91 (-6)	90 (-7)	1.56	1.59	1.57	1.63
	EC	1261.0 (-61.1)	486.1 (-85.0)	409.5 (-87.4)	26.3 (-99.2)	54 (-2)	51 (-5)	52 (-4)	51 (-5)	91 (-6)	77 (-20)	76 (-21)	66 (-31)	1.62	1.70	1.73	1.17
10-May	MC	1422.6 (-56.1)	1867.0 (-42.4)	1487.0 (-54.2)	1943.9 (-40.1)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	91 (-6)	91 (-6)	91 (-6)	90 (-7)	1.58	1.57	1.57	1.60
	EC	1393.8 (-57.0)	2069.2 (-36.2)	1643.1 (-49.3)	13.9 (-99.6)	54 (-2)	53 (-3)	53 (-3)	51 (-5)	91 (-6)	90 (-7)	86 (-11)	66 (-31)	1.62	1.64	1.65	1.03
15-May	MC	1429.4 (-55.9)	1365.0 (-57.9)	1407.6 (-56.6)	1272.2 (-60.8)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	91 (-6)	91 (-6)	91 (-6)	91 (-6)	1.74	1.71	1.72	1.71
	EC	1286.4 (-60.3)	1241.1 (-61.7)	1352.5 (-58.3)	240.6 (-92.6)	54 (-2)	54 (-2)	54 (-2)	51 (-5)	91 (-6)	90 (-7)	90 (-7)	72 (-25)	1.73	1.62	1.65	1.09
20-May	MC	1846.4 (-43.1)	1731.0 (-46.6)	1839.5 (-43.3)	1596.3 (-50.8)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-5)	92 (-5)	92 (-5)	91 (-6)	1.63	1.63	1.61	1.63
	EC	1615.8 (-50.2)	1268.1 (-60.9)	1200.9 (-63.0)	153.7 (-95.3)	54 (-2)	54 (-2)	54 (-2)	51 (-5)	91 (-6)	88 (-9)	87 (-10)	67 (-30)	1.63	1.63	1.64	1.36
25-May	MC	2369.3 (-27.0)	2207.5 (-32.0)	2383.8 (-26.5)	2005.7 (-38.2)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	93 (-4)	92 (-5)	92 (-5)	92 (-5)	1.78	1.80	1.78	1.80
	EC	2101.7 (-35.2)	1366.9 (-57.9)	1277.7 (-60.6)	657.1 (-79.7)	55 (-1)	53 (-3)	53 (-3)	51 (-5)	92 (-5)	86 (-11)	85 (-12)	79 (-18)	1.79	1.83	1.82	1.49

DOS	Time period	BASELINE: Yield =4-June (3244.3 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (97 DAS)				BASELINE: LAI=4-June (1.98)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	2149.7 (-33.7)	1981.6 (-38.9)	2179.4 (-32.8)	1854.9 (-42.8)	54 (-2)	53 (-3)	54 (-2)	53 (-3)	92 (-5)	91 (-6)	92 (-5)	90 (-7)	1.95	1.98	1.96	1.98
	EC	1946.5 (-40.0)	1233.4 (-62.0)	1133.7 (-65.0)	535.0 (-83.5)	53 (-3)	52 (-4)	52 (-4)	51 (-5)	91 (-6)	82 (-15)	82 (-15)	74 (-23)	1.93	2.10	2.09	1.82
09-June	MC	1939.5 (-40.2)	1947.9 (-40.0)	1997.7 (-38.4)	1822.6 (-43.8)	55 (-1)	55 (-1)	55 (-1)	54 (-2)	94 (-3)	93 (-4)	94 (-3)	92 (-5)	2.07	2.08	2.07	2.10
	EC	2065.9 (-36.3)	1099.9 (-66.1)	1488.0 (-54.1)	811.5 (-75.0)	55 (-1)	52 (-4)	52 (-4)	52 (-4)	93 (-4)	89 (-8)	89 (-8)	81 (-16)	2.07	2.15	2.10	2.11
14-June	MC	1866.0 (-42.5)	1727.5 (-46.8)	1922.6 (-40.7)	1869.2 (-42.4)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-2)	94 (-3)	95 (-2)	94 (-3)	2.04	2.04	2.03	2.05
	EC	1750.9 (-46.0)	1337.4 (-58.9)	1458.2 (-55.0)	557.2 (-82.8)	55 (-1)	54 (-2)	54 (-2)	52 (-4)	94 (-3)	91 (-6)	91 (-6)	82 (-15)	2.03	2.09	2.01	2.20
19-June	MC	1559.0 (-51.9)	1438.5 (-55.7)	1608.1 (-50.4)	1446.6 (-55.4)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-2)	94 (-3)	95 (-2)	94 (-3)	2.17	2.17	2.16	2.18
	EC	1463.6 (-54.9)	1222.1 (-62.3)	1100.2 (-66.1)	689.2 (-78.8)	55 (-1)	55 (-1)	54 (-2)	52 (-4)	94 (-3)	92 (-5)	92 (-5)	88 (-9)	2.17	2.24	2.12	2.28
24-June	MC	1247.1 (-61.6)	1438.5 (-55.7)	1289.1 (-60.3)	1109.4 (-65.8)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	95 (-2)	94 (-3)	95 (-2)	94 (-3)	2.04	2.05	2.04	2.08
	EC	1107.4 (-65.9)	1222.1 (-62.3)	827.0 (-74.5)	560.6 (-82.7)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	94 (-3)	92 (-5)	92 (-5)	88 (-9)	2.04	2.18	2.05	2.27

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.143: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Faridkot, Punjab

DOS	Time period	BASELINE: Yield=4-June (5697.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (59 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.04)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	5241.0 (-8.0)*	5065.7 (-11.1)	6069.2 (+6.5)	4504.6 (-20.9)	57 (-2)**	58 (-1)	58 (-1)	57 (-2)	94 (-4)**	94 (-4)	94 (-4)	93 (-5)	2.33	2.31	2.33	2.26
	EC	4009.5 (-29.6)	1498.5 (-73.7)	1921.9 (-66.3)	136.6 (-97.6)	57 (-2)	55 (-4)	55 (-4)	55 (-4)	93 (-5)	89 (-9)	90 (-8)	72 (-26)	2.35	2.15	2.17	1.58
10-May	MC	6560.1 (+15.1)	6236.3 (+9.4)	7054.0 (+23.8)	5765.4 (+1.2)	58 (-1)	57 (-2)	58 (-1)	57 (-2)	94 (-4)	93 (-5)	95 (-3)	93 (-5)	2.40	2.45	2.48	2.43
	EC	5184.4 (-9.0)	2681.1 (-53.0)	3110.7 (-45.4)	18.4 (-99.7)	56 (-3)	55 (-4)	55 (-4)	55 (-4)	91 (-7)	90 (-8)	90 (-8)	68 (-30)	2.53	2.32	2.31	1.54
15-May	MC	6297.7 (+10.5)	6251.9 (+9.7)	6694.0 (+17.5)	5823.6 (+2.2)	58 (-1)	57 (-2)	58 (-1)	57 (-2)	94 (-4)	93 (-5)	94 (-4)	93 (-5)	2.50	2.50	2.59	2.44
	EC	4747.8 (-16.7)	3322.6 (-41.7)	3729.0 (-34.6)	732.1 (-87.1)	58 (-1)	55 (-4)	55 (-4)	55 (-4)	93 (-5)	90 (-8)	90 (-8)	80 (-18)	2.56	2.20	2.22	1.39
20-May	MC	5663.2 (-0.6)	5535.8 (-2.8)	5973.8 (+4.8)	5130.4 (-10.0)	58 (-1)	58 (-1)	58 (-1)	58 (-1)	94 (-4)	94 (-4)	95 (-3)	93 (-5)	2.71	2.71	2.71	2.66
	EC	4511.6 (-20.8)	3005.7 (-47.2)	3253.0 (-42.9)	782.7 (-86.3)	58 (-1)	55 (-4)	55 (-4)	55 (-4)	93 (-5)	90 (-8)	90 (-8)	79 (-19)	2.70	2.34	2.45	1.51
25-May	MC	5781.4 (+1.5)	5664.5 (-0.6)	6358.4 (+11.6)	5147.2 (-9.7)	58 (-1)	58 (-1)	59 (0)	58 (-1)	95 (-3)	94 (-4)	95 (-3)	94 (-4)	2.99	2.96	3.02	2.87
	EC	4521.2 (-20.7)	2458.7 (-56.9)	2666.3 (-53.2)	583.4 (-89.8)	58 (-1)	55 (-4)	55 (-4)	55 (-4)	94 (-4)	86 (-12)	87 (-11)	75 (-23)	2.90	2.44	2.48	1.89

DOS	Time period	BASELINE: Yield=4-June (5697.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (59 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.04)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	5675.1 (-0.4)	5585.0 (-2.0)	6076.0 (+6.6)	5239.4 (-8.0)	59 (0)	58 (-1)	60 (1)	58 (-1)	96 (-2)	95 (-3)	96 (-2)	94 (-4)	3.19	3.12	3.21	3.07
	EC	4801.7 (-15.7)	2090.5 (-63.3)	2426.3 (-57.4)	722.9 (-87.3)	59 (0)	56 (-3)	56 (-3)	55 (-4)	94 (-4)	81 (-17)	83 (-15)	78 (-20)	3.12	2.82	2.87	2.27
09-June	MC	5495.8 (-3.6)	5124.2 (-10.1)	5405.0 (-5.1)	4906.9 (-13.9)	58 (-1)	58 (-1)	58 (-1)	57 (-2)	94 (-4)	94 (-4)	95 (-3)	93 (-5)	3.48	3.44	3.43	3.45
	EC	4697.8 (-17.6)	124.6 (-97.8)	674.8 (-88.2)	172.2 (-97.0)	57 (-2)	56 (-3)	56 (-3)	55 (-4)	93 (-5)	71 (-27)	75 (-23)	70 (-28)	3.45	3.40	3.42	3.30
14-June	MC	4837.5 (-15.1)	4629.9 (-18.7)	5211.2 (-8.5)	4295.7 (-24.6)	59 (0)	59 (0)	60 (1)	58 (-1)	96 (-2)	95 (-3)	97 (-1)	95 (-3)	3.72	3.69	3.67	3.69
	EC	3820.4 (-33.0)	2689.1 (-52.8)	2721.9 (-52.2)	612.8 (-89.2)	57 (-2)	56 (-3)	56 (-3)	55 (-4)	93 (-5)	91 (-7)	91 (-7)	77 (-21)	3.64	3.63	3.66	3.58
19-June	MC	4839.2 (-15.1)	4676.2 (-17.9)	4852.4 (-14.8)	4431.9 (-22.2)	59 (0)	58 (-1)	59 (0)	58 (-1)	97 (-1)	96 (-2)	97 (-1)	95 (-3)	3.95	3.90	3.85	3.91
	EC	4341.2 (-23.8)	3399.0 (-40.3)	3401.1 (-40.3)	1134.7 (-80.1)	57 (-2)	56 (-3)	56 (-3)	55 (-4)	94 (-4)	91 (-7)	91 (-7)	86 (-12)	3.90	3.90	3.92	3.76
24-June	MC	3789.9 (-33.5)	3581.5 (-37.1)	3759.0 (-34.0)	3601.3 (-36.8)	59 (0)	59 (0)	60 (1)	59 (0)	97 (-1)	97 (-1)	98 (0)	96 (-2)	3.48	3.50	3.42	3.60
	EC	3571.5 (-37.3)	2610.9 (-54.2)	2681.6 (-52.9)	1143.77 (-79.9)	58 (-1)	57 (-2)	57 (-2)	55 (-4)	96 (-2)	93 (-5)	93 (-5)	87 (-11)	3.54	3.88	3.88	3.72

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.144: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Faridkot, Punjab

DOS	Time period	BASELINE: Yield= 4-June (5697.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (59 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.04)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	4516.2 (-20.7)*	6629.8 (+16.3)	6795.0 (+19.2)	6319.93 (+10.9)	58 (-1)**	58 (-1)	58 (-1)	58 (-1)	94 (-4)**	95 (-3)	95 (-3)	95 (-3)	2.20	2.53	2.44	2.50
	EC	4546.8 (-20.2)	5846.8 (+2.6)	4855.6 (-14.8)	907.1 (-84.1)	58 (-1)	58 (-1)	58 (-1)	55 (-4)	94 (-4)	94 (-4)	93 (-5)	79 (-19)	2.30	2.45	2.37	2.28
10-May	MC	6154.3 (+8.0)	7274.7 (+27.7)	7237.0 (+27.0)	6935.0 (+21.7)	58 (-1)	58 (-1)	58 (-1)	58 (-1)	94 (-4)	95 (-3)	95 (-3)	95 (-3)	2.33	2.63	2.56	2.56
	EC	5807.0 (+1.9)	6962.8 (+22.2)	5834.1 (+2.4)	1118.7 (-80.4)	58 (-1)	58 (-1)	58 (-1)	55 (-4)	94 (-4)	95 (-3)	94 (-4)	77 (-21)	2.42	2.57	2.53	2.34
15-May	MC	4985.3 (-12.5)	6539.0 (+14.8)	6700.2 (+17.6)	6316.5 (+10.9)	58 (-1)	58 (-1)	58 (-1)	58 (-1)	94 (-4)	95 (-3)	95 (-3)	95 (-3)	2.44	2.80	2.74	2.79
	EC	4782.9 (-16.1)	5934.4 (+4.1)	4965.9 (-12.9)	2124.4 (-62.7)	58 (-1)	58 (-1)	58 (-1)	55 (-4)	94 (-4)	94 (-4)	93 (-5)	86 (-12)	2.45	2.74	2.68	2.30
20-May	MC	4835.8 (-15.1)	6021.7 (+5.7)	6199.0 (+8.8)	6133.2 (+7.6)	58 (-1)	58 (-1)	58 (-1)	58 (-1)	94 (-4)	95 (-3)	96 (-2)	95 (-3)	2.45	2.84	2.85	2.90
	EC	4589.1 (-19.5)	5295.2 (-7.1)	4387.3 (-23.0)	1773.3 (-68.9)	58 (-1)	58 (-1)	58 (-1)	55 (-4)	94 (-4)	95 (-3)	93 (-5)	85 (-13)	2.61	2.82	2.75	2.42
25-May	MC	5694.2 (-0.1)	7001.3 (+22.9)	6901.4 (+21.1)	6837.8 (+20.0)	59 (0)	59 (0)	59 (0)	59 (0)	95 (-3)	96 (-2)	97 (-1)	96 (-2)	2.79	3.17	3.11	3.12
	EC	5431.5 (-4.7)	6027.7 (+5.8)	4833.6 (-15.2)	1862.6 (-67.3)	59 (0)	59 (0)	59 (0)	55 (-4)	95 (-3)	96 (-2)	94 (-4)	86 (-12)	2.90	3.13	3.02	2.59

DOS	Time period	BASELINE: Yield= 4-June (5697.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (59 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.04)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	6394.4 (+12.2)	6828.8 (+19.9)	6660.4 (+16.9)	6808.1 (+19.5)	58 (-1)	60 (1)	60 (1)	59 (0)	95 (-3)	97 (-1)	97 (-1)	97 (-1)	3.24	3.51	3.41	3.44
	EC	6099.4 (+7.0)	5983.2 (+5.0)	4975.3 (-12.7)	1810.6 (-68.2)	59 (0)	59 (0)	59 (0)	56 (-3)	96 (-2)	96 (-2)	95 (-3)	81 (-17)	3.29	3.39	3.35	2.87
09-June	MC	4987.2 (-12.5)	5992.5 (5.2)	5899.9 (+3.5)	6227.9 (+9.3)	58 (-1)	59 (0)	60 (1)	59 (0)	95 (-3)	97 (-1)	98 (0)	97 (-1)	3.46	3.44	3.42	3.44
	EC	5316.5 (-6.7)	4968.8 (+12.8)	4329.0 (-24.0)	504.7 (-91.1)	57 (-2)	58 (-1)	57 (-2)	56 (-3)	95 (-3)	95 (-3)	93 (-5)	73 (-25)	3.45	3.44	3.42	3.35
14-June	MC	5433.7 (-4.6)	6071.6 (+6.6)	5965.3 (+4.7)	6208.0 (+9.0)	58 (-1)	59 (0)	59 (0)	59 (0)	95 (-3)	98 (0)	98 (0)	98 (0)	3.72	3.71	3.70	3.70
	EC	5903.3 (+3.6)	5633.5 (-1.1)	4441.7 (-22.0)	2212.6 (-61.2)	59 (0)	59 (0)	58 (-1)	56 (-3)	98 (0)	97 (-1)	95 (-3)	91 (-7)	3.74	3.71	3.70	3.60
19-June	MC	5120.4 (-10.1)	5259.1 (-7.7)	5192.8 (-8.9)	2732.2 (-52.0)	59 (0)	59 (0)	59 (0)	59 (0)	98 (0)	98 (0)	99 (1)	99 (1)	4.08	3.99	3.97	3.98
	EC	5241.2 (-8.0)	4729.7 (-17.0)	4247.7 (-25.4)	2212.7 (-61.2)	59 (0)	59 (0)	59 (0)	56 (-3)	98 (0)	97 (-1)	96 (-2)	91 (-7)	4.05	3.96	4.02	3.92
24-June	MC	3749.8 (-34.2)	4133.2 (-27.5)	4119.7 (-27.7)	5422.0 (-4.8)	59 (0)	60 (1)	60 (1)	59 (0)	98 (0)	99 (1)	100 (2)	99 (1)	3.61	3.56	3.51	3.68
	EC	3832.8 (-32.7)	3710.2 (-34.9)	3440.8 (-39.6)	2732.2 (-52.0)	59 (0)	58 (-1)	58 (-1)	57 (-2)	98 (0)	97 (-1)	96 (-2)	92 (-6)	3.55	3.53	3.69	3.90

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.145: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Faridkot, Punjab

DOS	Time period	BASELINE: Yield= 4-June (5697.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (59 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.04)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	6492.0 (+13.9)*	5587.6 (-1.9)	6135.6 (+7.7)	4545.2 (-20.2)	58 (-1)**	58 (-1)	58 (-1)	57 (-2)	95 (-3)**	94 (-4)	94 (-4)	93 (-5)	2.41	2.57	2.41	2.38
	EC	5416.7 (-4.9)	2093.9 (-63.2)	2493.4 (-56.2)	341.6 (-94.0)	58 (-1)	55 (-4)	55 (-4)	55 (-4)	94 (-4)	90 (-8)	90 (-8)	75 (-23)	2.41	2.29	2.41	1.60
10-May	MC	7109.6 (+24.8)	6551.9 (+15.0)	7007.0 (+23.0)	5977.6 (+4.9)	58 (-1)	57 (-2)	58 (-1)	56 (-3)	95 (-3)	93 (-5)	95 (-3)	92 (-6)	2.56	2.69	2.56	2.52
	EC	6818.1 (+19.7)	3734.0 (-34.5)	4364.5 (-23.4)	333.2 (-94.1)	58 (-1)	55 (-4)	56 (-3)	55 (-4)	94 (-4)	90 (-8)	91 (-7)	72 (-26)	2.53	2.42	2.53	1.63
15-May	MC	6697.5 (+17.5)	6504.5 (-14.2)	6554.3 (+15.0)	6033.5 (+5.9)	58 (-1)	57 (-2)	58 (-1)	57 (-2)	95 (-3)	93 (-5)	95 (-3)	92 (-6)	2.66	2.79	2.66	2.52
	EC	5955.9 (+4.5)	4949.8 (-13.1)	4966.3 (-12.8)	2022.6 (-64.5)	58 (-1)	55 (-4)	55 (-4)	55 (-4)	94 (-4)	90 (-8)	91 (-7)	89 (-9)	2.50	2.36	2.50	1.55
20-May	MC	6349.5 (+11.4)	5372.9 (-5.7)	6088.3 (+6.9)	5388.2 (-5.4)	58 (-1)	58 (-1)	58 (-1)	58 (-1)	95 (-3)	94 (-4)	95 (-3)	93 (-5)	2.78	2.75	2.78	2.71
	EC	5523.6 (-3.1)	4682.2 (-17.8)	4132.6 (-27.5)	2044.7 (-64.1)	58 (-1)	55 (-4)	56 (-3)	55 (-4)	94 (-4)	91 (-7)	91 (-7)	90 (-8)	2.55	2.46	2.55	1.60
25-May	MC	6810.1 (+19.5)	5603.5 (-1.7)	6558.2 (+15.1)	5558.0 (-2.4)	59 (0)	59 (0)	59 (0)	58 (-1)	96 (-2)	95 (-3)	96 (-2)	94 (-4)	3.04	3.07	3.04	2.94
	EC	6050.7 (+6.2)	4457.4 (-21.8)	4117.6 (-27.7)	1998.9 (-64.9)	59 (0)	55 (-4)	56 (-3)	55 (-4)	95 (-3)	91 (-7)	91 (-7)	86 (-12)	2.79	2.58	2.79	2.10

DOS	Time period	BASELINE: Yield= 4-June (5697.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (59 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.04)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	6888.2 (+20.9)	5410.1 (-5.0)	6273.3 (+10.1)	5746.8 (+0.9)	59 (0)	59 (0)	60 (1)	58 (-1)	97 (-1)	95 (-3)	97 (-1)	94 (-4)	3.26	3.30	3.26	3.11
	EC	6021.6 (+5.7)	4994.8 (-12.3)	4772.5 (-16.2)	1724.5 (-69.7)	59 (0)	56 (-3)	56 (-3)	55 (-4)	96 (-2)	91 (-7)	92 (-6)	81 (-17)	2.95	2.81	2.95	2.48
09-June	MC	5589.7 (-1.9)	5252.5 (-7.8)	5624.6 (-1.3)	5400.0 (-5.2)	58 (-1)	57 (-2)	58 (-1)	57 (-2)	96 (-2)	94 (-4)	95 (-3)	94 (-4)	3.41	3.38	3.41	3.43
	EC	4988.8 (-12.4)	3486.1 (-38.8)	4071.2 (-28.6)	129.7 (-97.7)	58 (-1)	57 (-2)	57 (-2)	56 (-3)	94 (-4)	92 (-6)	92 (-6)	71 (-27)	3.40	3.38	3.40	3.40
14-June	MC	5763.8 (+1.1)	4374.1 (-23.2)	5261.3 (-7.7)	4529.0 (-20.5)	60 (1)	59 (0)	60 (1)	58 (-1)	98 (0)	96 (-2)	97 (-1)	95 (-3)	3.68	3.60	3.68	3.67
	EC	5390.3 (-5.4)	3239.9 (-43.1)	3651.4 (-35.9)	1818.1 (-68.1)	59 (0)	57 (-2)	57 (-2)	56 (-3)	96 (-2)	93 (-5)	93 (-5)	90 (-8)	3.62	3.67	3.62	3.68
19-June	MC	4732.0 (-17.0)	4431.7 (-22.2)	4814.9 (-15.5)	4731.3 (-17.0)	60 (1)	59 (0)	59 (0)	58 (-1)	98 (0)	96 (-2)	98 (0)	96 (-2)	3.88	3.78	3.88	3.89
	EC	4760.0 (-16.5)	3385.4 (-40.6)	3881.2 (-31.9)	1957.1 (-65.7)	59 (0)	57 (-2)	57 (-2)	56 (-3)	97 (-1)	93 (-5)	93 (-5)	90 (-8)	3.87	3.92	3.87	3.90
24-June	MC	3690.6 (-35.2)	3533.3 (-38.0)	3816.5 (-33.0)	3610.3 (-36.6)	59 (0)	59 (0)	59 (0)	59 (0)	98 (0)	97 (-1)	98 (0)	96 (-2)	3.52	3.52	3.52	3.56
	EC	3676.3 (-35.5)	2833.6 (-50.3)	3086.2 (-45.8)	1365.8 (-76.0)	59 (0)	59 (0)	59 (0)	56 (-3)	97 (-1)	95 (-3)	95 (-3)	90 (-8)	3.76	3.79	3.76	3.71

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.146: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH1 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Faridkot, Punjab

DOS	Time period	BASELINE: Yield= 4-June (5697.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (59 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.04)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	6740.4 (+18.3)	6096.7 (+7.0)	6493.5 (+14.0)	5593.3 (-1.8)	58 (-1)**	58 (-1)	58 (-1)	58 (-1)	95 (-3)**	94 (-4)	95 (-3)	94 (-4)	2.60	2.49	2.40	2.51
	EC	6518.0 (+14.4)	3338.1 (-41.4)	3553.6 (-37.6)	576.4 (-89.9)	58 (-1)	55 (-4)	56 (-3)	55 (-4)	94 (-4)	91 (-7)	91 (-7)	77 (-21)	2.48	2.34	2.30	1.76
10-May	MC	7305.7 (+28.2)	6946.0 (+21.9)	7196.5 (+26.3)	6536.9 (+14.7)	58 (-1)	58 (-1)	58 (-1)	57 (-2)	95 (-3)	94 (-4)	95 (-3)	93 (-5)	2.66	2.54	2.51	2.60
	EC	7199.3 (+26.3)	4944.3 (-13.2)	5104.5 (-10.4)	932.1 (-83.6)	58 (-1)	55 (-4)	55 (-4)	55 (-4)	95 (-3)	91 (-7)	91 (-7)	76 (-22)	2.57	2.38	2.43	1.67
15-May	MC	6562.2 (+15.2)	5775.3 (+1.4)	6598.7 (+15.8)	5987.1 (+5.1)	58 (-1)	58 (-1)	58 (-1)	57 (-2)	95 (-3)	94 (-4)	95 (-3)	93 (-5)	2.72	2.60	2.64	2.63
	EC	6006.1 (+5.4)	5236.1 (-8.1)	5148.2 (-9.7)	1949.5 (-65.8)	58 (-1)	55 (-4)	55 (-4)	55 (-4)	95 (-3)	91 (-7)	91 (-7)	87 (-11)	2.63	2.35	2.37	1.61
20-May	MC	6138.8 (+7.7)	5624.9 (-1.3)	6157.9 (+8.1)	5353.8 (-6.0)	58 (-1)	58 (-1)	58 (-1)	57 (-2)	95 (-3)	95 (-3)	95 (-3)	94 (-4)	2.81	2.76	2.76	2.74
	EC	5649.8 (-0.8)	4217.9 (-26.0)	4272.5 (-25.0)	1900.8 (-66.7)	58 (-1)	57 (-2)	57 (-2)	55 (-4)	95 (-3)	92 (-6)	92 (-6)	86 (-12)	2.79	2.55	2.61	1.89
25-May	MC	6944.4 (+21.9)	6345.2 (-11.4)	6848.8 (+20.2)	5868.4 (+3.0)	59 (0)	59 (0)	59 (0)	58 (-1)	96 (-2)	96 (-2)	96 (-2)	94 (-4)	3.11	2.90	3.05	2.97
	EC	6551.1 (+15.0)	4406.1 (-22.7)	4290.6 (-24.7)	1810.4 (-68.2)	59 (0)	56 (-3)	56 (-3)	55 (-4)	96 (-2)	92 (-6)	92 (-6)	84 (-14)	3.06	2.60	2.66	2.34

DOS	Time period	BASELINE: Yield= 4-June (5697.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (59 DAS)				BASELINE: Maturity=4-June (98 DAS)				BASELINE: LAI=4-June (3.04)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	6690.6 (+17.4)	6189.6 (+8.6)	6646.7 (+16.7)	6072.7 (+6.6)	60 (1)	59 (0)	60 (1)	59 (0)	97 (-1)	96 (-2)	97 (-1)	95 (-3)	3.39	3.29	3.32	3.25
	EC	6416.2 (+12.6)	5168.8 (-9.3)	5134.5 (-9.9)	1572.4 (-72.4)	60 (1)	57 (-2)	57 (-2)	55 (-4)	97 (-1)	92 (-6)	92 (-6)	79 (-19)	3.35	3.09	3.10	2.70
09-June	MC	5522.3 (-3.1)	4859.7 (-14.7)	5570.3 (-2.2)	4735.8 (-16.9)	58 (-1)	58 (-1)	58 (-1)	58 (-1)	96 (-2)	95 (-3)	96 (-2)	95 (-3)	3.33	3.35	3.35	3.34
	EC	4947.9 (-13.2)	4287.3 (-24.8)	4140.9 (-27.3)	980.9 (-82.8)	58 (-1)	57 (-2)	57 (-2)	56 (-3)	95 (-3)	93 (-5)	93 (-5)	78 (-20)	3.37	3.40	3.41	3.38
14-June	MC	5819.8 (+2.1)	5396.0 (-5.3)	5888.2 (+3.3)	5240.3 (-8.0)	59 (0)	59 (0)	60 (1)	58 (-1)	98 (0)	97 (-1)	98 (0)	96 (-2)	3.58	3.62	3.66	3.58
	EC	5340.4 (-6.3)	3954.6 (-30.6)	3929.8 (-31.0)	1865.2 (-67.3)	59 (0)	57 (-2)	57 (-2)	56 (-3)	97 (-1)	93 (-5)	93 (-5)	90 (-8)	3.61	3.62	3.64	3.62
19-June	MC	4916.6 (-13.7)	4751.2 (-16.6)	5072.9 (-11.0)	4741.9 (-16.8)	59 (0)	59 (0)	59 (0)	59 (0)	98 (0)	97 (-1)	98 (0)	97 (-1)	3.79	3.85	3.88	3.83
	EC	4899.4 (-14.0)	4193.8 (-26.4)	4092.0 (-28.2)	2237.5 (-60.7)	59 (0)	58 (-1)	58 (-1)	56 (-3)	98 (0)	94 (-4)	95 (-3)	90 (-8)	3.81	3.90	3.94	3.81
24-June	MC	4026.3 (-29.3)	3823.2 (-32.9)	3953.9 (-30.6)	3855.8 (-32.3)	60 (1)	59 (0)	60 (1)	59 (0)	99 (1)	98 (0)	99 (1)	97 (-1)	3.58	3.60	3.49	3.63
	EC	3968.8 (-30.3)	3274.0 (-42.5)	3223.0 (-43.4)	2077.6 (-63.5)	59 (0)	58 (-1)	58 (-1)	56 (-3)	98 (0)	96 (-2)	96 (-2)	91 (-7)	3.61	3.79	3.78	3.88

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.147: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by CSIRO-Mk-3-6-0 model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Faridkot, Punjab

DOS	Time period	BASELINE: Yield =4-June (6242.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.67)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	1344.9 (-78.6)*	2873.6 (-54.0)	3596.9 (-42.4)	2548.7 (-55.3)	54 (-2)**	53 (-3)	54 (-2)	53 (-3)	90 (-6)**	91 (-5)	91 (-5)	91 (-5)	1.95	1.94	1.94	1.87
	EC	2977.6 (-52.3)	1167.8 (-81.3)	1347.3 (-78.4)	121.6 (-97.9)	53 (-3)	53 (-3)	53 (-3)	52 (-4)	91 (-5)	89 (-7)	72 (-24)	72 (-24)	1.95	1.96	1.90	1.44
10-May	MC	2440.1 (-60.9)	5430.2 (-13.0)	6253.3 (+0.2)	4942.8 (-13.2)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	91 (-5)	92 (-4)	91 (-5)	91 (-5)	2.01	2.38	2.35	2.30
	EC	5648.1 (-9.5)	2109.4 (-66.2)	2451.4 (-60.7)	104.0 (-98.2)	54 (-2)	52 (-4)	52 (-4)	51 (-5)	92 (-4)	89 (-7)	69 (-27)	67 (-29)	2.35	2.25	2.27	1.59
15-May	MC	4463.1 (-28.5)	6380.2 (+2.2)	7031.6 (+12.6)	6004.1 (+5.4)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	91 (-5)	92 (-4)	92 (-4)	91 (-5)	2.47	2.62	2.64	2.60
	EC	6710.0 (+7.5)	3198.5 (-48.8)	3555.7 (-43.0)	8.3 (-99.9)	54 (-2)	53 (-3)	52 (-4)	51 (-5)	92 (-4)	89 (-7)	84 (-12)	65 (-31)	2.59	2.43	2.40	1.41
20-May	MC	5477.1 (-12.3)	4978.2 (-20.3)	5400.4 (-13.5)	4658.8 (-18.2)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	91 (-5)	92 (-4)	92 (-4)	92 (-4)	2.73	2.55	2.65	2.50
	EC	5094.6 (-18.4)	2850.7 (-54.3)	3099.4 (-50.3)	692.6 (-87.8)	54 (-2)	54 (-2)	54 (-2)	51 (-5)	92 (-4)	90 (-6)	81 (-15)	77 (-19)	2.61	2.21	2.24	1.27
25-May	MC	4056.7 (-35.0)	5095.7 (-18.4)	5733.0 (-8.2)	4692.9 (-17.6)	54 (-2)	54 (-2)	55 (-1)	54 (-2)	91 (-5)	92 (-4)	93 (-3)	92 (-4)	2.49	2.60	2.66	2.55
	EC	5241.0 (-16.0)	2466.9 (-60.5)	2674.5 (-57.2)	707.5 (-87.6)	54 (-2)	54 (-2)	54 (-2)	51 (-5)	92 (-4)	86 (-10)	81 (-15)	75 (-21)	2.56	2.51	2.48	1.60

DOS	Time period	BASELINE: Yield =4-June (6242.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.67)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	3992.0 (-36.0)	6008.4 (-3.8)	6656.2 (+6.6)	5514.2 (-3.2)	54 (-2)	55 (-1)	56 (0)	55 (-1)	91 (-5)	93 (-3)	91 (-5)	93 (-3)	2.59	2.92	2.96	2.88
	EC	6238.4 (-0.1)	2093.9 (-66.5)	2411.2 (-61.4)	539.4 (-90.5)	55 (-1)	54 (-2)	54 (-2)	51 (-5)	93 (-3)	81 (-15)	71 (-25)	72 (-24)	2.87	2.69	2.69	2.85
09-June	MC	4370.6 (-30.0)	4061.5 (-34.9)	4263.0 (-31.7)	3901.6 (-31.5)	55 (-1)	54 (-2)	56 (0)	54 (-2)	93 (-3)	93 (-3)	93 (-3)	92 (-4)	3.31	3.59	3.63	3.53
	EC	4151.9 (-33.5)	741.1 (-88.1)	1132.5 (-81.9)	379.7 (-93.3)	55 (-1)	52 (-4)	52 (-4)	51 (-5)	93 (-3)	71 (-25)	71 (-25)	70 (-26)	3.62	3.25	3.28	2.93
14-June	MC	4006.8 (-35.8)	3801.5 (-39.1)	4287.2 (-31.3)	3723.3 (-34.7)	53 (-3)	55 (-1)	56 (0)	55 (-1)	91 (-5)	94 (-2)	94 (-2)	93 (-3)	3.59	3.50	3.48	3.50
	EC	4008.5 (-35.79)	810.7 (-87.0)	1503.6 (-75.9)	0 (-100)	55 (-1)	52 (-4)	52 (-4)	51 (-5)	94 (-2)	72 (-24)	89 (-7)	65 (-31)	3.54	3.42	3.46	3.33
19-June	MC	3380.0 (-45.9)	5309.3 (-14.9)	5054.1 (-19.0)	5119.2 (-10.1)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	93 (-3)	94 (-2)	95 (-1)	94 (-2)	3.50	3.62	3.57	3.65
	EC	5369.0 (-14.0)	2079.4 (-66.7)	2506.6 (-59.9)	598.1 (-89.5)	55 (-1)	53 (-3)	54 (-2)	51 (-5)	95 (-1)	90 (-6)	91 (-5)	74 (-22)	3.67	3.64	3.67	3.56
24-June	MC	5312.8 (-14.9)	3600.9 (-42.3)	3764.7 (-39.7)	3530.7 (-38.0)	55 (-1)	56 (0)	56 (0)	55 (-1)	93 (-3)	95 (-1)	94 (-2)	94 (-2)	3.63	3.90	3.86	3.91
	EC	3757.0 (-39.8)	2520.2 (-59.6)	2567.2 (-58.9)	1138.6 (-80.0)	56 (0)	54 (-2)	54 (-2)	52 (-4)	95 (-1)	91 (-5)	91 (-5)	85 (-11)	3.93	3.88	3.92	3.61

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.148: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by FIO-ESM model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Faridkot, Punjab

DOS	Time period	BASELINE: Yield = 4-June (6242.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.67)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	3215.2 (-48.5)*	4980.0 (-20.2)	5094.5 (-18.4)	4473.4 (-28.3)	54 (-2)**	54 (-2)	54 (-2)	54 (-2)	91 (-5)**	92 (-4)	92 (-4)	92 (-4)	1.89	2.17	2.05	2.17
	EC	3334.4 (-46.6)	4521.8 (-27.6)	3487.1 (-44.1)	744.0 (-88.1)	54 (-2)	54 (-2)	54 (-2)	53 (-3)	92 (-4)	92 (-4)	91 (-5)	79 (-17)	1.93	2.12	2.01	2.05
10-May	MC	5028.9 (-19.4)	6931.5 (+11.0)	6982.9 (+11.9)	6582.1 (+5.4)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	93 (-3)	93 (-3)	93 (-3)	2.24	2.58	2.49	2.49
	EC	4799.4 (-23.1)	6050.8 (-3.1)	5158.1 (-17.4)	1068.8 (-82.9)	54 (-2)	54 (-2)	54 (-2)	52 (-4)	92 (-4)	93 (-3)	92 (-4)	76 (-20)	2.32	2.52	2.41	2.30
15-May	MC	5629.1 (-9.8)	6992.8 (+12.0)	7275.0 (+16.5)	6810.3 (+9.1)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	93 (-3)	93 (-3)	92 (-4)	2.35	2.77	2.68	2.72
	EC	5355.6 (-14.2)	6319.9 (+1.2)	5510.8 (-11.7)	1903.9 (-69.5)	54 (-2)	54 (-2)	54 (-2)	53 (-3)	92 (-4)	92 (-4)	91 (-5)	82 (-14)	2.48	2.78	2.64	2.36
20-May	MC	4420.6 (-29.2)	5521.9 (-11.6)	5406.0 (-13.4)	5303.8 (-15.0)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	93 (-3)	93 (-3)	93 (-3)	2.41	2.94	2.88	2.89
	EC	4120.0 (-34.0)	4904.4 (-21.4)	4164.6 (-33.3)	1719.4 (-72.5)	54 (-2)	54 (-2)	54 (-2)	53 (-3)	92 (-4)	92 (-4)	91 (-5)	85 (-11)	2.59	2.91	2.78	2.32
25-May	MC	5100.5 (-18.3)	6263.7 (+0.3)	6311.6 (+1.1)	6308.3 (+1.0)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	93 (-3)	94 (-2)	94 (-2)	94 (-2)	2.46	2.81	2.79	2.80
	EC	4844.8 (-22.4)	5453.7 (-12.6)	4323.9 (-30.7)	1563.6 (-75.0)	55 (-1)	55 (-1)	54 (-2)	53 (-3)	93 (-3)	93 (-3)	92 (-4)	81 (-15)	2.56	2.79	2.66	2.45

DOS	Time period	BASELINE: Yield = 4-June (6242.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.67)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	6623.3 (+6.1)	7113.8 (+14.0)	7036.9 (-12.7)	7232.5 (+15.9)	55 (-1)	56 (0)	56 (0)	55 (-1)	94 (-2)	95 (-1)	95 (-1)	95 (-1)	2.92	3.18	3.11	3.14
	EC	6406.4 (+2.6)	6503.7 (+4.2)	5272.0 (-15.6)	1769.2 (-71.7)	55 (-1)	55 (-1)	55 (-1)	53 (-3)	94 (-2)	94 (-2)	92 (-4)	81 (-15)	2.96	3.11	3.08	2.70
09-June	MC	4482.0 (-28.2)	6488.4 (+3.9)	6109.1 (-2.1)	6218.7 (-0.4)	56 (0)	56 (0)	56 (0)	56 (0)	95 (-1)	96 (0)	96 (0)	96 (0)	3.54	3.71	3.67	3.72
	EC	4639.1 (-25.7)	4343.1 (-30.4)	4587.5 (-26.5)	983.6 (-84.2)	55 (-1)	55 (0)	55 (-1)	52 (-4)	95 (-1)	95 (-1)	93 (-3)	73 (-23)	3.52	3.64	3.68	3.31
14-June	MC	4593.2 (-26.4)	5313.2 (-14.9)	5224.2 (-16.3)	5578.1 (-10.7)	55 (-1)	55 (-1)	56 (0)	55 (-1)	95 (-1)	96 (0)	96 (0)	96 (0)	3.49	3.44	3.43	3.43
	EC	4743.1 (-24.0)	4433.7 (-29.0)	3968.4 (-36.4)	2477.1 (-60.3)	55 (-1)	55 (-1)	55 (-1)	52 (-4)	95 (-1)	94 (-2)	94 (-2)	89 (-7)	3.44	3.44	3.44	3.34
19-June	MC	4715.3 (-24.5)	5023.3 (-19.5)	5042.3 (-19.2)	5239.4 (-16.1)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	95 (-1)	96 (0)	99 (3)	96 (0)	3.74	3.68	3.69	3.69
	EC	5083.0 (-18.6)	4588.2 (-26.5)	3817.4 (-38.9)	2566.8 (-58.9)	55 (-1)	55 (-1)	55 (-1)	53 (-3)	96 (0)	95 (-1)	94 (-2)	90 (-6)	3.67	3.64	3.68	3.66
24-June	MC	4174. [*] (-33.1)	3941.2 (-36.9)	4037.9 (-35.3)	4200.1 (-32.7)	55 (-1)	57 (1)	57 (1)	56 (0)	95 (-1)	99 (3)	95 (-1)	98 (2)	3.99	4.03	4.01	3.99
	EC	4489.6 (-28.1)	3662.6 (-41.3)	3487.1 (-44.1)	2206.9 (-64.7)	55 (-1)	57 (1)	55 (-1)	54 (-2)	96 (0)	97 (1)	93 (-3)	91 (-5)	3.99	4.00	3.98	3.83

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.149: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by IPSL-CM5A-MR model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Faridkot, Punjab

DOS	Time period	BASELINE: Yield =4-June (6242.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.67)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	4649.9 (-25.5)*	3535.6 (-43.4)	3987.2 (-36.1)	2892.4 (-53.7)	54 (-2)**	54 (-2)	54 (-2)	54 (-2)	92 (-4)**	92 (-4)	92 (-4)	91 (-5)	2.10	2.17	1.99	1.96
	EC	3705.7 (-40.6)	1682.3 (-73.0)	2033.9 (-67.4)	250.0 (-96.0)	54 (-2)	53 (-3)	54 (-2)	51 (-5)	91 (-5)	89 (-7)	90 (-6)	75 (-21)	2.06	1.94	2.16	1.41
10-May	MC	6660.2 (+6.7)	5651.0 (-9.5)	6345.1 (+1.6)	5117.3 (-18.0)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	92 (-4)	93 (-3)	92 (-4)	2.52	2.59	2.43	2.42
	EC	5657.4 (-9.4)	3089.9 (-50.5)	3496.2 (-44.0)	360.0 (-94.2)	54 (-2)	53 (-3)	53 (-3)	51 (-5)	92 (-4)	90 (-6)	89 (-7)	71 (-25)	2.43	2.32	2.52	1.61
15-May	MC	7186.2 (+15.1)	6426.3 (+2.9)	7039.3 (+12.8)	6239.2 (-0.1)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	93 (-3)	92 (-4)	93 (-3)	92 (-4)	2.77	2.89	2.74	2.69
	EC	6489.6 (+4.0)	4662.9 (-25.3)	4716.0 (-24.5)	363.3 (-94.2)	54 (-2)	53 (-3)	54 (-2)	52 (-4)	92 (-4)	90 (-6)	91 (-5)	68 (-28)	2.71	2.52	2.72	1.49
20-May	MC	5416.5 (-13.2)	4978.5 (-20.2)	5312.8 (-14.9)	4770.1 (-23.6)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	92 (-4)	92 (-4)	93 (-3)	92 (-4)	2.79	2.86	2.76	2.57
	EC	4734.4 (-24.2)	4293.9 (-31.2)	3925.8 (-37.1)	1793.6 (-71.3)	54 (-2)	53 (-3)	54 (-2)	52 (-4)	92 (-4)	90 (-6)	91 (-5)	88 (-8)	2.72	2.43	2.51	1.42
25-May	MC	6746.8 (+8.1)	4953.9 (-20.7)	5989.1 (-4.1)	4984.5 (-20.2)	55 (-1)	55 (-1)	55 (-1)	54 (-2)	93 (-3)	93 (-3)	93 (-3)	92 (-4)	2.74	2.73	2.71	2.62
	EC	5417.4 (-13.2)	4329.2 (-30.7)	4008.6 (-35.8)	1916.7 (-69.3)	55 (-1)	54 (-2)	54 (-2)	52 (-4)	92 (-4)	91 (-5)	91 (-5)	86 (-10)	2.65	2.38	2.60	1.76

DOS	Time period	BASELINE: Yield =4-June (6242.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.67)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	7220.7 (+15.7)	5861.6 (-6.1)	6830.4 (+9.4)	6088.6 (-2.5)	55 (-1)	55 (-1)	56 (0)	55 (-1)	94 (-2)	93 (-3)	94 (-2)	93 (-3)	3.03	3.07	2.97	2.96
	EC	6528.5 (+4.6)	4847.0 (-22.4)	4697.4 (-24.8)	1721.6 (-72.4)	55 (-1)	54 (-2)	54 (-2)	52 (-4)	93 (-3)	91 (-5)	92 (-4)	81 (-15)	2.94	2.54	2.92	1.94
09-June	MC	5373.5 (-13.9)	3905.6 (-37.4)	4907.8 (-21.4)	4184.9 (-33.0)	56 (0)	56 (0)	56 (0)	55 (-1)	96 (0)	93 (-3)	95 (-1)	93 (-3)	3.61	3.69	3.63	3.61
	EC	4239.7 (-32.1)	3888.1 (-37.7)	3900.5 (-37.5)	841.1 (-86.5)	56 (0)	53 (-3)	53 (-3)	52 (-4)	94 (-2)	90 (-6)	90 (-6)	71 (-25)	3.62	3.15	3.52	3.04
14-June	MC	4926.0 (-21.1)	3677.0 (-41.1)	4496.2 (-28.0)	3847.2 (-38.4)	56 (0)	55 (-1)	55 (-1)	55 (-1)	96 (0)	94 (-2)	95 (-1)	94 (-2)	3.39	3.42	3.45	3.48
	EC	4271.1 (-31.6)	3992.1 (-36.0)	3703.0 (-40.7)	1032.0 (-83.5)	55 (-1)	53 (-3)	54 (-2)	53 (-3)	94 (-2)	91 (-5)	91 (-5)	77 (-19)	3.41	3.45	3.42	3.40
19-June	MC	4634.7 (-25.8)	5385.2 (-13.7)	4782.7 (-23.4)	5133.2 (-17.8)	56 (0)	55 (-1)	55 (-1)	55 (-1)	96 (0)	94 (-2)	95 (-1)	94 (-2)	3.57	3.50	3.60	3.61
	EC	4233.3 (-32.2)	2951.6 (-52.7)	4567.0 (-26.8)	1364.5 (-78.1)	55 (-1)	54 (-2)	55 (-1)	53 (-3)	95 (-1)	92 (-4)	93 (-3)	88 (-8)	3.59	3.67	3.59	3.66
24-June	MC	3660.5 (-41.4)	3373.0 (-46.0)	3669.4 (-41.2)	3601.3 (-42.3)	56 (0)	56 (0)	56 (0)	55 (-1)	97 (1)	95 (-1)	97 (1)	94 (-2)	3.83	3.79	3.89	3.88
	EC	3674.7 (-41.1)	2812.0 (-55.0)	3062.3 (-51.0)	1566.7 (-74.9)	55 (-1)	55 (-1)	55 (-1)	54 (-2)	95 (-1)	93 (-3)	93 (-3)	90 (-6)	3.87	3.96	3.84	3.80

*%deviation from baseline value

**Deviation from baseline in DAS

Table 4.150: Simulation of changes in maize yield (kg ha⁻¹), anthesis (DAS), maturity (DAS) and Leaf area index of PMH2 variety by Ensemble model during 21st century (MC: Mid-century and EC: End-century) under optimized sowing dates at Faridkot, Punjab

DOS	Time period	BASELINE: Yield =4-June (6242.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.67)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
05-May	MC	4996.7 (-20.0)*	4512.5 (-27.7)	4970.0 (-20.4)	3972.2 (-36.4)	54 (-2)**	54 (-2)	54 (-2)	54 (-2)	92 (-4)**	92 (-4)	92 (-4)	91 (-5)	2.35	2.23	2.06	2.20
	EC	4847.0 (-22.4)	2339.7 (-62.5)	2320.0 (-62.8)	502.6 (-92.0)	54 (-2)	53 (-3)	53 (-3)	52 (-4)	92 (-4)	90 (-6)	90 (-6)	76 (-20)	2.16	2.14	1.94	1.71
10-May	MC	6994.3 (+12.0)	6343.3 (+1.6)	6753.0 (+8.2)	5962.0 (-4.5)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	93 (-3)	92 (-4)	93 (-3)	92 (-4)	2.73	2.60	2.45	2.57
	EC	6843.0 (+9.6)	4509.8 (-27.8)	4429.3 (-29.0)	662.1 (-89.4)	54 (-2)	54 (-2)	54 (-2)	51 (-5)	93 (-3)	91 (-5)	91 (-5)	72 (-24)	2.53	2.46	2.40	1.78
15-May	MC	7259.4 (+16.3)	6845.1 (+9.7)	7201.8 (+15.4)	6400.9 (+2.5)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	93 (-3)	92 (-4)	93 (-3)	92 (-4)	2.83	2.66	2.65	2.73
	EC	7054.4 (+13.0)	5205.1 (-16.6)	5163.5 (-17.3)	1724.9 (-72.4)	54 (-2)	54 (-2)	54 (-2)	51 (-5)	92 (-4)	91 (-5)	91 (-5)	84 (-12)	2.73	2.48	2.49	1.45
20-May	MC	5429.4 (-13.0)	4703.5 (-24.7)	5127.1 (-17.9)	4694.4 (-24.8)	54 (-2)	54 (-2)	54 (-2)	54 (-2)	93 (-3)	92 (-4)	93 (-3)	92 (-4)	2.87	2.68	2.77	2.71
	EC	4797.6 (-23.1)	3871.1 (-38.0)	3891.9 (-37.7)	1778.7 (-71.5)	54 (-2)	54 (-2)	54 (-2)	51 (-5)	93 (-3)	91 (-5)	91 (-5)	84 (-12)	2.72	2.40	2.44	1.65
25-May	MC	6386.3 (+2.3)	5741.0 (-8.0)	6355.1 (+1.8)	5360.3 (-14.1)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	94 (-2)	93 (-3)	94 (-2)	93 (-3)	2.84	2.69	2.72	2.72
	EC	5720.7 (-8.4)	4194.9 (-32.8)	4083.9 (-34.6)	1628.1 (-73.9)	55 (-1)	54 (-2)	54 (-2)	52 (-4)	93 (-3)	92 (-4)	91 (-5)	81 (-15)	2.78	2.57	2.53	1.96

DOS	Time period	BASELINE: Yield =4-June (6242.9 kg ha ⁻¹)				BASELINE: Anthesis= 4-June (56 DAS)				BASELINE: Maturity=4-June (96 DAS)				BASELINE: LAI=4-June (3.67)			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
30-May	MC	7198.4 (+15.3)	6618.4 (+6.0)	7055.4 (+13.0)	6339.5 (+1.5)	56 (0)	55 (-1)	56 (0)	55 (-1)	95 (-1)	94 (-2)	95 (-1)	94 (-2)	3.14	3.02	3.01	3.01
	EC	6657.6 (+6.6)	5182.6 (-17.0)	5135.0 (-17.7)	1635.0 (-73.8)	56 (0)	55 (-1)	55 (-1)	52 (-4)	94 (-2)	92 (-4)	92 (-4)	79 (-17)	3.10	2.88	2.91	2.30
09-June	MC	6405.8 (+2.6)	5331.0 (-14.6)	6330.0 (+1.4)	4936.9 (-20.9)	56 (0)	56 (0)	56 (0)	55 (-1)	96 (0)	95 (-1)	96 (0)	94 (-2)	3.64	3.58	3.57	3.59
	EC	6047.3 (-3.1)	3625.6 (-41.9)	3661.9 (-41.3)	585.5 (-90.6)	56 (0)	53 (-3)	53 (-3)	52 (-4)	95 (-1)	91 (-5)	91 (-5)	69 (-27)	3.62	3.52	3.54	3.12
14-June	MC	5014.8 (-19.7)	4462.1 (-28.5)	5073.9 (-18.7)	4340.1 (-30.5)	56 (0)	55 (-1)	56 (0)	55 (-1)	96 (0)	95 (-1)	96 (0)	94 (-2)	3.35	3.37	3.40	3.35
	EC	4681.1 (-25.0)	3318.1 (-46.9)	3421.9 (-45.2)	1930.1 (-69.1)	55 (-1)	55 (-1)	54 (-2)	52 (-4)	95 (-1)	93 (-3)	92 (-4)	88 (-8)	3.37	3.42	3.43	3.36
19-June	MC	4753.3 (-23.9)	4442.5 (-28.8)	4847.3 (-22.3)	4366.2 (-30.1)	55 (-1)	55 (-1)	55 (-1)	55 (-1)	96 (0)	95 (-1)	96 (0)	95 (-1)	3.50	3.56	3.60	3.52
	EC	4572.0 (-26.8)	3572.6 (-42.8)	3613.9 (-42.1)	1781.2 (-71.5)	55 (-1)	55 (-1)	55 (-1)	52 (-4)	95 (-1)	93 (-3)	93 (-3)	88 (-8)	3.53	3.62	3.64	3.55
24-June	MC	3708.0 (-40.6)	3723.8 (-40.3)	3865.5 (-38.1)	3710.4 (-40.6)	57 (1)	54 (-2)	57 (1)	56 (0)	98 (2)	96 (0)	98 (2)	96 (0)	3.80	3.84	3.91	3.81
	EC	3744.8 (-40.0)	3213.3 (-48.5)	3213.7 (-48.5)	1899.5 (-69.6)	57 (1)	54 (-2)	55 (-1)	53 (-3)	98 (2)	93 (-3)	93 (-3)	90 (-6)	3.83	3.87	3.89	3.73

*%deviation from baseline value

**Deviation from baseline in DAS

4.6 Optimization of nitrogen application in maize cultivars under future projections

The nitrogen dose for the maize cultivars was optimized for lower as 65 kg ha⁻¹ to higher as 185 kg ha⁻¹. The deviations in yield were evaluated from the baseline (DOS=4th June; N-dose=125 kg ha⁻¹). The results obtained are discussed below.

Agroclimatic zone II (Ballowal Saunkhri)

At this zone for PMH1 (Table 4.151) the CSIRO-Mk-3-6-0 model observed decrement in the maize crop yield from the baseline under all the scenarios during the end-century. Under RCP2.6 a small increase might be seen at higher doses of nitrogen. The increase during the mid-century for all the scenarios as predicted by the model ranged RCP2.6 (0.2% to 27.6%), RCP4.5 (2.4% to 24.1%), RCP6.0 (4.5 to 37.3) and RCP8.5 (0.1% to 18.8%) during mid-century. The mid-century observed yield increment under lower doses of nitrogen too. During the end-century all the scenarios observed a yield decline except RCP2.6 where at higher doses (155-185 kg ha⁻¹) increase (0.9% to 9.6%) was observed. The other scenarios observed a decrease upto 89.1% with maximum decline under RCP8.5. However the other three GCMs still gave similar results to each other where the increase was observed under RCP2.6 for mid-century upto 62% and upto 59% during end-century. The yield increased as the nitrogen dose increased. Under RCP4.5 the three models projected the increase upto 35% during mid-century and upto 8% during end-century. The increase observed was higher at higher doses of nitrogen. Under RCP6.0 the increment was low for the end-century upto 1.1% only. The nitrogen doses could not contribute to the increment of yield. The RCP8.5 projected a yield loss upto 80% during the end-century while only a slight increment during the mid-century.

The PMH2 (Table 4.152) cultivar in this zone was projected to experience a yield decline under RCP2.6 by all the four GCMs. This decrease was observed upto 4.9% during the mid-century and upto 7.8% during the end-century even at higher doses of nitrogen. The RCP4.5 also projected the yield to decrease upto 4.9% and 12.5% during the mid and end-century. The decline during the mid-century was 2.5% and 17.5% during the end-century under RCP6.0 as projected by the Ensemble model. Under RCP8.5 the yield was predicted to increase slightly upto 0.5% at higher doses of nitrogen and the end-century experienced a yield decline upto 72.2%. The CSIRO-Mk-3-6-0 model under estimated the yield while FIO-ESM over estimated the yield at higher doses of nitrogen.

Table 4.151: Simulation of changes in maize yield (kg ha⁻¹) of PMH1 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Ballawal Saunkhri, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (4245.6 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	4108.4 (-3.2)*	3975.4 (-6.4)	4437.2 (+4.5)	3781.8 (-10.9)	5886.7 (+38.7)	5471.6 (+28.9)	5844.3 (+37.7)	5902.2 (+39.0)	5699.9 (+34.2)	3978.6 (-6.3)	4773.3 (+12.4)	4098.2 (-3.5)	6253.6 (+47.3)	4768.4 (+12.3)	4773.9 (+12.4)	5062.1 (+19.2)
	EC	3476.1 (-18.1)	868.4 (-79.6)	1439.9 (-66.1)	419.6 (-90.1)	5814.1 (+36.9)	4083.7 (-3.8)	3520.3 (-17.1)	937.3 (-77.9)	4301.3 (+1.3)	3538.6 (-16.7)	3314.2 (-21.9)	840.9 (-80.2)	6114.9 (+44.0)	3525.1 (-17.0)	3496.2 (-17.7)	732.5 (-82.8)
75	MC	4255.8 (+0.2)	4117.8 (-3.0)	4601.4 (+8.4)	3919.6 (-7.7)	5985.3 (+41.0)	5648.9 (+33.0)	5976.9 (+40.8)	6088.2 (+43.4)	5841.9 (+37.6)	4121.6 (-2.9)	4945.3 (+16.5)	4245.8 (0)	6382.8 (+50.3)	4913.0 (+15.7)	4918.1 (+15.8)	5201.4 (+22.5)
	EC	3598.3 (-15.2)	894.5 (-78.9)	1486.4 (-65.0)	427.3 (-89.9)	5918.9 (+39.4)	4222.1 (-0.6)	3595.8 (-15.3)	965.8 (-77.2)	4458.2 (+5.0)	3647.2 (-14.1)	3430.0 (-19.2)	853.8 (-79.9)	6217.1 (+46.4)	3654.9 (-13.9)	3590.4 (-15.4)	750.7 (-82.3)
85	MC	4385.5 (+3.3)	4244.5 (-0.03)	4745.0 (+11.8)	4040.7 (-4.8)	6106.2 (+43.8)	5821.2 (+37.1)	6098.0 (+43.6)	6257.9 (+47.4)	5968.2 (+40.6)	4257.5 (+0.3)	5099.9 (+20.1)	4375.6 (+3.1)	6509.6 (+53.3)	5038.3 (+18.7)	5075.7 (+19.6)	5326.4 (+25.4)
	EC	3703.5 (-12.8)	916.4 (-78.4)	1527.7 (-64.0)	433.4 (-89.8)	6021.7 (+41.8)	4345.7 (+2.4)	3674.8 (-13.4)	990.3 (-76.7)	4589.8 (+8.1)	3745.7 (-11.8)	3534.0 (-16.8)	866.4 (-79.6)	6296.6 (+48.3)	3772.1 (-11.1)	3687.5 (-13.1)	769.7 (-81.9)
95	MC	4512.4 (+6.3)	4349.6 (+2.4)	4866.2 (+14.6)	4141.7 (-2.4)	6215.6 (+46.4)	5960.2 (+40.4)	6204.6 (+46.1)	6402.1 (+50.8)	6064.7 (+42.8)	4363.9 (+2.8)	5225.2 (+23.1)	4492.0 (+5.8)	6614.0 (+55.8)	5133.2 (+20.9)	5187.6 (+22.2)	5422.6 (+27.7)
	EC	3803.7 (-10.4)	936.9 (-77.9)	1564.5 (-63.1)	438.5 (-89.7)	6118.6 (+44.1)	4457.7 (+5.0)	3746.5 (-11.8)	1012.7 (-76.1)	4694.1 (+10.6)	3824.5 (-9.9)	3636.6 (-14.3)	876.6 (-79.3)	6360.9 (+49.8)	3862.6 (-9.0)	3767.8 (-11.2)	786.5 (-81.5)
105	MC	4603.9 (+8.4)	4454.7 (+4.9)	4981.8 (+17.3)	4250.7 (+0.1)	6308.7 (+48.6)	6101.6 (+43.7)	6307.7 (+48.6)	6555.1 (+54.4)	6161.1 (+45.1)	4469.4 (+5.3)	5345.5 (+25.9)	4603.3 (+8.4)	6686.0 (+57.5)	5222.7 (+23.01)	5303.9 (+24.9)	5513.8 (+29.9)
	EC	3888.9 (-8.4)	956.6 (-77.5)	1602.4 (-62.3)	442.8 (-89.6)	6196.7 (+46.0)	4570.7 (+7.7)	3814.4 (-10.2)	1033.1 (-75.7)	4794.6 (+12.9)	3924.1 (-7.6)	3733.4 (-12.1)	885.8 (-79.1)	6407.8 (+50.9)	3960.3 (-6.7)	3849.9 (-9.3)	802.3 (-81.1)
115	MC	4710.3 (+11.0)	4558.0 (+7.4)	5090.8 (+19.9)	4347.0 (+2.4)	6431.4 (+51.5)	6228.2 (+46.7)	6398.3 (+50.7)	6680.4 (+57.3)	6247.0 (+47.1)	4568.1 (+7.6)	5461.9 (+28.7)	4708.3 (+10.9)	6750.0 (+59.0)	5303.0 (+24.9)	5412.5 (+27.5)	5593.7 (+31.8)
	EC	3971.1 (-6.5)	978.6 (-76.95)	1634.9 (-61.5)	446.1 (-89.5)	6265.9 (+47.6)	4661.3 (+9.8)	3880.8 (-8.6)	1052.7 (-75.2)	4884.3 (+15.0)	4007.5 (-5.6)	3824.2 (-9.9)	893.5 (-79.0)	6448.5 (+51.9)	4046.1 (-4.7)	3925.8 (-7.5)	816.9 (-80.8)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (4245.6 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	4894.7 (+15.3)	4740.5 (+11.7)	5285.0 (+24.5)	4525.5 (+6.6)	6598.3 (+55.4)	6467.1 (+53.3)	6529.4 (+53.8)	6906.7 (+62.7)	6406.9 (+50.9)	4740.8 (+11.7)	5684.7 (+33.9)	4893.8 (+15.3)	6857.9 (+61.5)	5439.7 (+28.1)	5580.5 (+31.4)	5758.2 (+35.6)
	EC	4135.7 (-2.6)	1017.1 (-76.0)	1708.2 (-59.8)	451.7 (-89.4)	6378.5 (+50.4)	4825.3 (+13.7)	3999.3 (-5.8)	1092.4 (-74.3)	5048.9 (+18.9)	4212.4 (-0.8)	3990.6 (-6.0)	908.8 (-78.6)	6530.1 (+53.8)	4206.6 (-0.9)	4065.0 (-4.2)	846.3 (-80.1)
145	MC	4980.6 (+17.3)	4822.9 (+13.6)	5369.9 (+26.5)	4605.1 (+8.5)	6656.6 (+56.8)	6572.8 (+54.8)	6588.3 (+55.2)	7022.5 (+65.4)	6478.4 (+52.6)	4817.8 (+13.5)	5782.8 (+36.2)	4978.1 (+17.2)	6889.6 (+62.3)	5496.7 (+29.5)	5655.0 (+33.2)	5825.8 (+37.2)
	EC	4201.7 (-1.0)	1040.7 (-75.5)	1739.8 (-59.0)	454.5 (-89.3)	6444.7 (+51.8)	4912.2 (+15.7)	4061.2 (-4.3)	1113.4 (-73.8)	5122.0 (+20.6)	4293.4 (+1.1)	4058.7 (-4.4)	913.2 (-78.5)	6558.4 (+54.5)	4276.8 (+0.7)	4128.5 (-2.8)	858.9 (-79.8)
155	MC	5063.6 (+19.3)	4906.1 (+15.6)	5459.1 (+28.6)	4682.4 (+10.3)	6718.0 (+58.2)	6681.4 (+57.4)	6654.3 (+56.7)	7131.1 (+68.0)	6575.3 (+54.9)	4899.6 (+15.4)	5885.7 (+38.6)	5065.2 (+19.3)	6922.2 (+63.0)	5557.3 (+30.9)	5731.1 (+35.0)	5899.5 (+39.0)
	EC	4283.7 (+0.9)	1056.6 (-75.1)	1768.5 (-58.3)	456.7 (-89.2)	6514.9 (+53.4)	5000.4 (+17.8)	4115.8 (-3.1)	1126.7 (-73.5)	5190.8 (+22.3)	4359.6 (+2.7)	4135.2 (-2.6)	918.4 (-78.4)	6586.9 (+55.1)	4345.4 (+2.3)	4188.3 (-1.3)	872.5 (-79.4)
165	MC	5133.4 (+20.9)	4977.0 (+17.2)	5536.6 (+30.4)	4756.9 (+12.0)	6768.3 (+59.4)	6782.0 (+59.7)	6713.4 (+58.1)	7239.3 (+70.5)	6658.8 (+56.8)	4966.8 (+17.0)	5966.5 (+40.5)	5140.4 (+21.1)	6951.0 (+63.7)	5618.5 (+32.3)	5796.5 (+36.5)	5961.9 (+40.4)
	EC	4356.4 (+2.6)	1072.2 (-74.8)	1803.4 (-57.5)	458.4 (-89.2)	6584.4 (+55.1)	5069.0 (+19.4)	4163.5 (-1.9)	1135.7 (-73.2)	5251.9 (+23.7)	4446.3 (+4.7)	4216.3 (-0.7)	924.8 (-78.2)	6610.7 (+55.7)	4417.4 (+4.0)	4243.0 (-0.1)	887.9 (-79.1)
175	MC	5207.4 (+22.7)	5045.2 (+18.8)	5604.6 (+32.0)	4827.7 (+13.7)	6834.3 (+61.0)	6867.4 (+61.8)	6768.2 (+59.4)	7325.1 (+72.5)	6719.7 (+58.3)	5030.5 (+18.5)	6046.2 (+42.4)	5212.3 (+22.8)	6981.8 (+64.4)	5691.9 (+34.1)	5855.1 (+37.9)	6042.1 (+42.3)
	EC	4415.7 (+4.0)	1087.9 (-74.4)	1829.0 (-56.9)	460.1 (-89.2)	6650.2 (+56.6)	5184.2 (+22.1)	4225.4 (-0.5)	1143.2 (-73.1)	5315.7 (+25.2)	4530.5 (+6.7)	4290.6 (+1.1)	928.4 (-78.1)	6634.0 (+56.3)	4490.7 (+5.8)	4293.5 (+1.1)	899.0 (-78.8)
185	MC	5282.2 (+24.4)	5121.7 (+20.6)	5678.7 (+33.8)	4896.6 (+15.3)	6894.2 (+62.4)	6961.5 (+64.0)	6826.6 (+60.8)	7423.5 (+74.9)	6776.9 (+59.6)	5106.3 (+20.3)	6125.3 (+44.3)	5290.1 (+24.6)	7009.0 (+65.1)	5756.6 (+35.6)	5922.5 (+39.5)	6100.0 (+43.7)
	EC	4476.9 (+5.4)	1103.7 (-74.0)	1851.3 (-56.4)	461.2 (-89.1)	6737.2 (58.7)	5250.8 (+23.7)	4267.2 (+0.5)	1147.5 (-73.0)	5377.9 (+26.7)	4599.2 (+8.3)	4367.7 (+2.9)	931.4 (-78.1)	6655.4 (+56.8)	4584.2 (+8.0)	4352.0 (+2.5)	907.3 (-78.6)

*%deviation from baseline value

Table 4.152: Simulation of changes in maize yield (kg ha⁻¹) of PMH2 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Ballawal Saunkhri, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (5584.2 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	3847.5 (-31.1)*	3817.6 (-31.6)	4080.0 (-26.9)	3658.2 (-34.5)	4193.6 (-24.9)	4325.6 (-22.5)	4221.1 (-24.4)	4763.9 (-14.7)	4080.0 (-26.9)	3710.0 (-33.6)	3985.8 (-28.6)	4131.9 (-26.0)	4030.7 (-27.8)	4004.8 (-28.3)	4181.9 (-25.1)	4137.6 (-25.9)
	EC	3537.4 (-36.7)	1233.6 (-77.9)	1668.5 (-70.1)	553.7 (-90.1)	4512.2 (-19.2)	3732.5 (-33.2)	3399.5 (-39.1)	1307.6 (-76.6)	3889.3 (-30.3)	3516.0 (-37.0)	3387.0 (-39.3)	1236.4 (-77.9)	4185.1 (-25.0)	3611.2 (-35.3)	3444.9 (-38.3)	1268.4 (-77.3)
75	MC	3999.5 (-28.4)	3967.8 (-29.0)	4234.3 (-24.2)	3800.3 (-32.0)	4357.3 (-22.0)	4517.9 (-19.1)	4393.7 (-21.3)	4981.6 (-10.8)	4225.9 (-24.3)	3853.0 (-31.0)	4163.1 (-25.4)	4313.3 (-22.8)	4160.5 (-25.5)	4140.7 (-25.9)	4331.4 (-22.4)	4284.7 (-23.3)
	EC	3677.7 (-34.1)	1273.3 (-77.2)	1772.6 (-69.1)	562.1 (-89.9)	4681.0 (-16.2)	3883.0 (-30.5)	3539.8 (-36.6)	1346.8 (-75.9)	4019.7 (-28.0)	3634.0 (-34.9)	3530.6 (-36.8)	1256.2 (-77.5)	4338.2 (-22.3)	3742.0 (-33.0)	3574.2 (-36.0)	1301.8 (-76.7)
85	MC	4151.5 (-25.7)	4123.0 (-26.2)	4394.7 (-21.3)	3942.5 (-29.4)	4513.9 (-19.2)	4700.1 (-15.8)	4549.9 (-18.5)	5173.5 (-7.3)	4388.6 (-21.4)	3992.4 (-28.5)	4320.8 (-22.6)	4471.9 (-19.9)	4311.9 (-22.9)	4286.8 (-23.2)	4476.0 (-19.8)	4444.8 (-20.4)
	EC	3818.6 (-31.6)	1309.8 (-76.5)	1775.9 (-68.2)	569.1 (-89.8)	4829.5 (-13.5)	4017.3 (-28.1)	3666.6 (-34.3)	1376.3 (-75.3)	4161.3 (-25.4)	3760.2 (-32.7)	3660.6 (-34.4)	1273.0 (-77.2)	4509.2 (-19.2)	3882.5 (-30.5)	3707.9 (-33.6)	1336.2 (-76.1)
95	MC	4302.5 (-23.0)	4268.2 (-23.6)	4538.9 (-18.7)	4077.6 (-27.0)	4663.2 (-16.5)	4870.7 (-12.8)	4685.0 (-16.1)	5350.2 (-4.2)	4532.3 (-18.8)	4116.1 (-26.3)	4466.6 (-20.0)	4618.9 (-17.3)	4447.2 (-20.4)	4398.9 (-21.2)	4591.2 (-17.8)	4576.1 (-18.0)
	EC	3956.3 (-29.1)	1351.6 (-75.8)	1828.0 (-67.3)	575.0 (-89.7)	4956.1 (-11.2)	4157.5 (-25.6)	3788.8 (-32.1)	1403.7 (-74.9)	4281.3 (-23.3)	3880.7 (-30.5)	3772.8 (-32.4)	1289.8 (-76.9)	4644.7 (-16.8)	4017.3 (-28.1)	3828.0 (-31.45)	1367.5 (-75.5)
105	MC	4415.1 (-20.9)	4392.6 (-21.3)	4668.2 (-16.4)	4183.3 (-25.1)	4781.0 (-14.4)	5001.8 (-10.4)	4821.0 (-13.7)	5514.3 (-1.2)	4663.2 (-16.5)	4227.9 (-24.3)	4596.9 (-17.7)	4749.6 (-15.0)	4573.7 (-18.1)	4523.8 (-19.0)	4709.6 (-15.7)	4722.0 (-15.4)
	EC	4062.4 (-27.2)	1388.1 (-75.1)	1877.8 (-66.4)	579.2 (-89.6)	5046.3 (-9.6)	4265.9 (-23.6)	3900.5 (-30.1)	1429.0 (-74.4)	4390.0 (-21.4)	3990.9 (-28.5)	3871.5 (-30.7)	1302.6 (-76.7)	4781.5 (-14.4)	4139.4 (-25.9)	3956.3 (-29.1)	1395.1 (-75.0)
115	MC	4536.7 (-18.8)	4509.1 (-19.2)	4786.7 (-14.3)	4293.3 (-23.1)	4891.8 (-12.4)	5134.2 (-8.1)	4942.7 (-11.5)	5689.3 (+1.9)	4780.6 (-14.4)	4333.4 (-22.4)	4712.4 (-15.6)	4872.2 (-12.8)	4688.4 (-16.0)	4626.0 (-17.2)	4821.3 (-13.7)	4852.9 (-13.1)
	EC	4166.1 (-25.4)	1423.9 (-74.5)	1923.2 (-65.6)	583.3 (-89.6)	5148.7 (-7.8)	4375.1 (-21.7)	4019.3 (-28.0)	1451.0 (-74.0)	4501.0 (-19.4)	4115.9 (-26.29)	3965.5 (-29.0)	1316.1 (-76.4)	4900.8 (-12.2)	4241.9 (-24.0)	4062.0 (-27.3)	1419.7 (-74.6)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (5584.2 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	4751.1 (-14.9)	4722.1 (-15.4)	5000.3 (-10.5)	4492.0 (-19.6)	5133.2 (-8.1)	5380.7 (-3.6)	5177.9 (-7.3)	6012.5 (+7.7)	5015.3 (-10.2)	4538.8 (-18.7)	4952.7 (-11.3)	5087.3 (-8.9)	4902.2 (-12.2)	4847.8 (-13.2)	5057.5 (-9.4)	5083.0 (-9.0)
	EC	4352.2 (-22.1)	1494.3 (-73.2)	2016.0 (-63.9)	591.1 (-89.4)	5340.0 (-4.4)	4572.9 (-18.1)	4220.6 (-24.4)	1497.0 (-73.2)	4703.4 (-15.8)	4316.9 (-22.7)	4140.6 (-25.9)	1330.8 (-76.2)	5123.7 (-8.2)	4426.3 (-20.7)	4245.8 (-24.0)	1466.1 (-73.7)
145	MC	4841.5 (-13.3)	4813.5 (-13.8)	5085.0 (-8.9)	4579.7 (-18.0)	5235.9 (-6.2)	5498.5 (-1.5)	5293.2 (-5.2)	6180.0 (+10.7)	5108.5 (-8.5)	4635.6 (-17.0)	5058.3 (-9.4)	5191.5 (-7.0)	4979.3 (-10.8)	4935.0 (-11.6)	5139.8 (-8.0)	5181.3 (-7.2)
	EC	4428.8 (-20.7)	1524.1 (-72.7)	2057.1 (-63.2)	593.6 (-89.4)	5456.1 (-2.3)	4666.3 (-16.4)	4332.0 (-22.4)	1509.3 (-73.0)	4781.7 (-14.4)	4425.4 (-20.8)	4246.2 (-24.0)	1337.6 (-76.0)	5225.1 (-6.4)	4506.1 (-19.3)	4326.6 (-22.5)	1488.3 (-73.3)
155	MC	4940.4 (-11.5)	4920.8 (-11.9)	5201.5 (-6.9)	4674.4 (-16.3)	5380.2 (-3.7)	5648.2 (+1.1)	5411.1 (-3.1)	6323.0 (+13.2)	5214.0 (-6.6)	4732.3 (-15.2)	5195.7 (-7.0)	5309.5 (-4.9)	5062.6 (-9.3)	5050.7 (-9.5)	5225.2 (-6.4)	5285.9 (-5.3)
	EC	4519.7 (-19.1)	1563.5 (-72.0)	2097.7 (-62.4)	595.4 (-89.3)	5577.7 (-0.1)	4796.7 (-14.1)	4427.0 (-20.7)	1523.1 (-72.7)	4871.7 (-12.8)	4503.7 (-19.3)	4343.7 (-22.2)	1341.1 (-76.0)	5327.5 (-4.6)	4591.9 (-17.8)	4409.2 (-21.0)	1507.0 (-73.0)
165	MC	5029.1 (-9.9)	4993.7 (-10.6)	5301.9 (-5.1)	4761.9 (-14.7)	5478.8 (-1.9)	5747.5 (+2.9)	5515.1 (-1.2)	6463.9 (+15.8)	5350.4 (-4.2)	4837.2 (-13.4)	5307.4 (-4.9)	5409.6 (-3.1)	5199.9 (-6.9)	5135.6 (-8.0)	5305.9 (-5.0)	5408.1 (-3.1)
	EC	4625.6 (-17.2)	1592.4 (-71.5)	2127.7 (-61.9)	596.8 (-89.3)	5691.9 (+1.9)	4895.2 (-12.3)	4490.7 (-19.6)	1531.2 (-72.6)	4994.8 (-10.5)	4607.4 (-17.5)	4455.4 (-20.2)	1344.6 (-75.9)	5466.2 (-2.1)	4715.5 (-15.6)	4494.5 (-19.5)	1525.1 (-72.7)
175	MC	5107.8 (-8.5)	5069.6 (-9.2)	5383.4 (-3.6)	4852.0 (-13.1)	5561.9 (-0.4)	5842.3 (+4.6)	5643.6 (+1.1)	6614.9 (+18.5)	5446.8 (-2.5)	4930.6 (-11.7)	5400.6 (-3.3)	5528.4 (-1.0)	5273.8 (-5.6)	5231.7 (-6.3)	5442.0 (-2.5)	5508.0 (-1.4)
	EC	4738.4 (-15.1)	1622.4 (-71.0)	2174.9 (-61.0)	597.9 (-89.3)	5799.1 (+3.9)	4981.9 (-10.8)	4549.5 (-18.5)	1536.2 (-72.5)	5075.7 (-9.1)	4694.6 (-15.9)	4564.3 (-18.3)	1347.9 (-75.9)	5568.4 (-0.3)	4792.3 (-14.2)	4607.1 (-17.5)	1541.1 (-72.4)
185	MC	5203.0 (-6.8)	5190.3 (-7.0)	5472.9 (-2.00)	4942.1 (-11.5)	5661.8 (+1.4)	5949.4 (+6.5)	5743.1 (+2.8)	6762.3 (+21.1)	5524.2 (-1.1)	5034.6 (-9.8)	5495.3 (-1.6)	5634.0 (+0.9)	5339.5 (-4.4)	5310.1 (-4.9)	5528.3 (-1.0)	5611.5 (+0.49)
	EC	4830.7 (-13.5)	1644.1 (-70.6)	2212.6 (-60.4)	599.1 (-89.3)	5904.8 (+5.7)	5056.2 (-9.4)	4618.7 (-17.3)	1541.6 (-72.4)	5148.9 (-7.8)	4776.4 (-14.5)	4659.9 (-16.5)	1350.7 (-75.8)	5650.2 (+1.2)	4887.2 (-12.5)	4684.4 (-16.1)	1549.2 (-72.3)

*%deviation from baseline value

Agroclimatic zone III (Ludhiana, Amritsar and Patiala)

At Ludhiana the CSIRO-Mk-3-6-0 model depicted yield decrease under all the scenarios for PMH1 and PMH2 at all the nitrogen doses. The models projected a yield increase for PMH1 (Table 4.153) under RCP2.6 upto 22% as per ensemble model during the mid-century and upto 11% during the end-century. The Ensemble model projected a yield increase upto 56% during the mid-century and upto 36% during the end-century. For both the scenarios predicted yield would increase with the increase in nitrogen dose application. The three models FIO-ESM, IPSL-CM5A-MR and Ensemble depicted an increase in yield during the mid-century upto 65% on an average while slight increase upto 22% during the end-century. The FIO-ESM model overestimated the yield under different nitrogen doses. The ensemble model showed a decline in yield for both the mid and end-century upto 34% and 95%, respectively. However, the IPSL-CM5A-MR model showed a yield increase upto 46% with increasing nitrogen doses during the mid-century.

Except for CSIRO-Mk-3-6-0 model the other models gave similar results for PMH2 (Table 4.154) cultivar under RCP2.6 where on an average a yield increase of 50% and 34% was observed during mid and end-century, respectively. Under RCP4.5 scenario the Ensemble and IPSL-CM5A-MR model gave similar results with yield increase upto 67% during mid-century and 50% during end-century at increasing nitrogen doses. The three models observed similar increase in yield under RCP6.0 which was upto 70% and 45%, respectively for mid and end century. The ensemble model showed a yield decline upto 6.9% during the mid-century and 89% during the end-century under RCP8.5 while IPSL-CM5A-MR model observed a yield increase during mid-century for the same scenario. The FIO-ESM overestimated the yield.

The cultivar PMH1 (Table 4.155) and PMH2 (Table 4.156) at Amritsar showed the same response where the CSIRO-Mk-3-6-0 model projected decline in yield under all the four scenarios. The simulated yield decline for PMH1 was observed to be 20% and 30% as predicted by CSIRO-Mk-3-6-0 model under RCP2.6 while ensemble and FIO-ESM showed a yield increase by 4.5% and 16.0% respectively during end-century. The IPSL-CM5A-MR model predicted decline in yield under all the four scenarios. The maize crop would not perform well under the future scenario RCP4.5 where decline in yield was projected by all the models. The ensemble showed a yield decrease by 10% during the mid-century and 34% during the end-century at higher doses of nitrogen. The scenario RCP6.0 also observed a yield decline for both the centuries. The Ensemble model observed this decline upto 36% during end-century and a little increase by 1.3% during the mid-century. The FIO-ESM and IPSL-CM5A-MR model projected decrease in yield. Under RCP8.5 too decline in yield was observed as per the model projections and Ensemble showed this decline to be 11% and 83%, respectively during mid and end-century.

At Amritsar the PMH2 (Table 4.156) cultivar performed the same as PMH1 where all the four GCMs prediction showed a yield decline under the four RCPs. The Ensemble and IPSL-CM5A-MR observed a yield decline upto 13% and 16% during mid and end-century under RCP2.6. The two models under RCP4.5 predicted the yield decline by 19% and 35% during mid and end-century which were nearly same as predicted by IPSL-CM5A-MR. The FIO-ESM overestimated the yield. The FIO-ESM, IPSL-CM5A-MR and Ensemble model observed similar yield decline upto 11% and 39% during mid and end-century, respectively under RCP6.0. The respective models gave similar decline under RCP8.5 upto 21% and 77%, respectively during mid and end-century. The CSIRO-Mk-3-6-0 model underestimated the yield.

The CSIRO-Mk-3-6-0 model showed the same response for PMH1 (Table 4.157) and PMH2 (Table 4.158) with a yield decline under all the four scenarios and considered sowing window. The simulated yield for CSIRO-Mk-3-6-0 showed a decline upto 21% for PMH1 and PMH2 during the mid-century under RCP8.5 at higher doses of nitrogen while under RCP2.6, RCP4.5 and RCP6.0 yield decline observed was upto 13% for PMH1 and PMH2. The yield decline of upto 80% was observed during the end-century as predicted by the model for PMH1 with lowest decline observed under RCP2.6. The FIO-ESM model predicted a yield increment from 155-185 kg ha⁻¹ N-dose during mid and end-century under RCP2.6 while under RCP4.5 the yield increase was observed only during mid-century from 145-185 kg ha⁻¹ N-dose. RCP6.0 and RCP8.5 also observed yield increment at higher doses of nitrogen during mid-century while the end-century observed yield decline even at higher doses under the three scenarios. The IPSL-CM5A-MR model and Ensemble model also observed a yield increment under RCP2.6 during the mid-century at higher doses of nitrogen. The yield decline predicted were upto 80% under RCP8.5 as predicted by the three models during end-century.

None of the models projected yield increment even at higher doses for PMH2 (Table 4.158) at Patiala. The maximum decline at all doses of nitrogen was observed by CSIRO-Mk-3-6-0 model upto 20% during mid-century under all the four scenarios and upto 87% decline under RCP8.5 during end-century. The end-century observed high declination in yield. The FIO-ESM model though over estimated the yield but still showed the decline upto 13% during the mid and end-century under RCP2.6 and upto 88% under RCP8.5 during end-century. The Ensemble model observed a lower yield decline under all the scenarios in comparison to other three models during both mid and end-century with maximum decrease upto 72% during end-century under RCP8.5 at higher doses of nitrogen. The IPSL-CM5A-MR model showed similar decline under RCP8.5 and upto 13% and 16% during mid and end-century under RCP2.6. None of the models predicted a yield increment under lower doses of nitrogen.

Table 4.153: Simulation of changes in maize yield (kg ha⁻¹) of PMH1 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Ludhiana, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (3689.3 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	785.6 (-78.7)*	975.7 (-73.5)	1737.3 (-52.9)	770.4 (-79.1)	4256.9 (+15.4)	4012.4 (+8.8)	5946.7 (+61.2)	5843.0 (+58.4)	3937.1 (+6.7)	4391.1 (+19.0)	4753.7 (+28.9)	4149.1 (+12.5)	4111.8 (+11.4)	4539.1 (+23.0)	4901.1 (+32.9)	2218.1 (-39.9)
	EC	271.4 (-92.6)	446.5 (-87.9)	470.5 (-87.2)	478.3 (-87.0)	3900.4 (+5.7)	160.3 (-95.6)	3829.7 (+3.8)	1358.3 (-63.2)	2844.0 (-22.9)	3755.1 (+1.8)	3387.3 (-8.2)	652.7 (-82.3)	3640.9 (-1.3)	3663.8 (-0.7)	3488.6 (-5.4)	192.1 (-94.8)
75	MC	801.8 (-78.3)	997.6 (-73.0)	1780.8 (-51.7)	787.9 (-78.6)	4310.5 (+16.8)	4077.3 (+10.5)	6079.6 (+64.8)	6011.4 (+62.9)	3977.8 (+7.8)	4567.0 (+23.8)	4920.3 (+33.4)	4312.1 (+16.9)	4151.2 (+12.5)	4709.1 (+27.6)	5077.1 (+37.6)	2246.1 (-39.1)
	EC	273.1 (-92.6)	448.3 (-87.8)	472.7 (-87.2)	485.0 (-86.9)	3975.9 (+7.8)	162.2 (-95.6)	3938.9 (+6.8)	1403.8 (-62.0)	2927.5 (-20.7)	3867.5 (+4.8)	3506.4 (-5.0)	662.7 (-82.0)	3687.7 (-0.1)	3804.7 (+3.1)	3616.2 (-2.0)	192.3 (-94.8)
85	MC	817.1 (-77.9)	1020.3 (-72.3)	1835.8 (-50.2)	809.6 (-78.1)	4371.0 (+18.5)	4152.9 (+12.6)	6248.0 (+69.3)	6202.6 (+68.1)	4016.6 (+8.9)	4719.5 (+27.9)	5066.9 (+37.3)	4460.9 (+20.9)	4198.7 (+13.8)	4806.8 (+30.3)	5241.2 (+42.1)	2270.2 (-38.5)
	EC	274.6 (-92.6)	449.7 (-87.8)	474.8 (-87.1)	492.3 (-86.7)	4065.2 (+10.2)	164.5 (-95.5)	4078.5 (+10.5)	1457.8 (-60.5)	2999.2 (-18.7)	3962.4 (+7.4)	3616.0 (-2.00)	670.5 (-81.8)	3743.0 (+1.5)	3890.5 (+5.45)	3722.4 (+0.9)	192.3 (-94.8)
95	MC	836.1 (-77.3)	1046.0 (-71.7)	1871.8 (-49.3)	823.1 (-77.7)	4413.2 (+19.6)	4206.1 (+14.0)	6380.7 (+72.9)	6340.0 (+71.9)	4049.9 (+9.8)	4848.8 (+31.4)	5188.0 (+40.6)	4580.1 (+24.1)	4223.3 (+14.5)	4971.5 (+34.76)	5358.1 (+45.2)	2291.5 (-37.9)
	EC	276.9 (-92.5)	451.6 (-87.8)	476.1 (-87.1)	497.3 (-86.5)	4124.8 (+11.8)	166.2 (-95.5)	4182.6 (+13.4)	1496.1 (-59.4)	3069.4 (-16.8)	4040.6 (+9.5)	3717.6 (+0.8)	677.4 (-81.6)	3773.0 (+2.3)	4056.7 (+10.0)	3812.4 (+3.3)	192.3 (-94.8)
105	MC	849.3 (-77.0)	1064.4 (-71.1)	1906.5 (-48.3)	835.0 (-77.4)	4449.7 (+20.6)	4255.6 (+15.3)	6479.0 (+75.6)	6454.0 (+74.9)	4081.3 (+10.6)	4910.3 (+33.1)	5321.3 (+44.2)	4698.9 (+27.4)	4258.2 (+15.4)	5077.17 (+37.6)	5485.1 (+48.7)	2311.7 (-37.3)
	EC	278.1 (-92.5)	452.6 (-87.7)	477.3 (-87.1)	501.2 (-86.4)	4180.6 (+13.3)	167.7 (-95.4)	4273.5 (+15.8)	1532.1 (-58.5)	3129.1 (-15.2)	4078.9 (+10.6)	3812.6 (+3.3)	682.9 (-81.5)	3815.3 (+3.4)	4151.0 (+12.5)	3898.2 (+5.7)	192.4 (-94.8)
115	MC	866.3 (-76.5)	1089.1 (-70.5)	1948.5 (-47.2)	850.1 (-77.0)	4493.6 (+21.8)	4308.8 (+16.8)	6613.0 (+79.2)	6590.6 (+78.6)	4106.4 (+11.3)	5085.9 (+37.9)	5430.3 (+47.2)	4803.4 (+30.2)	4288.1 (+16.2)	5180.3 (+40.4)	5598.9 (+51.76)	2331.7 (-36.8)
	EC	280.3 (-92.4)	453.9 (-87.7)	478.3 (-87.0)	506.5 (-86.3)	4247.2 (+15.1)	169.6 (-95.4)	4380.2 (+18.7)	1577.5 (-57.2)	3183.8 (-13.7)	4230.5 (+14.7)	3891.4 (+5.5)	688.6 (-81.3)	3854.6 (+4.5)	4242.5 (+15.0)	3975.5 (+7.8)	192.2 (-94.8)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (3689.3 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	889.7 (-75.9)	1119.5 (-69.7)	2008.4 (-45.6)	872.2 (-76.4)	4559.2 (+23.6)	4364.8 (+18.3)	6794.1 (+84.2)	6797.8 (+84.3)	4156.4 (+12.7)	5295.3 (+43.5)	5532.9 (+50.0)	4989.0 (+35.2)	4345.5 (+17.8)	5367.10 (+45.48)	5793.5 (+57.0)	2365.4 (-35.9)
	EC	282.9 (-92.3)	455.3 (-87.7)	479.4 (-87.0)	512.4 (-86.1)	4359.6 (+18.2)	172.8 (-95.3)	4536.2 (+23.0)	1642.1 (-55.5)	3310.2 (-10.3)	4458.0 (+20.8)	3997.8 (+8.4)	698.7 (-81.1)	3922.7 (+6.3)	4421.63 (+19.85)	4118.6 (+11.6)	192.3 (-94.8)
145	MC	906.0 (-75.4)	1142.7 (-69.0)	2049.0 (-44.5)	517.4 (-86.0)	4599.9 (+24.7)	4404.8 (+19.4)	6883.0 (+86.6)	6928.3 (+87.8)	4181.2 (+13.3)	5389.2 (+46.1)	5724.6 (+55.2)	5079.1 (+37.7)	4374.2 (+18.6)	5455.00 (+47.86)	5884.8 (+59.5)	2384.6 (-35.4)
	EC	284.2 (-92.3)	456.5 (-87.6)	479.6 (-87.0)	893.7 (-75.8)	4438.4 (+20.3)	174.4 (-95.3)	4630.5 (+25.5)	1680.8 (-54.4)	3387.0 (-8.2)	4556.4 (+23.5)	4153.4 (+12.6)	702.8 (-81.0)	3963.1 (+7.4)	4499.50 (+23.86)	4193.2 (+13.7)	192.3 (-94.8)
155	MC	918.5 (-75.1)	1161.3 (-68.5)	2092.7 (-43.3)	893.7 (-75.8)	4633.8 (+25.6)	4437.2 (+20.3)	6965.7 (+88.8)	7054.6 (+91.2)	4206.6 (+14.0)	5480.9 (+48.6)	5820.3 (+57.8)	5165.1 (+40.0)	4402.7 (+19.3)	5534.00 (+50.00)	5971.3 (+61.9)	2400.4 (-34.9)
	EC	285.1 (-92.3)	457.1 (-87.6)	479.9 (-87.0)	519.8 (-85.9)	4507.9 (+22.2)	175.5 (-95.2)	4713.2 (+27.8)	1702.4 (-53.9)	3424.9 (-7.2)	4635.8 (+25.7)	4236.9 (+14.8)	707.0 (-80.8)	4014.1 (+8.8)	4569.60 (+23.86)	4264.4 (+15.6)	192.3 (-94.8)
165	MC	935.1 (-74.7)	1176.0 (-68.1)	2131.6 (-42.2)	908.1 (-75.4)	4664.8 (+26.4)	4459.0 (+20.9)	7027.9 (+90.5)	7164.3 (+94.2)	4235.1 (+14.8)	5563.1 (+50.8)	5899.6 (+59.9)	5242.8 (+42.1)	4431.9 (+20.1)	5614.60 (+52.19)	6051.4 (+64.0)	2416.3 (-34.5)
	EC	285.9 (-92.2)	457.7 (-87.6)	480.2 (-87.0)	521.6 (-85.9)	4555.6 (+23.5)	177.1 (-95.2)	4787.2 (+29.8)	1717.3 (-53.4)	3465.8 (-6.1)	4713.3 (+27.8)	4328.6 (+17.3)	710.8 (-80.7)	4046.5 (+9.7)	4640.27 (+25.79)	4353.2 (+18.0)	192.3 (-94.8)
175	MC	948.2 (-74.3)	1202.8 (-67.4)	2169.1 (-41.2)	921.1 (-75.0)	4702.0 (+27.4)	4484.2 (+21.5)	7119.4 (+93.0)	7324.3 (+98.5)	4255.1 (+15.3)	5639.9 (+52.9)	5996.7 (+62.5)	5316.1 (+44.1)	4451.0 (+20.7)	5693.60 (+54.33)	6129.9 (+66.1)	2434.1 (-34.0)
	EC	287.8 (-92.2)	458.5 (-87.6)	480.4 (-87.0)	523.6 (-85.8)	4634.0 (+25.6)	179.1 (-95.1)	4892.8 (+32.6)	1735.3 (-53.4)	3502.2 (-5.1)	4822.0 (+30.7)	4402.1 (+19.3)	714.4 (-80.6)	4069.4 (+10.3)	4713.53 (+27.76)	4444.4 (+20.5)	192.3 (-94.8)
185	MC	957.3 (-74.0)	1215.8 (-67.0)	2192.7 (-40.6)	929.4 (-74.8)	4727.5 (+28.1)	4504.9 (+20.1)	7181.7 (+94.7)	7324.3 (+98.5)	4272.5 (+15.8)	5742.8 (+55.7)	6098.3 (+65.3)	53915 (+46.1)	4490.0 (+21.7)	5771.27 (+56.43)	6200.7 (+68.1)	2445.4 (-33.7)
	EC	288.6 (-92.2)	458.7 (-87.6)	480.6 (-87.0)	524.8 (-85.8)	4692.6 (+27.2)	180.1 (-95.1)	4991.7 (+35.3)	1735.5 (-53.0)	3553.6 (-3.7)	4898.0 (+32.8)	4474.5 (+21.3)	717.6 (-80.6)	4110.0 (+11.4)	4786.07 (+29.73)	4513.2 (+22.3)	192.3 (-94.8)

*%deviation from baseline value

Table 4.154: Simulation of changes in maize yield (kg ha⁻¹) of PMH2 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Ludhiana, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (3405.0 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	1356.0 (-60.2)*	1529.5 (-55.1)	2161.7 (-36.5)	1285.4 (-62.2)	3738.3 (+9.8)	3789.2 (+11.3)	4178.4 (+22.7)	4747.5 (+39.4)	3687.5 (+8.3)	4125.4 (+21.1)	4337.0 (+27.4)	4127.4 (+21.2)	3654.2 (+7.3)	4236.2 (+24.4)	4360.2 (+28.0)	2438.3 (-28.4)
	EC	812.6 (-76.1)	604.2 (-82.3)	635.4 (-81.3)	653.1 (-80.8)	3415.1 (+0.3)	857.0 (-74.8)	3667.4 (+7.7)	1643.5 (-51.7)	3187.2 (-6.4)	3789.0 (+11.3)	3583.2 (+5.2)	965.9 (-71.6)	3344.6 (-1.8)	3737.0 (+9.8)	3578.4 (+5.1)	371.7 (-89.1)
75	MC	1399.1 (-58.9)	1579.3 (-53.6)	2237.5 (-34.3)	1322.3 (-61.2)	3891.1 (+14.3)	3951.2 (+16.0)	4354.7 (+27.9)	4964.9 (+45.8)	3839.1 (+12.8)	4315.1 (+26.7)	4533.5 (+33.1)	4311.1 (+26.6)	3807.0 (+11.8)	4425.5 (+30.0)	4553.1 (+33.7)	2526.5 (-25.8)
	EC	834.0 (-75.5)	605.5 (-82.2)	636.8 (-81.3)	660.9 (-80.6)	3528.1 (+3.6)	885.3 (-74.0)	3824.9 (+12.3)	1706.3 (-49.9)	3309.4 (-2.8)	3937.9 (+15.7)	3724.6 (+9.4)	982.1 (-71.2)	3471.2 (+2.0)	3901.0 (+14.6)	3728.9 (+9.5)	371.5 (-89.1)
85	MC	1438.6 (-57.8)	1624.5 (-52.3)	2305.4 (-32.3)	1354.6 (-60.2)	4031.0 (+18.4)	4103.6 (+20.5)	4496.5 (+32.1)	5153.6 (+51.3)	3983.0 (+17.0)	4482.6 (+31.7)	4702.5 (+38.1)	4480.8 (+31.6)	3943.7 (+15.8)	4589.6 (+34.8)	4713.9 (+38.4)	2602.6 (-23.6)
	EC	851.7 (-75.0)	606.6 (-82.2)	637.8 (-81.3)	667.0 (-80.4)	3641.2 (+6.9)	911.2 (-73.2)	3952.4 (+16.1)	1763.1 (-48.2)	3412.5 (+0.2)	4077.9 (+19.8)	3850.4 (+13.1)	995.0 (-70.8)	3588.7 (+5.4)	4047.6 (+18.9)	3863.7 (+13.5)	371.5 (-89.1)
95	MC	1475.7 (-56.7)	1663.7 (-51.1)	2368.9 (-30.4)	1384.5 (-59.3)	4156.1 (+22.1)	4238.0 (+24.5)	4667.5 (+37.1)	5320.7 (+56.3)	4114.0 (+20.8)	4633.9 (+36.1)	4865.2 (+42.9)	4628.7 (+35.9)	4070.3 (+19.5)	4709.6 (+38.3)	4837.30 (+42.1)	2671.6 (-21.5)
	EC	861.07 (-74.7)	607.7 (-82.1)	637.9 (-81.3)	673.4 (-80.2)	3731.2 (+9.6)	934.0 (-72.6)	4079.8 (+19.8)	1815.1 (-46.7)	3519.0 (+3.3)	4222.1 (+24.0)	3968.0 (+16.5)	1007.7 (-70.4)	3692.6 (+8.4)	4179.0 (+22.7)	3985.4 (+17.0)	371.5 (-89.1)
105	MC	1509.6 (-55.7)	1702.0 (-50.0)	2429.1 (-28.7)	1410.8 (-58.6)	4282.5 (+25.8)	4359.9 (+28.0)	4807.6 (+41.2)	5479.8 (+60.9)	4244.0 (+24.6)	4765.8 (+39.4)	5011.6 (+47.2)	4769.7 (+40.1)	4191.2 (+23.1)	4838.2 (+42.1)	4969.7 (+46.0)	2736.4 (-19.6)
	EC	865.7 (-74.6)	608.7 (-82.1)	637.9 (-81.3)	678.7 (-80.1)	3814.7 (+12.0)	955.6 (-71.9)	4201.0 (+23.4)	1861.7 (-45.3)	3605.2 (+5.9)	4330.2 (+27.2)	4070.7 (+19.6)	1019.0 (-70.1)	3793.1 (+11.4)	4303.1 (+26.4)	4098.7 (+20.4)	371.3 (+89.1)
115	MC	1543.1 (-54.7)	1736.6 (-49.0)	2482.5 (-27.1)	1434.9 (-57.9)	4394.0 (+29.0)	4461.6 (+31.0)	4937.8 (+45.0)	5625.2 (+65.2)	4352.0 (+27.8)	4885.7 (+43.5)	5137.5 (+50.9)	4898.0 (+43.9)	4301.3 (+26.3)	4958.2 (+45.6)	5086.3 (+49.4)	2799.5 (-17.8)
	EC	871.5 (-74.4)	610.1 (-82.1)	637.8 (-81.3)	683.5 (-79.9)	3902.4 (+14.6)	974.8 (-71.4)	4304.7 (+26.4)	1903.5 (-44.1)	3683.8 (+8.2)	4475.0 (+31.4)	4166.6 (+22.4)	1029.7 (-69.8)	3888.4 (+14.2)	4402.1 (+29.3)	4206.9 (+23.6)	371.2 (-89.1)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (3405.0 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	1605.8 (-52.8)	1804.7 (-47.0)	2607.8 (-23.4)	1485.8 (-56.4)	4630.0 (+36.0)	4676.3 (+37.3)	5176.8 (+52.0)	5926.0 (+74.0)	4605.4 (+35.2)	5131.4 (+50.7)	5384.1 (+58.1)	5133.1 (-50.75)	4545.5 (+33.5)	5211.4 (+53.0)	5315.9 (+56.1)	2925.73 (-14.08)
	EC	879.6 (-74.2)	612.1 (-82.0)	637.5 (-81.3)	690.7 (-79.7)	4077.9 (+19.8)	1016.6 (-70.1)	4503.8 (+32.3)	1973.7 (-42.0)	3907.7 (+14.8)	4682.9 (+37.5)	4380.5 (+28.7)	1048.9 (-69.2)	4114.2 (+20.8)	4604.3 (+35.2)	4386.3 (+28.8)	370.73 (-89.11)
145	MC	1640.1 (-51.8)	1848.9 (-45.7)	2682.0 (-21.2)	1513.2 (-55.6)	4748.4 (+39.4)	4779.0 (+40.3)	5286.7 (+55.3)	6070.0 (+78.3)	4722.2 (+38.7)	5243.7 (+54.0)	5488.4 (+61.2)	5237.0 (+53.8)	4678.5 (+37.4)	5316.4 (+56.1)	5439.3 (+59.7)	2985.43 (-12.32)
	EC	884.2 (-74.0)	613.0 (-82.0)	637.3 (-81.3)	692.8 (-79.7)	4172.9 (+22.5)	1033.5 (-69.7)	4616.4 (+35.6)	2007.8 (-41.0)	3976.8 (+16.8)	4772.4 (+40.2)	4492.5 (+31.9)	1055.2 (-69.0)	4203.4 (+23.4)	4691.3 (+37.8)	4508.0 (+32.4)	370.70 (-89.11)
155	MC	1663.3 (-51.1)	1879.4 (-44.8)	2728.9 (-19.9)	1533.8 (-55.0)	4863.4 (+42.8)	4867.3 (+43.0)	5410.2 (+58.9)	6199.9 (+82.1)	4808.0 (+41.2)	5354.0 (+57.2)	5595.5 (+64.3)	5346.5 (+57.0)	4776.6 (+40.3)	5420.3 (+59.2)	5537.7 (+62.6)	3039.63 (-10.73)
	EC	887.4 (-73.9)	613.7 (-82.0)	637.0 (-81.3)	694.3 (-79.6)	4250.6 (+24.8)	1057.9 (-68.9)	4715.7 (+38.5)	2047.4 (-39.9)	4048.4 (+18.9)	4856.7 (+42.6)	4598.6 (+35.0)	1060.1 (-68.9)	4299.8 (+26.3)	4779.5 (+40.4)	4608.6 (+35.3)	370.60 (-89.12)
165	MC	1692.3 (-50.3)	1909.5 (-43.9)	2793.1 (-18.0)	1553.6 (-54.4)	4976.8 (+46.2)	4922.8 (+44.6)	5530.7 (+62.4)	6357.7 (+86.7)	4870.3 (+43.0)	5501.6 (+61.6)	5714.5 (+67.8)	5459.3 (+60.3)	4877.3 (+43.2)	5503.2 (+61.6)	5618.0 (+65.0)	3084.20 (-9.42)
	EC	889.6 (-73.9)	614.7 (-82.0)	636.9 (-81.3)	696.0 (-79.6)	4341.9 (+27.5)	1074.4 (-68.4)	4827.3 (+41.8)	2079.9 (-38.9)	4138.0 (+21.5)	4997.5 (+46.8)	4693.0 (+37.8)	1066.9 (-68.7)	4400.9 (+29.2)	4860.9 (+42.8)	4692.6 (+37.8)	370.40 (-89.12)
175	MC	1715.3 (-49.6)	1940.2 (-43.0)	2855.5 (-16.1)	1580.0 (-53.6)	5097.4 (+49.7)	4976.8 (+44.8)	5619.1 (+65.0)	6496.5 (+90.8)	4914.0 (+44.3)	5609.2 (+64.7)	5889.3 (+73.0)	5563.2 (+63.4)	5030.2 (+47.7)	5627.7 (+65.3)	5767.0 (+69.4)	3136.47 (-7.89)
	EC	891.9 (-73.8)	614.9 (-81.9)	636.7 (-81.3)	697.2 (-79.5)	4422.9 (+29.9)	1089.1 (-68.0)	4915.8 (+44.4)	2094.7 (-38.5)	4180.8 (+22.8)	5084.2 (+49.3)	4828.6 (+41.8)	1071.5 (-68.5)	4533.2 (+33.1)	5016.0 (+47.3)	4786.9 (+40.6)	370.40 (-89.12)
185	MC	1733.8 (-49.0)	1969.5 (-42.2)	2898.2 (-14.9)	1599.2 (-53.0)	5186.6 (+52.3)	5006.5 (+47.0)	5714.0 (+67.8)	6621.3 (+94.5)	4951.3 (+45.4)	5709.3 (+67.7)	5979.3 (+75.6)	5656.6 (+66.1)	5100.8 (+49.8)	5712.7 (+67.8)	5850.9 (+71.8)	3171.57 (-6.86)
	EC	894.2 (-73.7)	615.0 (-81.9)	636.4 (-81.3)	698.5 (-79.5)	4495.6 (+32.0)	1103.9 (-67.6)	5022.5 (+47.5)	2106.6 (-38.1)	4223.8 (+24.0)	5157.7 (+51.5)	4921.9 (+44.6)	1074.9 (-68.4)	4580.2 (+34.5)	5104.4 (+49.9)	4893.7 (+43.7)	370.20 (-89.13)

*%deviation from baseline value

Table 4.155: Simulation of changes in maize yield (kg ha⁻¹) of PMH1 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Amritsar, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (5636.9 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	3399.7 (-39.7)*	3078.5 (-45.4)	3707.2 (-34.2)	3128.7 (-44.5)	5387.2 (-4.4)	4122.5 (-26.9)	3933.7 (-30.2)	4310.6 (-23.5)	4173.2 (-26.0)	3331.6 (-40.9)	3738.1 (-33.7)	3408.4 (-39.5)	4223.4 (-25.1)	3865.3 (-31.4)	4619.7 (-18.0)	3788.3 (-32.8)
	EC	2942.4 (-47.8)	627.4 (-88.9)	833.1 (-85.2)	385.3 (-93.2)	5506.1 (-2.3)	4103.2 (-27.2)	3120.8 (-44.6)	1023.5 (-81.8)	3638.5 (-35.4)	3294.9 (-41.6)	2312.0 (-59.0)	661.0 (-88.3)	4906.2 (-13.0)	2738.2 (-51.4)	2732.9 (-51.5)	736.3 (-86.9)
75	MC	3516.6 (-37.6)	3174.8 (-43.7)	3823.9 (-32.2)	3234.6 (-42.6)	5513.2 (-2.2)	4251.2 (-24.6)	4054.2 (-28.1)	4452.4 (-21.0)	4311.2 (-23.5)	3430.6 (-39.1)	3852.3 (-31.7)	3507.1 (-37.8)	4329.1 (-23.2)	3949.0 (-29.9)	4703.4 (-16.6)	3883.4 (-31.1)
	EC	3055.0 (-45.8)	650.33 (-88.5)	862.20 (-84.7)	391.6 (-93.0)	5610.0 (-0.5)	4245.4 (-24.7)	3224.7 (-42.8)	1056.2 (-81.3)	3748.2 (-33.5)	3411.1 (-39.5)	2378.7 (-57.8)	673.3 (-88.0)	4989.6 (-11.5)	2825.3 (-49.9)	2816.0 (-50.0)	757.7 (-86.6)
85	MC	3626.2 (-35.7)	3265.0 (-42.1)	3937.4 (-30.1)	3348.0 (-40.6)	5619.0 (-0.3)	4370.4 (-22.5)	4170.0 (-26.0)	4579.2 (-18.8)	4430.3 (-21.4)	3523.2 (-37.5)	3977.3 (-29.4)	3603.4 (-36.1)	4458.5 (-20.9)	4042.4 (-28.3)	4801.8 (-14.8)	3997.3 (-29.1)
	EC	3170.8 (-43.8)	671.0 (-88.1)	891.2 (-84.2)	397.6 (-93.0)	5707.6 (+1.2)	4355.5 (-22.7)	3306.1 (-41.3)	1088.0 (-80.7)	3883.6 (-31.1)	3528.2 (-37.4)	2453.2 (-56.5)	683.8 (-87.9)	5075.3 (-10.0)	2909.1 (-48.4)	2903.5 (-48.5)	776.2 (-86.2)
95	MC	3704.4 (-34.3)	3346.7 (-40.6)	4030.2 (-28.5)	3419.5 (-39.3)	5691.5 (+1.0)	4460.8 (-20.9)	4259.9 (-24.4)	4677.8 (-17.0)	4522.8 (-19.8)	3594.7 (-36.2)	4056.9 (-28.0)	3691.3 (-34.5)	4543.1 (-19.4)	4129.7 (-26.7)	4896.7 (-13.1)	4098.6 (-27.3)
	EC	3241.6 (-42.5)	688.1 (-87.8)	912.0 (-83.8)	402.2 (-92.9)	5807.1 (-3.0)	4451.2 (-21.0)	3380.3 (-40.0)	1112.4 (-80.3)	3957.3 (-29.8)	3601.3 (-36.1)	2594.5 (-55.6)	692.2 (-87.7)	5151.4 (-8.6)	2975.2 (-47.2)	2976.5 (-47.2)	790.4 (-86.0)
105	MC	3795.0 (-32.7)	3421.2 (-39.3)	4144.4 (-26.5)	3509.3 (-37.7)	5794.1 (+2.8)	4552.9 (-19.2)	4362.6 (-22.6)	4782.7 (-15.1)	4620.3 (-18.0)	3695.7 (-34.4)	4168.6 (-26.0)	3771.1 (-33.1)	4632.3 (-17.8)	4201.3 (-25.5)	4979.3 (-11.7)	4189.2 (-25.7)
	EC	3340.2 (-40.7)	706.5 (-87.5)	939.1 (-83.3)	407.0 (-92.8)	5876.6 (+4.2)	4587.7 (-18.6)	3447.5 (-38.8)	1136.4 (-79.8)	4053.2 (-28.1)	3720.8 (-34.0)	2585.6 (-54.1)	700.9 (-87.6)	5219.5 (-7.4)	3039.8 (-46.1)	3038.0 (-46.1)	806.5 (-85.7)
115	MC	3916.8 (-30.5)	3545.8 (-37.1)	4265.6 (-24.3)	3615.0 (-35.9)	5889.7 (+4.5)	4665.7 (-17.2)	4469.1 (-20.7)	4876.4 (-13.5)	4711.6 (-16.4)	3776.5 (-33.0)	4280.2 (-24.1)	3896.5 (-30.9)	4736.6 (-16.0)	4338.5 (-23.03)	5097.7 (-9.6)	4304.5 (-23.6)
	EC	3444.9 (-38.9)	723.8 (-87.2)	961.8 (-82.9)	411.1 (-92.7)	5944.8 (+5.5)	4690.3 (-16.8)	3526.6 (-37.4)	1167.4 (-79.3)	4183.9 (-25.8)	3800.5 (-32.6)	2638.9 (-53.2)	708.2 (-87.4)	5333.7 (-5.4)	3120.3 (-44.7)	3141.6 (-44.3)	821.3 (-85.4)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (5636.9 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	4072.7 (-27.8)	3678.4 (-34.7)	4434.7 (-21.3)	3754.6 (-33.4)	6033.4 (+7.0)	4861.0 (-13.8)	4660.4 (-17.3)	5072.7 (-10.0)	4876.7 (-13.5)	3955.7 (-29.8)	4432.1 (-21.4)	4039.3 (-28.3)	4887.5 (-13.3)	4486.3 (-20.4)	5274.9 (-6.4)	4446.4 (-21.1)
	EC	3583.8 (-36.4)	759.8 (-86.5)	1003.6 (-82.2)	418.1 (-92.6)	6139.9 (+8.9)	4920.7 (-12.7)	3664.6 (-35.0)	1212.2 (-78.5)	4333.1 (-23.1)	3951.9 (-29.9)	2747.0 (-51.3)	721.0 (-87.2)	5451.4 (-3.3)	3251.0 (-42.3)	3249.7 (-42.3)	853.7 (-84.9)
145	MC	4143.1 (-26.50)	3743.6 (-33.6)	4522.7 (-19.8)	3827.9 (-32.1)	6132.2 (+8.8)	4955.0 (-12.1)	4743.9 (-15.8)	5190.3 (-7.9)	5008.0 (-11.2)	4020.7 (-28.7)	4542.2 (-19.4)	4106.1 (-27.2)	4999.6 (-11.3)	4559.5 (-19.1)	5348.4 (-5.1)	4527.2 (-20.0)
	EC	3670.2 (-34.9)	777.5 (-86.2)	1027.2 (-81.8)	421.4 (-92.5)	6212.6 (+10.2)	5028.6 (-10.8)	3748.5 (-33.5)	1232.8 (-78.1)	4418.3 (-21.6)	4056.7 (-28.0)	2817.4 (-50.0)	726.8 (-87.1)	5515.4 (-2.2)	3310.4 (-41.3)	3306.5 (-41.3)	866.9 (-84.6)
155	MC	4224.2 (-25.1)	3817.7 (-32.3)	4593.7 (-18.5)	3908.6 (-30.7)	6200.9 (+10.0)	5035.1 (-10.7)	4838.3 (-14.2)	5266.3 (-6.6)	5078.6 (-9.9)	4079.3 (-27.6)	4627.8 (-17.9)	4165.2 (-26.1)	5084.3 (-9.8)	4623.3 (-18.0)	5413.1 (-4.0)	4595.4 (-18.5)
	EC	3755.4 (-33.4)	789.9 (-86.0)	1045.3 (-81.5)	424.2 (-92.5)	6281.9 (+11.4)	5106.3 (-9.4)	3802.2 (-32.5)	1252.2 (-77.8)	4527.1 (-19.7)	4123.7 (-26.8)	2875.6 (-49.0)	732.4 (-87.0)	5605.8 (-0.6)	3367.6 (-40.3)	3369.0 (-40.2)	878.5 (-84.4)
165	MC	4325.3 (-23.3)	3931.2 (-30.3)	4709.0 (-16.5)	3983.5 (-29.3)	6285.8 (+11.5)	5159.3 (-8.5)	4928.5 (-12.6)	5353.6 (-5.0)	5163.1 (-8.4)	4155.1 (-26.3)	4721.3 (-16.2)	4290.6 (-23.9)	5171.5 (-8.3)	4771.3 (-15.4)	5538.8 (-1.7)	4726.6 (-16.1)
	EC	3820.7 (-32.2)	805.0 (-85.7)	1064.6 (-81.1)	427.1 (-92.4)	6350.9 (+12.7)	5185.8 (-8.0)	3866.4 (-31.4)	1271.9 (-77.4)	4608.1 (-18.2)	4197.4 (-25.5)	2923.7 (-48.1)	738.0 (-86.9)	5751.4 (+2.0)	3470.7 (-38.4)	3478.0 (-38.3)	899.4 (-84.0)
175	MC	4406.7 (-21.8)	3992.9 (-29.2)	4798.4 (-14.9)	4111.9 (-27.0)	6343.7 (+12.5)	5275.0 (-6.4)	5048.7 (-10.4)	5486.4 (-2.7)	5244.5 (-7.0)	4274.2 (-24.2)	4811.6 (-14.6)	4356.9 (-22.7)	5278.7 (-6.3)	4848.0 (-14.0)	5643.1 (+0.1)	4811.3 (-14.7)
	EC	3883.4 (-31.1)	819.8 (-85.5)	1083.5 (-80.8)	430.6 (-92.4)	6416.2 (+13.8)	5261.4 (-6.7)	3918.7 (-30.5)	1290.9 (-77.1)	4676.7 (-17.0)	4269.6 (-24.3)	2970.8 (-47.3)	743.4 (-86.8)	5837.7 (+3.6)	3535.9 (-37.3)	3533.5 (-37.3)	911.9 (-83.8)
185	MC	4466.6 (-20.8)	4048.6 (-28.2)	4862.5 (-13.7)	4173.0 (-26.0)	6400.1 (+13.5)	5345.6 (-5.2)	5116.8 (-9.2)	5595.0 (-0.7)	5390.1 (-4.4)	4329.7 (-23.2)	4875.7 (-13.5)	4415.3 (-21.7)	5361.1 (-4.9)	4916.0 (-12.8)	5709.5 (+1.29)	4879.6 (-13.4)
	EC	3940.7 (-30.1)	834.2 (-85.2)	1101.6 (-80.5)	431.7 (-92.3)	6486.9 (+15.1)	5331.6 (-5.4)	3969.0 (-29.6)	1309.8 (-76.8)	4737.9 (-16.0)	4336.5 (-23.1)	3018.9 (-46.4)	747.6 (-86.7)	5890.2 (4.5)	3585.9 (-36.4)	3582.5 (-36.4)	923.5 (-83.6)

*%deviation from baseline value

Table 4.156: Simulation of changes in maize yield (kg ha⁻¹) of PMH2 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Amritsar, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (5370.5kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	2966.6 (-44.8)*	2798.1 (-47.9)	3295.7 (-38.6)	2748.7 (-48.8)	3750.3 (-30.2)	3756.1 (-30.1)	3558.6 (-33.7)	3904.9 (-27.3)	3696.6 (-31.2)	3046.1 (-43.2)	3448.2 (-35.8)	3155.1 (-41.2)	3425.9 (-36.2)	3141.1 (-41.5)	3512.2 (-34.6)	3124.6 (-41.8)
	EC	2580.7 (-52.0)	1049.6 (-80.5)	1116.1 (-79.2)	538.8 (-90.0)	4167.1 (-22.4)	3628.4 (-32.4)	2786.1 (-48.1)	1111.4 (-79.3)	3293.9 (-38.7)	2938.7 (-45.3)	2365.9 (-56.0)	994.6 (-81.5)	3278.3 (-39.0)	2564.3 (-52.2)	2403.1 (-55.2)	950.3 (-82.3)
75	MC	3069.1 (-42.9)	2893.5 (-46.1)	3405.2 (-36.6)	2852.4 (-46.9)	3872.3 (-27.9)	3871.4 (-27.9)	3669.7 (-31.7)	4033.3 (-24.9)	3814.4 (-29.0)	3142.0 (-41.5)	3572.5 (-33.5)	3259.7 (-39.3)	3544.5 (-34.0)	3244.3 (-39.6)	3624.5 (-32.5)	3235.9 (-39.8)
	EC	2685.3 (-50.0)	1092.4 (-79.7)	1160.3 (-78.4)	544.6 (-89.9)	4342.6 (-19.1)	3757.9 (-30.0)	2881.6 (-46.3)	1151.7 (-78.6)	3413.1 (-36.4)	3058.1 (-43.0)	2468.6 (-54.0)	1006.2 (-81.3)	3381.4 (-37.0)	2652.2 (-50.6)	2489.9 (-53.6)	982.6 (-81.7)
85	MC	3170.5 (-41.0)	2997.9 (-44.2)	3521.8 (-34.4)	2949.0 (-45.1)	4000.0 (-25.5)	3981.9 (-25.9)	3784.9 (-29.5)	4155.6 (-22.6)	3928.9 (-26.8)	3256.1 (-39.4)	3679.3 (-31.5)	3386.3 (-37.0)	3659.6 (-31.9)	3363.7 (-37.4)	3769.0 (-29.8)	3351.5 (-37.6)
	EC	2770.6 (-48.4)	1127.8 (-79.0)	1201.9 (-77.6)	549.2 (-89.8)	4521.7 (-15.8)	3903.7 (-27.3)	2974.9 (-44.6)	1195.6 (-77.7)	3525.3 (-34.4)	3200.0 (-440.4)	2564.0 (-52.3)	1017.3 (-81.1)	3511.6 (-34.6)	2740.2 (-49.0)	2581.3 (-51.9)	1013.0 (-81.1)
95	MC	3260.3 (-39.3)	3074.9 (-42.7)	3612.5 (-32.7)	3036.3 (-43.5)	4104.6 (-23.6)	4085.7 (-23.9)	3884.2 (-27.7)	4264.8 (-20.6)	4033.6 (-24.9)	3328.3 (-38.0)	3756.9 (-30.0)	3473.1 (-35.3)	3737.2 (-30.4)	3437.4 (-36.0)	3853.7 (-28.2)	3426.4 (-36.2)
	EC	2880.9 (-46.4)	1153.5 (-78.5)	1234.6 (-77.0)	552.6 (-89.7)	4624.3 (-13.9)	3996.0 (-25.6)	3058.6 (-43.0)	1225.0 (-77.2)	3607.5 (-32.8)	3306.7 (-38.4)	2644.4 (-50.8)	1026.0 (-80.9)	3587.7 (-33.2)	2812.5 (-47.6)	2642.1 (-50.8)	1038.3 (-80.7)
105	MC	3392.1 (-36.8)	3195.1 (-40.5)	3731.9 (-30.5)	3162.1 (-41.1)	4230.1 (-21.2)	4202.6 (-21.8)	4003.4 (-25.5)	4371.4 (-18.6)	4127.6 (-23.1)	3412.0 (-36.5)	3905.0 (-27.3)	3607.6 (-32.8)	3836.0 (-28.6)	3562.5 (-33.7)	3975.3 (26.0)	3561.1 (-33.7)
	EC	2986.0 (-44.4)	1185.7 (-77.9)	1267.8 (-76.4)	555.7 (-89.7)	4737.5 (-11.8)	4106.8 (-23.5)	3148.8 (-41.4)	1259.3 (-76.6)	3781.0 (-29.6)	3401.0 (-36.7)	2719.3 (-49.4)	1033.9 (-80.8)	3695.1 (-31.2)	2908.1 (-45.9)	2754.1 (-48.7)	1065.8 (-80.1)
115	MC	3494.1 (-34.9)	3296.5 (-38.6)	3871.5 (-27.9)	3247.8 (-39.5)	4377.2 (-18.5)	4315.3 (-19.7)	4102.0 (-23.6)	4458.6 (-17.0)	4210.9 (-21.6)	3558.3 (33.7)	4018.8 (-25.2)	3721.5 (-30.7)	3930.8 (-26.8)	3656.5 (-31.9)	4101.3 (-23.6)	3646.9 (-32.1)
	EC	3065.0 (-42.9)	1217.0 (-77.3)	1300.9 (-75.8)	558.1 (-89.6)	4923.3 (-8.3)	4248.2 (-20.9)	3233.2 (-39.8)	1294.0 (-75.9)	3876.2 (-27.8)	3490.7 (35.0)	2791.0 (-48.0)	1041.1 (-80.6)	3812.9 (-29.0)	2988.8 (-44.3)	2836.1 (-47.2)	1093.8 (-79.6)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (5370.5kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	3673.4 (-31.6)	3443.1 (-35.9)	4054.4 (-24.5)	3430.3 (-36.1)	4597.3 (-14.4)	4512.7 (-16.0)	4297.8 (-20.0)	4692.4 (-12.6)	4425.8 (-17.6)	3721.9 (-30.7)	4193.2 (-21.9)	3882.4 (-27.7)	4119.6 (-23.3)	3825.5 (-28.8)	4269.6 (-20.5)	4269.6 (-20.5)
	EC	3260.7 (-39.3)	1267.9 (-76.4)	1361.4 (-74.7)	561.7 (-89.5)	5184.4 (3.5)	4490.3 (-16.4)	3412.2 (-36.5)	1344.3 (-75.0)	4059.0 (-24.4)	3685.7 (-31.4)	2932.7 (-45.4)	1053.8 (-80.4)	3965.2 (-26.2)	3136.0 (-41.6)	2972.1 (-44.7)	2972.1 (-44.7)
145	MC	3776.7 (-29.7)	3561.8 (-33.7)	4144.8 (-22.8)	3505.5 (-34.7)	4727.4 (-12.0)	4629.7 (-13.8)	4424.0 (-17.6)	4772.4 (-11.1)	4499.8 (-16.2)	3794.7 (-29.3)	4341.9 (-19.1)	3997.5 (-25.6)	4262.7 (-20.6)	3964.6 (-26.2)	4385.7 (-18.3)	3988.9 (-25.7)
	EC	3338.7 (-37.8)	1293.6 (-75.9)	1388.6 (-74.1)	563.0 (-89.5)	5302.0 (-1.3)	4585.1 (-14.6)	3482.8 (-35.1)	1367.7 (-74.5)	4208.8 (-21.6)	3763.4 (-29.9)	2991.1 (-44.3)	1061.5 (-80.2)	4102.5 (-23.6)	3239.67 (-39.7)	3093.9 (-42.4)	1173.7 (-78.1)
155	MC	3862.5 (-28.1)	3654.0 (-32.0)	4233.5 (-21.2)	3583.4 (-33.3)	4829.6 (-10.1)	4740.1 (-11.7)	4515.4 (-15.9)	4855.3 (-74.1)	4601.5 (-14.3)	3868.2 (-28.0)	4419.5 (-17.7)	4100.5 (-23.7)	4348.3 (-19.0)	4072.9 (-24.2)	4518.6 (-15.9)	4071.7 (-24.2)
	EC	3403.1 (-36.6)	1318.4 (-75.4)	1413.3 (-73.7)	564.0 (-89.5)	5401.1 (+0.6)	4670.0 (-13.0)	3549.5 (-33.9)	1389.8 (-74.1)	4285.8 (-20.2)	3832.1 (-28.6)	3046.2 (-43.3)	1068.3 (-80.1)	4194.9 (-21.9)	3323.9 (-38.1)	3165.4 (-41.1)	1201.8 (-77.6)
165	MC	3958.1 (-26.3)	3728.5 (-30.6)	4372.8 (-18.6)	3657.6 (-31.9)	4955.4 (-7.7)	4859.4 (-9.5)	4649.8 (-13.4)	5016.7 (-6.6)	4726.8 (-12.0)	4032.7 (-24.9)	4516.0 (-15.9)	4184.9 (-22.1)	4486.5 (-16.5)	4167.7 (-22.4)	4667.0 (-13.1)	4163.9 (-22.5)
	EC	3475.4 (-35.3)	1343.1 (-75.0)	1438.5 (-73.2)	564.9 (-89.5)	5508.9 (+2.6)	4762.5 (-11.3)	3611.4 (-32.8)	1411.0 (-73.7)	4372.8 (-18.6)	3904.9 (-27.3)	3101.6 (-42.2)	1074.8 (-80.0)	4338.8 (-19.2)	3400.7 (-36.7)	3235.3 (-39.8)	1223.8 (-77.2)
175	MC	4036.4 (-24.8)	3798.8 (-29.3)	4456.0 (-17.0)	3727.0 (-30.6)	5049.0 (-6.0)	4956.7 (-7.7)	4731.2 (-11.9)	5131.6 (-4.4)	4259.4 (-20.7)	4109.7 (-23.5)	4616.3 (-14.0)	4259.4 (-20.7)	4567.1 (-15.0)	4248.8 (-20.9)	4758.3 (-11.4)	4245.9 (-20.9)
	EC	3546.1 (-34.0)	1372.6 (-74.4)	1463.1 (-72.8)	565.6 (-89.5)	5613.7 (4.5)	4863.2 (-9.4)	3674.1 (-31.6)	1433.6 (-73.3)	1080.5 (-79.9)	3976.9 (-26.0)	3155.3 (-41.2)	1080.5 (-79.9)	4421.8 (-17.7)	3466.7 (-35.4)	3300.23 (-38.6)	1245.7 (-76.8)
185	MC	4106.3 (-23.5)	3860.4 (-28.1)	4528.3 (-15.7)	3787.5 (-29.5)	5132.3 (-4.4)	5033.7 (-6.3)	4806.2 (-10.5)	5212.8 (-2.9)	4918.2 (-8.4)	4176.5 (-22.2)	4688.6 (-12.7)	4326.1 (-19.4)	4643.7 (-13.5)	4322.5 (-19.5)	4840.5 (-9.9)	4320.7 (-19.6)
	EC	3609.3 (-32.8)	1399.5 (-73.9)	1486.2 (-72.3)	566.4 (-89.4)	5711.9 (+6.4)	4953.6 (-7.8)	3774.2 (-29.7)	1455.3 (-72.9)	4525.7 (-15.7)	4045.6 (-24.7)	3208.0 (-40.3)	1085.1 (-80.0)	4496.8 (-16.3)	3524.7 (-34.4)	3357.6 (-37.5)	1264.8 (-76.4)

*%deviation from baseline value

Table 4.157: Simulation of changes in maize yield (kg ha⁻¹) of PMH1 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Patiala, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (5726.6 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	3797.1 (-33.7)*	3761.1 (-34.3)	3994.4 (-30.2)	3511.3 (-38.7)	4600.8 (-19.7)	4802.0 (-16.1)	4618.6 (-19.3)	4837.2 (-15.5)	4601.2 (-19.7)	3740.0 (-34.7)	4307.3 (-24.8)	4104.7 (-28.3)	4671.5 (-18.4)	4223.8 (-26.2)	4490.0 (-21.6)	3917.6 (-31.6)
	EC	3397.7 (-40.7)	782.1 (-86.3)	1374.8 (-76.0)	522.0 (-91.0)	4825.6 (-15.7)	3896.5 (-32.0)	3590.2 (-37.3)	979.6 (-82.9)	4437.9 (-22.5)	3122.5 (-45.5)	3138.2 (-45.2)	783.1 (-86.3)	4367.6 (-23.7)	3378.9 (-41.0)	3334.7 (-41.8)	898.0 (-84.3)
75	MC	3943.1 (-31.1)	3904.3 (-31.8)	4141.9 (-27.8)	3643.3 (-36.4)	4784.7 (-16.4)	4974.4 (-13.1)	4784.2 (-16.5)	5004.0 (-12.6)	4780.6 (-16.5)	3881.8 (-32.2)	4470.3 (-21.9)	4256.3 (-25.7)	4832.1 (-15.6)	4391.0 (-23.3)	4652.3 (-18.8)	4076.0 (-28.8)
	EC	3535.2 (-38.3)	804.4 (-86.0)	1417.6 (-75.2)	530.5 (-90.7)	4992.3 (-12.8)	4049.2 (-29.3)	3687.9 (-35.6)	1009.2 (-82.4)	4608.0 (-19.5)	3232.9 (-43.6)	3239.1 (-43.4)	798.0 (-86.1)	4536.2 (-20.8)	3498.2 (-38.9)	3453.1 (-39.7)	920.8 (-83.9)
85	MC	4064.9 (-29.0)	4026.6 (-29.7)	4277.8 (-25.3)	3755.5 (-34.4)	4925.8 (-14.0)	5115.5 (-10.7)	4928.3 (-13.9)	5161.2 (-9.9)	4918.1 (-14.1)	4005.6 (-30.0)	4611.7 (-19.5)	4382.2 (-23.5)	5005.1 (-12.6)	4532.3 (-20.9)	4805.0 (-16.1)	4203.8 (-26.6)
	EC	3639.9 (-36.4)	823.9 (-85.6)	1454.7 (-74.6)	537.6 (-90.6)	5150.7 (-10.1)	4170.8 (-27.2)	3791.8 (-33.8)	1032.5 (-82.0)	4746.8 (-17.1)	3325.6 (-41.9)	3325.4 (-41.9)	811.6 (-85.8)	4683.8 (-18.2)	3605.8 (-37.0)	3554.4 (-37.9)	941.3 (-83.6)
95	MC	4147.3 (-27.6)	4109.1 (-28.2)	4368.2 (-23.7)	3831.6 (-33.1)	5029.8 (-12.2)	5248.8 (-8.3)	5046.5 (-11.9)	5309.2 (-7.3)	5018.3 (-12.4)	4087.1 (-28.6)	4710.2 (-17.8)	4473.5 (-21.9)	5112.5 (-10.7)	4626.9 (-19.2)	4904.5 (-14.4)	4298.6 (-24.9)
	EC	3718.0 (-35.1)	841.0 (-85.3)	1484.9 (-74.1)	543.3 (-90.5)	5242.6 (-8.4)	4260.5 (-25.6)	3868.5 (-32.4)	1055.5 (-81.6)	4842.2 (-15.4)	3398.8 (-40.7)	3395.4 (-40.7)	823.9 (-85.6)	4784.0 (-16.5)	3686.4 (-35.6)	3633.3 (-36.6)	957.9 (-83.3)
105	MC	4243.2 (-25.9)	4204.1 (-26.6)	4466.9 (-22.0)	3920.7 (-31.5)	5160.6 (-9.9)	5392.5 (-5.8)	5174.3 (-9.6)	5469.1 (-4.5)	5127.4 (-10.5)	4181.0 (-27.0)	4816.5 (-15.9)	4571.4 (-20.2)	5228.6 (-8.7)	4735.4 (-17.3)	5013.6 (-12.4)	4401.4 (-23.1)
	EC	3872.0 (-32.4)	859.1 (-85.0)	1515.7 (-73.5)	549.1 (-90.4)	5366.5 (-6.3)	4358.0 (-23.9)	3953.5 (-31.0)	1077.7 (-81.2)	4950.6 (-13.6)	3473.3 (-39.4)	3467.3 (-39.4)	836.8 (-85.4)	4893.2 (-14.6)	3773.4 (-34.1)	3720.9 (-35.0)	979.5 (-82.9)
115	MC	4479.4 (-21.8)	4284.0 (-25.2)	4553.3 (-20.5)	3995.8 (-30.2)	5303.9 (-7.4)	5531.2 (-3.4)	5307.6 (-7.3)	5608.6 (-2.1)	5270.5 (-8.0)	4261.1 (-25.6)	4959.4 (-13.4)	4656.9 (-18.7)	5392.0 (-5.8)	4861.3 (-15.1)	5108.5 (-10.8)	4543.4 (-20.7)
	EC	4019.7 (-29.8)	880.4 (-84.6)	1546.6 (-73.0)	555.1 (-90.3)	5481.2 (-4.3)	4488.8 (-21.6)	4032.8 (-29.6)	1106.3 (-80.7)	5044.6 (-11.9)	3540.1 (-38.2)	3556.7 (-37.9)	849.3 (-85.2)	5038.7 (-12.0)	3889.7 (-32.1)	3808.6 (-33.5)	997.2 (-82.6)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (5726.6 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	4479.4 (-21.8)	4433.8 (-22.6)	4720.9 (-17.6)	4151.0 (-27.5)	5515.0 (-3.7)	5756.6 (+0.5)	5508.6 (-3.8)	5858.1 (+2.3)	5469.2 (-4.5)	4419.2 (-22.8)	5135.1 (-10.3)	4856.3 (-15.2)	5576.8 (+2.6)	5048.7 (-11.8)	5295.4 (-7.5)	4721.1 (-17.6)
	EC	4019.7 (-29.8)	921.8 (-83.9)	1614.3 (-71.8)	564.6 (-90.1)	5722.0 (-0.1)	4641.5 (-19.0)	4229.3 (-26.1)	1143.8 (-80.0)	5266.2 (-8.0)	3699.9 (-35.4)	3718.0 (-35.1)	867.2 (-84.9)	5216.4 (-8.9)	4035.2 (-29.5)	3966.1 (-30.7)	1034.0 (-81.9)
145	MC	4579.1 (-20.0)	4532.9 (-20.8)	4821.2 (-15.8)	4532.9 (-20.8)	5662.1 (-1.1)	5916.9 (+3.3)	5647.3 (-1.4)	5986.3 (+4.5)	5643.3 (-1.4)	4511.2 (-21.2)	5295.7 (-7.5)	4936.7 (-13.8)	5792.2 (+1.1)	5185.2 (-9.4)	5407.0 (-5.6)	4867.5 (-15.0)
	EC	4073.4 (-28.9)	943.0 (-83.5)	1644.9 (-71.3)	943.0 (-83.5)	5818.7 (+1.6)	4779.5 (-16.5)	4289.0 (-25.1)	1161.7 (-79.7)	5353.0 (-6.5)	3762.2 (-34.3)	3819.5 (-33.3)	874.8 (-84.7)	5424.8 (-5.3)	4167.6 (-27.2)	4053.2 (-29.2)	1049.1 (-81.7)
155	MC	4643.2 (-18.9)	4592.6 (-19.8)	4889.2 (-14.6)	4284.3 (-25.2)	5741.2 (+0.2)	6002.8 (+4.8)	5739.6 (+0.2)	6074.5 (+6.1)	5717.6 (-0.2)	4574.0 (-20.1)	5369.7 (-6.2)	5005.7 (-12.6)	5877.6 (+2.6)	5260.0 (-8.1)	5475.2 (-4.4)	4945.4 (-13.6)
	EC	4133.2 (-27.8)	961.3 (-83.2)	1678.1 (-70.7)	570.6 (-90.0)	5890.4 (+2.9)	4848.7 (-15.3)	4289.0 (-25.1)	1178.3 (-79.4)	5426.9 (-5.2)	3839.6 (-33.0)	3900.6 (-31.9)	883.6 (-84.6)	5503.8 (-3.9)	4239.2 (-26.0)	4118.3 (-28.1)	1063.4 (-81.4)
165	MC	4738.5 (-17.3)	4681.9 (-18.2)	4973.3 (-13.1)	4362.5 (-23.8)	5826.5 (+1.7)	6097.5 (+6.5)	5840.4 (+2.0)	6207.3 (+8.4)	5835.9 (+1.9)	4661.1 (-18.6)	5466.2 (-4.5)	5126.4 (-10.5)	5969.3 (+4.2)	5345.5 (-6.7)	5541.8 (-3.2)	5036.1 (-12.1)
	EC	4253.6 (-25.7)	977.4 (-82.9)	1718.2 (-70.0)	572.7 (-90.0)	6002.5 (+4.8)	4929.1 (-13.9)	4349.8 (-24.0)	1207.7 (-78.9)	5600.2 (-2.2)	3946.7 (-31.1)	3983.0 (-30.4)	891.7 (-84.4)	5595.7 (-2.3)	4314.4 (-24.7)	4204.9 (-26.6)	1078.2 (-81.2)
175	MC	4862.2 (-15.1)	4817.1 (-15.9)	5116.0 (-10.7)	4491.1 (-21.6)	5913.8 (+3.3)	6240.7 (+9.0)	5923.3 (+3.4)	6380.4 (+11.4)	5919.8 (+3.4)	4784.8 (-16.4)	5572.0 (-2.7)	5265.5 (-8.0)	6054.9 (+5.7)	5466.9 (-4.5)	5718.2 (-0.1)	5118.5 (-10.6)
	EC	4326.2 (-24.4)	1003.4 (-82.5)	1749.5 (-69.4)	574.4 (-90.0)	6107.0 (+6.6)	5064.4 (-11.6)	4431.9 (-22.6)	1226.6 (-78.6)	5687.9 (-0.7)	4011.8 (-30.0)	4046.9 (-29.3)	898.9 (-84.3)	5668.5 (-1.0)	4389.0 (-23.4)	4295.4 (-25.0)	1098.9 (-80.8)
185	MC	4935.3 (-13.8)	4889.1 (-14.6)	5180.0 (-9.5)	4554.9 (-20.5)	5997.0 (+4.7)	6328.7 (+10.5)	6047.4 (+5.6)	6480.8 (+13.2)	6004.3 (+4.9)	4888.5 (-14.6)	5647.0 (-1.4)	5349.9 (-6.6)	6133.8 (+7.1)	5550.4 (-3.1)	5804.1 (+1.3)	5197.0 (-9.2)
	EC	4391.1 (-23.3)	1024.6 (-82.1)	1777.9 (-69.0)	576.0 (-89.9)	6185.9 (+8.0)	5150.1 (-10.1)	4497.3 (-21.5)	1242.6 (-78.3)	5777.8 (+0.9)	4086.7 (-28.6)	4117.5 (-28.1)	904.3 (-84.2)	5740.2 (+0.2)	4479.2 (-21.8)	4373.3 (-23.6)	1113.7 (-80.6)

*%deviation from baseline value

Table 4.158: Simulation of changes in maize yield (kg ha⁻¹) of PMH2 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Patiala, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (5751.0kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	3614.9 (-37.1)*	3639.0 (-36.7)	3739.7 (-35.0)	3365.2 (-41.5)	3939.0 (-31.5)	4189.8 (-27.1)	3985.5 (-30.7)	4248.5 (-26.1)	4094.6 (-28.8)	3557.0 (-38.1)	3900.3 (-32.2)	4038.0 (-29.8)	4016.6 (-30.2)	3966.9 (-31.0)	4210.3 (-26.8)	3684.9 (-35.9)
	EC	3174.2 (-44.8)	1282.9 (-77.7)	1652.4 (-71.3)	712.4 (-87.6)	4117.5 (-28.4)	3589.0 (-37.6)	3014.2 (-47.6)	1242.2 (-78.4)	3911.7 (-32.0)	3039.0 (-47.2)	3085.7 (-46.3)	1247.3 (-78.3)	3975.4 (-30.9)	3441.5 (-40.2)	3331.8 (-42.1)	1266.0 (-78.0)
75	MC	3760.9 (-34.6)	3785.6 (-34.2)	3888.6 (-32.4)	3499.4 (-39.1)	4082.4 (-29.0)	4353.3 (-24.3)	4138.5 (-28.0)	4417.8 (-23.2)	4247.1 (-26.1)	3699.4 (-35.7)	4049.5 (-29.6)	4199.4 (-27.0)	4166.2 (-27.6)	4122.1 (-28.3)	4370.8 (-24.0)	3830.0 (-33.4)
	EC	3303.9 (-42.5)	1322.3 (-77.0)	1710.7 (-70.2)	720.0 (-87.5)	4275.5 (-25.7)	3722.3 (-35.3)	3136.4 (-45.5)	1281.8 (-77.7)	4060.9 (-29.4)	3180.4 (-44.7)	3202.1 (-44.3)	1263.0 (-78.0)	4125.6 (-28.3)	3587.1 (-37.6)	3475.2 (-39.6)	1297.7 (-77.4)
85	MC	3887.5 (-32.4)	3914.9 (-31.9)	4015.0 (-30.2)	3617.4 (-37.1)	4207.8 (-26.8)	4502.5 (-21.7)	4265.1 (-25.8)	4584.8 (-20.3)	4382.1 (-23.8)	3821.6 (-33.5)	4180.0 (-27.3)	4342.3 (-24.5)	4295.7 (-25.3)	4259.0 (-25.9)	4510.8 (-21.6)	3959.0 (-31.2)
	EC	3418.5 (-40.6)	1354.4 (-76.4)	1763.1 (-69.3)	727.1 (-87.4)	4407.6 (-23.4)	3482.3 (-33.2)	3244.8 (-43.6)	1325.0 (-77.0)	4192.4 (-27.1)	3297.9 (-42.7)	3311.6 (-42.4)	1277.2 (-77.8)	4255.3 (-26.0)	3740.4 (-35.0)	3605.1 (-37.3)	1326.5 (-76.9)
95	MC	3986.8 (-30.7)	4021.2 (-30.1)	4114.0 (-28.5)	3714.6 (-35.4)	4318.9 (-25.0)	4611.3 (-19.8)	4376.7 (-23.9)	4699.4 (-18.3)	4485.7 (-22.0)	3918.5 (-31.9)	4282.7 (-25.5)	4462.7 (-22.4)	4395.8 (-23.6)	4371.3 (-24.0)	4618.7 (-19.7)	4070.8 (-29.2)
	EC	3509.1 (-39.0)	1383.7 (-75.9)	1807.4 (-68.6)	732.7 (-87.3)	4516.6 (-21.5)	3932.2 (-31.6)	3349.5 (-41.8)	1359.6 (-76.4)	4192.4 (-27.1)	3384.9 (-41.1)	3405.2 (-40.8)	1287.9 (-77.6)	4355.9 (-24.3)	3847.0 (-33.1)	3716.1 (-35.4)	1350.8 (-76.5)
105	MC	4092.3 (-28.8)	4135.5 (-28.1)	4219.3 (-26.6)	3817.6 (-33.6)	4463.4 (-22.4)	4757.0 (-17.3)	4521.4 (-21.4)	4852.5 (-15.6)	4631.3 (-19.5)	4025.6 (-30.0)	4432.2 (-22.9)	4587.0 (-20.2)	4556.9 (-20.8)	4525.4 (-21.3)	4734.4 (-17.7)	4241.8 (-26.2)
	EC	3612.0 (-37.2)	1417.5 (-75.3)	1851.0 (-67.8)	738.6 (-87.2)	4650.0 (-19.1)	4077.4 (-29.1)	3448.4 (-40.0)	1398.0 (-75.7)	4403.2 (-23.4)	3470.5 (-39.7)	3506.5 (-39.0)	1301.1 (-77.4)	4509.4 (-21.6)	3992.8 (-30.6)	3840.3 (-33.2)	1378.8 (-76.0)
115	MC	4219.5 (-26.6)	4242.5 (-26.2)	4346.6 (-24.4)	3929.9 (-31.7)	4607.3 (-19.9)	4909.2 (-14.6)	4660.1 (-19.0)	5018.8 (-12.7)	4752.2 (-17.4)	4135.0 (-28.1)	4552.3 (-20.8)	4714.4 (-18.0)	4681.7 (-18.6)	4655.2 (-19.0)	4851.1 (-15.7)	4367.2 (-24.1)
	EC	3727.0 (-35.2)	1452.1 (-74.8)	1898.2 (-67.0)	742.8 (-87.1)	4796.0 (-16.6)	4192.3 (-27.1)	3563.0 (-38.0)	1426.1 (-75.2)	4575.6 (-20.4)	3561.0 (-38.1)	3601.7 (-37.8)	1311.5 (-77.2)	4623.7 (-19.6)	4110.5 (-28.5)	3937.5 (-31.5)	1409.1 (-75.5)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (5751.0kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	4456.3 (-22.5)	4486.5 (-22.0)	4597.9 (-20.0)	4138.8 (-28.0)	4897.8 (-14.8)	5219.8 (-9.2)	4936.6 (-14.2)	5314.6 (-7.6)	5065.7 (-11.9)	4371.6 (-24.0)	4858.9 (-15.5)	4971.4 (-13.6)	5004.2 (-13.0)	4947.3 (-14.0)	5153.2 (-10.4)	4652.0 (-19.1)
	EC	3927.2 (-31.7)	1514.3 (-73.7)	1982.8 (-65.5)	749.5 (-87.0)	5082.7 (-11.6)	4469.3 (-22.3)	3787.4 (-34.1)	1475.1 (-74.3)	4802.8 (-16.5)	3727.6 (-35.2)	3785.0 (-34.2)	1332.3 (-76.8)	4947.9 (-14.0)	4358.9 (-24.2)	4158.5 (-27.7)	1449.8 (-74.8)
145	MC	4573.9 (-20.5)	4574.0 (-20.5)	4724.0 (-17.9)	4237.9 (-26.3)	5003.9 (-13.0)	5337.4 (-7.2)	5066.0 (-12.0)	5460.2 (-5.1)	5180.4 (-9.9)	4480.3 (-22.1)	4968.7 (-13.6)	5076.6 (-11.7)	5114.4 (-11.1)	5054.3 (-12.1)	5251.7 (-8.7)	4754.1 (-17.3)
	EC	4004.1 (-30.4)	1544.4 (-73.1)	2030.2 (-64.7)	751.5 (-86.9)	5225.2 (-9.1)	4570.4 (-20.5)	3869.2 (-32.7)	1510.6 (-73.7)	4976.2 (-13.5)	3845.3 (-33.1)	3880.1 (-32.5)	1341.7 (-76.7)	5067.1 (-11.9)	4449.9 (-22.6)	4239.8 (-26.3)	1469.9 (-74.4)
155	MC	4662.8 (-18.9)	4675.0 (-18.7)	4837.0 (-15.9)	4334.0 (-24.6)	5096.3 (-11.4)	5445.1 (-5.3)	5162.6 (-10.2)	5580.9 (-3.0)	5304.6 (-7.8)	4577.9 (-20.4)	5074.2 (-11.8)	5222.6 (-9.2)	5210.4 (-9.4)	5193.2 (-9.7)	5426.0 (-5.7)	4844.2 (-15.8)
	EC	4114.8 (-28.4)	1576.9 (-72.6)	2071.3 (-64.0)	753.3 (-86.9)	5337.5 (-7.2)	4654.7 (-19.1)	3945.1 (-31.4)	1533.6 (-73.3)	5090.7 (-11.5)	3934.4 (-31.6)	3955.4 (-31.2)	1347.5 (-76.6)	5166.4 (-10.2)	4533.1 (-21.2)	4324.7 (-24.8)	1487.3 (-74.1)
165	MC	4790.1 (-16.7)	4815.6 (-16.3)	4964.7 (-13.7)	4448.6 (-22.7)	5196.5 (-9.6)	5596.1 (-2.7)	5259.5 (-8.6)	5746.6 (-0.1)	5407.9 (-6.0)	4702.3 (-18.2)	5169.1 (-10.1)	5339.8 (-7.1)	5310.6 (-7.7)	5291.0 (-8.0)	5555.2 (-3.4)	4936.5 (-14.2)
	EC	4204.2 (-26.9)	1612.8 (-72.0)	2109.6 (-63.3)	755.0 (-86.9)	5438.6 (-5.4)	4745.5 (-17.5)	4049.3 (-29.6)	1557.9 (-72.9)	5192.3 (-9.7)	4008.1 (-30.3)	4022.7 (-30.0)	1351.2 (-76.5)	5266.8 (-8.4)	4618.7 (-19.7)	4438.7 (-22.8)	1512.7 (-73.7)
175	MC	4867.7 (-15.4)	4893.6 (-14.9)	5049.8 (-12.2)	4522.5 (-21.4)	5332.9 (-7.3)	5709.0 (-0.7)	5403.8 (-6.0)	5863.3 (+2.0)	5529.4 (-3.9)	4780.5 (-16.9)	5280.8 (-8.2)	5429.6 (-5.6)	5465.0 (-5.0)	5411.5 (-5.9)	5649.0 (-1.8)	5111.6 (-11.1)
	EC	4270.6 (-25.7)	1643.7 (-71.4)	2146.9 (-62.7)	756.3 (-86.9)	5588.5 (-2.8)	4873.7 (-15.2)	4138.1 (-28.0)	1581.7 (-72.5)	5284.0 (-8.1)	4078.4 (-29.1)	4130.6 (-28.2)	1353.8 (-76.5)	5378.0 (-6.5)	4725.2 (-17.8)	4547.8 (-20.9)	1528.0 (-73.4)
185	MC	4941.3 (-14.1)	4968.2 (-13.6)	5129.3 (-10.8)	4593.1 (-20.1)	5427.2 (-5.6)	5843.5 (+1.6)	5519.3 (-4.0)	5967.6 (+3.8)	5647.7 (-1.8)	4854.3 (-15.6)	5417.2 (-5.8)	5516.0 (-4.1)	5582.6 (-2.9)	5498.5 (-4.4)	5736.3 (-0.3)	5216.8 (-9.3)
	EC	4334.7 (-24.6)	1665.4 (-71.0)	2180.0 (-62.1)	757.5 (-86.8)	5679.4 (-1.2)	4993.3 (-13.2)	4207.6 (-26.8)	1603.3 (-72.1)	5370.0 (-6.6)	4147.2 (-27.9)	4214.3 (-26.7)	1356.6 (-76.4)	5542.2 (-3.6)	4855.6 (-15.6)	4624.4 (-19.6)	1542.7 (-73.2)

*%deviation from baseline value

Agroclimatic zone IV (Bathinda)

The zone observed decline in yield for PMH1 (Table 4.159) cultivar under all the scenarios and by all the models. The Ensemble model projected a decline upto 11% and 15% under RCP2.6 during mid and end-century, respectively at the increasing nitrogen doses. Similarly, under RCP4.5 the projected decline was by 13% and 30% during mid and end-century, respectively. The IPSL-CM5A-MR model too depicted decline while FIO-ESM model overestimated the yield showing an increase at higher doses (175 kg ha⁻¹ and 185 kg ha⁻¹) during mid under RCP2.6 (0.9% and 3.3%), RCP4.5 (1.4% and 3.8%), RCP8.5 (5.4% and 7.9%) during mid-century and under RCP2.6 (3.0% and 5.2%) during end-century, respectively. Under RCP6.0 the Ensemble model projected the yield decrease by 8% and 44%, respectively during mid and end-century while under RCP8.5, the model projected a decline by 18% and 87% for the respective century.

The models projected yield decline for PMH2 (Table 4.160) under all the scenarios. Under RCP2.6 and RCP4.5 the Ensemble model observed yield decline upto 20% and 21% during mid-century and upto 26% and 32%, respectively during end-century. The model under RCP6.0 and RCP8.5 observed the yield decline upto 19% and 25% during mid-century and by 45% and 80%, respectively during the end-century.

Agroclimatic zone V (Abohar and Faridkot)

At Abohar the cultivar PMH1 (Table 4.161) and PMH2 (Table 4.162) showed a yield decline during both the centuries for all the four GCMs. The Ensemble model for PMH1 projected a decline upto 13% and 22% under RCP2.6, 20% and 60% under RCP4.5, 12% and 62% under RCP6.0, 26% and 86% under RCP8.5 during mid and end-century respectively at high doses of nitrogen. The CSIRO-Mk-3-6-0 model projected a yield decline upto 76% and 97% under RCP2.6 and RCP8.5 during end-century while FIO-ESM model projected a yield increase at 175 kg ha⁻¹ (1.6%) and 185 kg ha⁻¹ (4.0%) during end-century under RCP8.5.

The Ensemble model for PMH2 depicted a yield decline upto 20 to 30% under the four scenarios during the mid-century and upto 26% (RCP2.6), 52 to 55% (RCP4.5 and RCP6.0) and 84% (RCP8.5) during the end-century at higher doses of nitrogen. The CSIRO-Mk-3-6-0 model projected a yield decline upto 67% and 95% while FIO-ESM model projected this decline upto 17% and 88% under RCP2.6 and RCP8.5, respectively during end-century. The IPSL-CM5A-MR and Ensemble model gave almost same decline in yield at higher doses of nitrogen.

The PMH1 (Table 4.163) cultivar at Faridkot performed well during mid-century if the nitrogen doses were increased. The models predicted the yield to show a significant yield increase under RCP2.6 at higher doses of nitrogen. The Ensemble model predicted the yield

increase upto 32% and 31% under RCP2.6 during mid and end-century. All the models showed an increase in yield after the increase in nitrogen dose application. The Ensemble model projected a yield increase upto 26.9% under RCP4.5 while under RCP6.0 and RCP8.5 the yield increase projected was upto 34% and 23% during mid-century and decline upto 1.3% and 84% during end-century, respectively. Application of nitrogen at higher doses would be beneficial to both the cultivars.

At Faridkot, the PMH2 (Table 4.164) cultivar gave similar results as PMH1. Under RCP2.6 the yield increase as projected by Ensemble model was by 33% and 26% for mid and end-century, respectively while under RCP4.5 the increase was observed upto 20% and decrease upto 5% during the respective centuries. The scenario RCP6.0 observed an increase upto 32% and decrease upto 9%, respectively during mid and end-century. RCP8.5 observed a significant decrease on an average by 78% during end-century and increase by 15.5% during the mid-century.

Deb *et al* (2015) observed yield increment upto 1.72% on application of higher doses of farm yard manure (FYM). They found FYM application rate of 60% improved the yield by 6.2% and 7.1% for 2055s and 2085s, respectively from the yield obtained at current rate of application. Nagy J and Hauzsvai (1996) reported the effect of precipitation on maize yield and their analysis showed that fertilization had favourable effect on the maize crop on utilization of precipitation in absolute volumes. The above study shows yield increase at good rainfall (<1000mm) agroclimatic zone II and III with higher doses of nitrogen under RCP2.6 (low-emission scenario) and yield decline at low rainfall (<500mm) agroclimatic zone IV and V (Abohar). These changes at higher doses were observed during the *kharif* season in Punjab and during mid-century while the end of 21st century at higher doses of nitrogen depicted major yield decline under RCP8.5 (high emission scenario). Falconnier *et al* (2020) reported in a study done for impact on maize yield under low nitrogen input conditions in sub-Saharan Africa that climate change and nitrogen input interaction require attention while considering the adaptation practices under climate change. Similar study in Zambia by Satwiinda *et al* (2021) reported fertilizer strategies to improve nitrogen use efficiency would boost the crop production avoiding the adverse impact of climate change. Under Punjab conditions higher doses of nitrogen were found suitable for the maize crop which if done with optimized date of planting would yield good production under future climatic scenarios.

Table 4.159: Simulation of changes in maize yield (kg ha⁻¹) of PMH1 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Bathinda, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (3244.0 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	1664.0 (-48.7)*	348.4 (-89.3)	1848.5 (-43.0)	1403.1 (-56.8)	2369.2 (-27.0)	2351.0 (-27.5)	2258.3 (-30.4)	2421.3 (-25.4)	2168.2 (-33.3)	1572.6 (-51.5)	1982.6 (-38.9)	1647.9 (-49.2)	2029.4 (-37.4)	1966.7 (-39.4)	2077.8 (-36.0)	1847.5 (-43.0)
	EC	1193.8 (-63.2)	186.2 (-94.3)	421.5 (-87.0)	200.1 (-93.8)	2445.9 (-24.6)	1969.3 (-39.3)	1484.9 (-54.2)	326.1 (-90.0)	1807.5 (-44.3)	1512.6 (-53.4)	1259.6 (-61.2)	375.5 (-88.4)	1942.3 (-40.1)	1576.1 (-51.4)	1240.4 (-61.8)	289.9 (-91.1)
75	MC	1736.0 (-46.5)	365.2 (-88.7)	1920.6 (-40.8)	1459.2 (-55.0)	2444.8 (-24.6)	2432.7 (-25.0)	2336.7 (-28.0)	2509.9 (-22.6)	2259.2 (-30.4)	1636.1 (-49.6)	2065.0 (-36.3)	1713.7 (-47.2)	2105.1 (-35.1)	2028.0 (-37.5)	2168.7 (-33.1)	1912.2 (-41.0)
	EC	1240.1 (-61.8)	199.1 (-93.9)	439.2 (-86.5)	209.1 (-93.6)	2532.7 (-21.9)	2065.0 (-36.3)	1538.6 (-52.6)	340.0 (-89.5)	1899.0 (-41.5)	1584.5 (-51.2)	1307.5 (-59.7)	402.3 (-87.6)	2003.1 (-38.2)	1635.4 (-49.6)	1318.7 (-59.3)	303.6 (-90.6)
85	MC	1800.5 (-44.5)	379.4 (-88.3)	1990.1 (-38.7)	1514.3 (-53.3)	2576.2 (-20.6)	2562.4 (-21.0)	2460.3 (-24.2)	2645.2 (-18.5)	2359.8 (-27.3)	1702.0 (-47.5)	2154.2 (-33.6)	1776.5 (-45.2)	2206.6 (-32.0)	2137.6 (-34.1)	2261.3 (-30.3)	2009.9 (-38.0)
	EC	1283.9 (-60.4)	211.6 (-93.5)	455.3 (-86.0)	218.3 (-93.3)	2652.3 (-18.2)	2147.9 (-33.8)	1619.5 (-50.1)	352.8 (-89.1)	1963.6 (-39.5)	1672.8 (-48.4)	1351.4 (-58.3)	427.3 (-86.8)	2109.9 (-35.0)	1720.2 (-47.0)	1367.3 (-57.9)	314.2 (-90.3)
95	MC	1859.6 (-42.7)	393.6 (-87.9)	2056.8 (-36.6)	1563.1 (-51.8)	2653.9 (-18.2)	2642.1 (-18.6)	2538.1 (-21.8)	2730.1 (-15.8)	2429.0 (-25.1)	1759.5 (-45.8)	2222.4 (-31.5)	1836.0 (-43.4)	2271.4 (-30.0)	2199.8 (-32.2)	2326.5 (-28.3)	2070.0 (-36.2)
	EC	1325.5 (-59.1)	224.1 (-93.1)	472.4 (-85.4)	226.4 (-93.0)	2726.8 (-15.9)	2214.9 (-31.7)	1669.5 (-48.5)	362.3 (-88.8)	2024.0 (-37.6)	1729.4 (-46.7)	1393.4 (-57.0)	451.0 (-86.1)	2170.9 (-33.1)	1771.0 (-45.4)	1411.0 (-56.5)	324.6 (-90.0)
105	MC	1920.1 (-40.8)	406.8 (-87.5)	2125.3 (-34.5)	1612.9 (-50.3)	2733.8 (-15.7)	2725.9 (-16.0)	2618.9 (-19.3)	2820.0 (-13.1)	2501.1 (-22.9)	1817.6 (-44.0)	2293.7 (-29.3)	1895.8 (-41.6)	2338.1 (-27.9)	2266.4 (-30.1)	2394.8 (-26.2)	2133.4 (-34.2)
	EC	1366.7 (-57.9)	236.7 (-92.7)	490.9 (-84.9)	234.7 (-92.8)	2803.3 (-13.6)	2284.3 (-29.6)	1723.0 (-46.9)	372.8 (-88.5)	2087.5 (-35.7)	1792.2 (-44.8)	1472.2 (-54.6)	476.2 (-85.3)	2234.8 (-31.1)	1826.4 (-43.7)	1456.4 (-55.1)	335.4 (-89.7)
115	MC	2024.2 (-37.6)	420.7 (-87.0)	2208.4 (-31.9)	1702.8 (-47.5)	2812.0 (-13.3)	2807.5 (-13.4)	2697.6 (-16.8)	2907.7 (-10.4)	2573.8 (-20.7)	1905.0 (-41.3)	2388.4 (-26.4)	1979.4 (-39.0)	2405.4 (-25.9)	2334.2 (-28.0)	2467.4 (-23.9)	2196.8 (-32.3)
	EC	1449.2 (-55.3)	247.9 (-92.4)	512.1 (-84.2)	241.4 (-92.6)	2877.9 (-11.3)	2352.2 (-27.5)	1775.6 (-45.3)	382.0 (-88.2)	2229.2 (-31.3)	1866.3 (-42.5)	1519.2 (-53.2)	500.8 (-84.6)	2297.6 (-29.2)	1879.6 (-42.1)	1501.0 (-53.7)	345.9 (-89.3)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (3244.0 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	2152.0 (-33.7)	445.2 (-86.3)	2375.1 (-26.8)	1815.5 (-44.0)	2966.8 (-8.6)	2970.6 (-8.4)	2850.6 (-12.1)	3078.7 (-5.1)	2718.8 (-16.2)	2049.2 (-36.8)	2533.8 (-21.9)	2143.9 (-33.9)	2543.1 (-21.6)	2467.7 (-23.9)	2606.3 (-19.7)	2323.5 (-28.4)
	EC	1536.4 (-52.6)	267.5 (-91.8)	540.4 (-83.3)	253.8 (-92.2)	3035.6 (-8.6)	2487.4 (-23.3)	1876.6 (-42.1)	402.1 (-87.6)	2295.1 (-29.2)	1979.9 (-39.0)	1609.8 (-50.4)	542.8 (-83.3)	2427.1 (-25.2)	1987.3 (-38.7)	1588.0 (-51.0)	369.5 (-88.6)
145	MC	2217.6 (-31.6)	457.0 (-85.9)	2474.9 (-23.7)	1872.1 (-42.3)	3045.5 (-6.1)	3053.1 (-5.9)	2926.2 (-9.8)	3166.0 (-2.4)	2793.0 (-13.9)	2113.3 (-34.9)	2608.2 (-19.6)	2209.6 (-31.9)	2612.9 (-19.5)	2534.9 (-21.9)	2678.3 (-17.4)	2387.5 (-26.4)
	EC	1584.3 (-51.2)	276.8 (-91.5)	555.3 (-82.9)	259.7 (-92.0)	3112.5 (-4.0)	2554.0 (-21.3)	1925.7 (-40.6)	410.9 (-87.3)	2361.1 (-27.2)	2040.5 (-37.1)	1656.3 (-48.9)	555.8 (-82.9)	2493.0 (-23.1)	2045.7 (-36.9)	1631.5 (-49.7)	383.8 (-88.2)
155	MC	2281.5 (29.7)	468.6 (-85.6)	2543.9 (-21.6)	1923.8 (-40.7)	3122.7 (-3.7)	3130.6 (-3.5)	3004.8 (-7.4)	3248.9 (+0.1)	2867.2 (-11.6)	2173.5 (-33.0)	2680.0 (-17.4)	2270.7 (-30.0)	2682.8 (-17.3)	2602.2 (-19.8)	2751.6 (-15.2)	2451.0 (-24.4)
	EC	1625.0 (-49.9)	285.6 (-91.2)	569.2 (-82.4)	265.5 (-91.8)	3189.2 (-1.7)	2619.4 (-19.2)	1970.9 (39.2)	418.8 (-87.1)	2426.9 (-25.2)	2092.6 (-35.5)	1698.1 (-47.7)	568.3 (-82.5)	2558.6 (-21.1)	2101.3 (-35.2)	1675.6 (-48.3)	395.6 (-87.8)
165	MC	2348.7 (-27.6)	480.6 (-85.2)	2617.5 (-19.3)	1979.7 (-39.0)	3198.8 (-1.4)	3210.3 (-1.0)	3081.0 (-5.0)	3333.9 (+2.8)	2944.1 (-9.2)	2237.5 (-31.0)	2754.4 (-15.1)	2338.2 (-27.9)	2754.5 (-15.1)	2670.1 (-17.7)	2825.3 (-12.9)	2516.4 (-22.4)
	EC	1669.6 (-48.5)	294.7 (-90.9)	583.3 (-82.0)	271.2 (-91.6)	3265.3 (+0.7)	2685.9 (-17.2)	2016.9 (-37.8)	427.3 (-86.8)	2493.5 (-23.1)	2157.1 (-33.5)	1742.4 (-46.3)	579.9 (-82.1)	2626.2 (-19.0)	2157.3 (-33.5)	1721.1 (-47.0)	407.2 (-87.4)
175	MC	2413.6 (-25.6)	494.2 (-84.8)	2692.1 (-17.0)	2034.6 (-37.3)	3274.5 (+0.9)	3289.7 (+1.4)	3156.7 (-2.7)	3418.2 (+5.4)	3021.4 (-6.9)	2302.1 (-29.0)	2828.4 (-12.8)	2404.7 (-25.9)	2826.6 (-12.9)	2738.8 (-15.6)	2898.8 (-10.6)	2582.1 (-20.4)
	EC	1714.3 (-47.1)	303.5 (-90.7)	597.9 (-81.6)	277.0 (-91.5)	3340.3 (+3.0)	2752.8 (-15.1)	2060.9 (-36.5)	437.5 (-86.5)	2561.7 (-21.0)	2215.5 (-31.7)	1785.9 (-45.0)	591.2 (-81.8)	2694.5 (-16.9)	2211.8 (-31.8)	1766.3 (-45.5)	416.8 (-87.2)
185	MC	2475.2 (-23.7)	506.7 (-84.4)	2762.5 (-14.8)	2087.5 (-35.7)	3350.3 (+3.3)	3367.9 (+3.8)	3232.2 (-0.4)	3501.6 (+7.9)	3097.1 (-4.5)	2366.5 (-27.0)	2901.1 (-10.6)	2468.2 (-23.9)	2899.8 (-10.6)	2808.9 (-13.4)	2973.2 (-8.3)	2649.0 (-18.3)
	EC	1754.9 (-45.9)	311.6 (-90.4)	612.1 (-81.1)	282.2 (-91.3)	3414.2 (+5.2)	2820.8 (-13.0)	2106.0 (-35.1)	446.4 (-86.2)	2627.4 (-19.0)	2268.6 (-30.1)	1824.0 (-43.8)	601.6 (-81.4)	2762.2 (-14.9)	2264.1 (-30.2)	1812.6 (-44.1)	426.1 (-86.9)

*%deviation from baseline value

Table 4.160: Simulation of changes in maize yield (kg ha⁻¹) of PMH2 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Bathinda, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (3214.6 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	1442.7 (-55.1)*	435.7 (-86.4)	1578.4 (-50.9)	1267.0 (-60.6)	1848.9 (-42.5)	1985.6 (-38.2)	1903.5 (-40.8)	2042.1 (-36.5)	1825.8 (-43.2)	1401.3 (-56.4)	1745.3 (-45.7)	1499.7 (-53.3)	1620.4 (-49.6)	1614.5 (-49.8)	1650.2 (-48.7)	1491.2 (-53.6)
	EC	1174.0 (-63.5)	259.6 (-91.9)	488.5 (-84.8)	212.6 (-93.4)	1908.7 (-40.6)	1679.4 (-47.8)	1234.4 (-61.6)	373.2 (-88.4)	1519.7 (-52.7)	1248.6 (-61.2)	1099.8 (-65.8)	574.4 (-82.1)	1506.2 (-53.1)	1262.0 (-60.7)	1053.1 (-67.2)	365.2 (-88.6)
75	MC	1522.6 (-52.6)	463.3 (-85.6)	1656.4 (-48.5)	1331.2 (-58.6)	1983.5 (-38.3)	2130.1 (-33.7)	2028.2 (-36.9)	2201.4 (-31.5)	1968.3 (-38.8)	1473.5 (-54.2)	1859.5 (-42.1)	1573.4 (-51.1)	1745.1 (-45.7)	1734.3 (-46.0)	1774.6 (-65.0)	1603.3 (-50.1)
	EC	1230.0 (-61.7)	279.2 (-91.3)	514.9 (-84.0)	225.6 (-93.0)	2041.7 (-36.5)	1801.5 (-44.0)	1326.9 (-58.7)	393.4 (-87.8)	1620.8 (-49.6)	1334.7 (-58.5)	1157.1 (-64.0)	614.3 (-80.9)	1619.5 (-49.5)	1358.3 (-57.8)	1124.2 (-65.0)	388.2 (-87.9)
85	MC	1590.8 (-50.5)	486.2 (-84.9)	1730.0 (-46.2)	1392.5 (-56.7)	2067.7 (-35.7)	2226.3 (-30.7)	2137.7 (-33.5)	2311.3 (-28.1)	2056.9 (-36.0)	1538.1 (-52.1)	1950.9 (-39.3)	1645.3 (-48.8)	1822. (-43.3)	1811.6 (-43.7)	1851.8 (-42.4)	1672.9 (-48.0)
	EC	1290.3 (-59.9)	298.1 (-90.7)	549.2 (-82.9)	236.3 (-92.7)	2125.3 (-33.9)	1879.4 (-41.5)	1389.7 (-56.8)	410.3 (-87.2)	1690.3 (47.4)	1412.4 (-56.1)	1256.1 (-60.9)	645.9 (-79.9)	1689.2 (-47.4)	1423.1 (-55.7)	1174.6 (-63.5)	412.6 (-87.2)
95	MC	1667.7 (-48.1)	506.9 (-84.2)	1800.5 (-44.0)	1456.0 (-54.7)	2146.4 (-33.2)	2312.8 (-28.1)	2226.0 (-30.8)	2408.5 (-25.1)	2134.2 (-33.6)	1608.3 (-50.0)	2046.8 (-36.3)	1723.9 (-46.4)	1889.8 (-41.2)	1877.3 (-41.6)	1920.4 (-40.3)	1736.8 (-46.0)
	EC	1369.8 (-57.4)	317.2 (-90.1)	580.8 (-81.9)	246.5 (-92.3)	2201.6 (-31.5)	1952.1 (-39.3)	1446.7 (-55.0)	425.2 (-86.8)	1754.5 (-45.4)	1490.8 (-53.6)	1314.6 (-59.1)	673.0 (-79.1)	1754.1 (-45.4)	1479.8 (-54.0)	1222.2 (-62.0)	434.8 (-86.5)
105	MC	1780.5 (-44.6)	533.5 (-83.4)	1907.6 (-40.7)	1566.6 (-51.3)	2219.5 (-31.0)	2405.4 (-25.2)	2316.6 (-27.9)	2508.1 (-22.0)	2218.1 (-31.0)	1712.8 (-46.7)	2141.7 (-33.4)	1861.5 (-42.1)	1962.1 (-39.0)	1950.1 (-39.3)	1994.9 (-37.9)	1804.0 (-43.9)
	EC	1446.9 (-55.0)	337.2 (-89.5)	611.5 (-81.0)	257.8 (-92.0)	2277.7 (-29.1)	2026.5 (-37.0)	1508.6 (-53.1)	441.9 (-86.2)	1839.8 (-42.8)	1569.1 (-51.2)	1378.1 (-57.1)	698.8 (-78.3)	1823.3 (-43.3)	1541.8 (-52.0)	1271.2 (-60.5)	459.2 (-85.7)
115	MC	1856.7 (-42.2)	556.3 (-82.7)	2031.4 (-36.8)	1638.0 (-49.0)	2284.4 (-28.9)	2495.1 (-22.4)	2404.1 (-25.2)	2606.8 (-18.9)	2301.7 (-28.4)	1804.5 (-43.9)	2228.3 (-30.7)	1947.5 (-39.4)	2036.7 (-36.6)	2017.5 (-37.7)	2065.0 (-35.8)	1872.3 (-41.8)
	EC	1508.2 (-53.1)	356.5 (-88.9)	640.1 (-80.1)	268.2 (-91.7)	2340.0 (-27.2)	2097.7 (-34.8)	1569.6 (-51.2)	460.4 (-85.7)	1910.6 (-40.6)	1643.9 (-48.9)	1442.7 (-55.1)	722.8 (-77.5)	1891.0 (-41.2)	1602.9 (-50.1)	1320.5 (-58.9)	484.9 (-84.9)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (3214.6 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	2004.1 (-37.7)	602.2 (-81.3)	2177.2 (-32.3)	1768.7 (-45.0)	2405.4 (-25.2)	2661.0 (-17.2)	2570.1 (-20.0)	2807.0 (-12.7)	2463.9 (-23.3)	1940.5 (-39.6)	2395.2 (-25.5)	2103.9 (-34.6)	2182.0 (-32.1)	2165.0 (-32.7)	2208.8 (-31.3)	2008.1 (-37.5)
	EC	1623.3 (-49.5)	385.2 (-88.0)	698.0 (-78.3)	284.6 (-91.1)	2453.7 (-23.7)	2234.1 (-30.5)	1686.5 (-47.5)	488.6 (-84.8)	2046.5 (-36.3)	1788.3 (-44.4)	1568.8 (-51.2)	760.8 (76.3)	2030.2 (-36.8)	1723.3 (-46.4)	1417.3 (-55.9)	532.3 (-83.4)
145	MC	2080.7 (-35.3)	630.6 (-80.4)	2254.0 (-29.9)	1837.4 (-42.8)	2468.6 (-23.2)	2735.4 (-14.9)	2640.4 (-17.9)	2891.6 (-10.0)	2543.9 (-20.9)	2010.3 (-37.5)	2475.4 (-23.0)	2187.2 (-32.0)	2257.2 (-29.8)	2240.1 (-30.3)	2284.6 (-28.9)	2078.3 (-35.3)
	EC	1685.0 (-47.6)	396.1 (-87.7)	728.0 (-77.3)	291.5 (-90.9)	2514.8 (-21.8)	2300.2 (-28.4)	1745.5 (-45.7)	505.8 (-84.3)	2116.7 (-34.1)	1868.2 (-41.9)	1638.3 (-49.0)	776.0 (-75.9)	2100.2 (-34.7)	1787.1 (-44.4)	1467.0 (-54.4)	552.8 (-82.8)
155	MC	2154.7 (-33.0)	655.0 (-79.6)	2323.0 (-27.7)	1900.2 (-40.9)	2528.5 (-21.3)	2805.0 (-12.7)	2709.0 (-15.7)	2965.4 (-7.8)	2622.3 (-18.4)	2073.3 (-35.5)	2551.3 (-20.6)	2264.9 (-29.5)	2332.0 (-27.5)	2314.1 (-28.0)	2359.8 (-26.6)	2150.3 (-33.1)
	EC	1741.7 (-45.8)	404.7 (-87.4)	756.7 (-76.5)	297.6 (-90.7)	2570.4 (-20.0)	2362.5 (-26.5)	1795.7 (-44.1)	518.8 (-83.9)	2184.9 (-32.0)	1944.4 (-39.5)	1703.8 (-47.0)	790.4 (-75.4)	2174.5 (-32.4)	1850.8 (-42.4)	1517.8 (-52.8)	571.0 (-82.2)
165	MC	2233.1 (-30.5)	688.0 (-78.6)	2397.3 (-25.4)	1969.4 (-38.7)	2590.7 (-19.4)	2881.5 (-10.4)	2780.8 (-13.5)	3046.0 (-5.2)	2703.4 (-15.9)	2142.6 (-33.3)	2629.2 (-18.2)	2343.4 (-27.1)	2411.3 (-25.0)	2392.1 (-25.6)	2438.8 (-24.1)	2225.0 (-30.8)
	EC	1809.3 (-43.7)	410.3 (-87.2)	786.8 (-75.5)	302.8 (-90.6)	2632.7 (-18.1)	2423.0 (-24.6)	1843.4 (-42.7)	532.0 (-83.4)	2258.1 (-29.8)	2028.4 (-36.9)	1774.5 (-44.8)	803.1 (-75.0)	2249.8 (-30.0)	1921.9 (-40.2)	1591.5 (-50.5)	590.0 (-81.7)
175	MC	2311.6 (-28.1)	720.6 (-77.6)	2471.0 (-23.1)	2039.5 (-36.6)	2654.3 (-17.4)	2966.9 (-7.7)	2852.2 (-11.3)	3130.1 (-2.6)	2782.0 (-13.5)	2211.7 (-31.2)	2710.6 (-15.7)	2421.3 (-24.7)	2490.0 (-22.5)	2470.6 (-23.1)	2518.3 (-21.7)	2322.0 (-27.8)
	EC	1870.9 (-41.8)	1414.5 (-87.1)	816.8 (-74.6)	307.6 (-90.4)	2694.9 (-16.2)	2500.3 (-22.2)	1191.9 (-40.5)	543.7 (-83.1)	2424.8 (-24.6)	2110.8 (-34.3)	1832.1 (-43.0)	813.5 (-74.7)	2322.6 (-27.8)	2108.1 (-34.4)	1692.3 (-47.4)	608.0 (-81.1)
185	MC	2382.2 (-25.9)	750.5 (-76.7)	2535.1 (-21.1)	2101.7 (-34.6)	2712.9 (-15.6)	3036.7 (-5.5)	2922.2 (-9.1)	3206.5 (-0.2)	2859.6 (-11.0)	2272.4 (-29.3)	2792.6 (-13.1)	2489.1 (-22.6)	2569.6 (-20.1)	2541.2 (-21.0)	2601.7 (-19.1)	2393.4 (-25.6)
	EC	1921.2 (-40.2)	419.1 (-87.0)	845.4 (-73.7)	312.6 (-90.3)	2780.1 (-13.5)	2574.7 (-19.9)	1969.0 (-38.8)	554.6 (-82.8)	2509.3 (-21.9)	2195.1 (-31.7)	1883.3 (-41.4)	822.7 (-74.4)	2386.1 (-25.8)	2183.5 (-32.1)	1753.9 (-45.4)	625.9 (-80.5)

*%deviation from baseline value

Table 4.161: Simulation of changes in maize yield (kg ha⁻¹) of PMH1 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Abohar, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (3210.1 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	1601.2 (-51.6)*	1494.3 (-54.9)	1774.4 (-46.4)	1230.1 (-62.8)	2310.8 (-30.2)	2415.7 (-27.0)	2265.7 (-31.5)	2395.7 (-27.6)	2271.0 (-31.4)	1534.2 (-53.7)	2000.0 (-39.6)	1721.1 (-48.0)	2018.9 (-39.0)	1866.0 (-43.6)	2044.7 (-38.2)	1729.0 (-47.8)
	EC	560.2 (-83.1)	418.5 (-87.4)	421.2 (-87.3)	72.9 (-97.8)	2207.1 (-33.3)	1932.6 (-41.6)	1092.8 (-67.0)	273.1 (-91.8)	1748.9 (-47.2)	1438.7 (-56.5)	1170.6 (-64.6)	391.2 (-88.2)	1822.1 (-45.0)	925.4 (-72.0)	858.6 (-74.1)	334.6 (-89.9)
75	MC	1661.7 (-49.8)	1550.2 (-53.2)	1841.9 (-44.4)	1276.3 (-61.4)	2392.6 (-27.7)	2513.9 (-24.0)	2340.5 (-29.3)	2479.8 (-25.1)	2349.5 (-29.0)	1593.1 (-51.9)	2070.0 (-37.5)	1786.7 (-46.0)	2080.8 (-37.1)	1935.3 (-41.5)	2114.5 (-36.1)	1804.7 (-45.5)
	EC	579.9 (-82.5)	436.0 (-86.8)	439.4 (-86.7)	76.5 (-97.7)	2270.7 (-31.4)	2015.6 (-39.1)	1142.3 (-65.5)	282.7 (-91.5)	1815.6 (-45.1)	1501.1 (-54.7)	1214.4 (-63.3)	409.4 (-87.6)	1917.5 (-42.1)	975.6 (-70.5)	907.1 (-72.6)	348.7 (-89.5)
85	MC	1720.0 (-48.0)	1604.6 (-51.5)	1907.1 (-42.4)	1320.5 (-60.1)	2510.2 (-24.2)	2620.0 (-20.9)	2466.8 (-25.5)	2613.3 (-21.0)	2465.4 (-25.5)	1648.7 (-50.2)	2161.7 (-34.7)	1849.4 (-44.1)	2196.2 (-33.7)	2032.4 (-38.6)	2224.3 (-32.8)	1880.2 (-43.2)
	EC	598.7 (-81.9)	458.6 (-86.1)	462.8 (-86.0)	79.9 (-97.6)	2330.9 (-29.6)	2082.8 (-37.1)	1185.6 (-64.2)	291.7 (-91.2)	1879.8 (-43.2)	1581.8 (-52.2)	1261.2 (-61.9)	425.7 (-87.1)	1983.9 (-40.1)	1009.4 (-69.5)	938.7 (-71.6)	358.9 (-89.2)
95	MC	1776.2 (-46.3)	1658.0 (-49.9)	1970.0 (-40.5)	1363.2 (-58.8)	2590.0 (-21.8)	2699.3 (-18.4)	2546.4 (-23.1)	2697.7 (-18.5)	2544.8 (-23.1)	1702.4 (-48.6)	2231.7 (-32.6)	1912.7 (-42.2)	2260.8 (-31.7)	2093.4 (-36.8)	2293.5 (-30.7)	1935.7 (-41.5)
	EC	616.3 (-81.4)	474.1 (-85.7)	478.6 (-85.5)	82.4 (-97.5)	2383.7 (-28.0)	2143.7 (-35.2)	1219.1 (-63.2)	299.4 (-91.0)	1942.8 (-41.3)	1635.6 (-50.6)	1300.1 (-60.7)	440.8 (-86.7)	2041.1 (-38.3)	1040.5 (-68.6)	968.1 (-70.8)	368.2 (-88.9)
105	MC	1833.4 (-44.6)	1709.5 (-48.3)	2034.4 (-38.5)	1405.9 (-57.5)	2666.4 (-19.4)	2778.4 (-16.1)	2625.6 (-20.7)	2783.5 (-15.9)	2624.4 (-20.7)	1755.2 (-47.0)	2303.6 (-30.4)	2010.6 (-39.3)	2326.3 (-29.7)	2155.6 (-34.9)	2361.4 (-28.7)	1993.4 (-39.8)
	EC	634.3 (-80.8)	491.4 (-85.1)	495.7 (-85.0)	84.9 (-97.4)	2432.9 (-26.5)	2205.7 (-33.4)	1253.4 (-62.1)	307.3 (-90.7)	2005.3 (-39.4)	1689.6 (-49.0)	1361.6 (-58.9)	459.5 (-86.1)	2099.8 (-36.6)	1072.1 (-67.6)	998.7 (-69.8)	377.8 (-88.6)
115	MC	1896.8 (-42.7)	1776.4 (-46.3)	2098.0 (-36.6)	1464.2 (-55.8)	2741.9 (-17.2)	2855.6 (-13.7)	2702.7 (-18.3)	2868.2 (-13.3)	2716.4 (-17.9)	1819.2 (-45.0)	2404.5 (-27.4)	2084.0 (-37.0)	2392.1 (-27.7)	2218.1 (-33.0)	2429.0 (-26.6)	2051.1 (-38.0)
	EC	2053.0 (-38.0)	508.3 (-84.6)	512.7 (-84.5)	87.2 (-97.4)	2482.9 (-25.0)	2266.4 (-31.5)	1287.2 (-61.1)	316.5 (-90.4)	2127.0 (-35.7)	1741.6 (-47.4)	1401.7 (-57.7)	475.1 (-85.7)	2159.7 (-34.8)	1103.8 (-66.7)	1028.7 (-68.9)	386.9 (-88.3)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (3210.1 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	705.3 (-78.7)	1918.6 (-42.0)	2289.0 (-30.9)	1512.4 (-54.3)	2891.9 (-12.6)	3009.2 (-9.1)	2854.5 (-13.8)	3035.1 (-8.3)	2893.6 (-12.6)	1984.7 (-40.0)	2550.9 (-22.9)	2213.4 (-33.1)	2522.2 (-23.8)	2340.3 (-29.3)	2563.2 (-22.6)	2165.4 (-34.6)
	EC	2108.3 (-36.3)	539.4 (-83.7)	544.4 (-83.6)	89.4 (-97.3)	2588.7 (-21.8)	2385.1 (-28.0)	1351.5 (-59.2)	335.0 (-89.9)	2266.2 (-31.5)	1835.7 (-44.5)	1475.0 (-55.4)	504.6 (-84.8)	2284.1 (-31.0)	1166.1 (-64.8)	1088.1 (-67.1)	406.8 (-87.7)
145	MC	723.8 (-78.1)	1970.2 (-40.5)	2352.8 (-28.9)	1574.8 (-52.4)	2967.9 (-10.3)	3084.4 (-6.8)	2932.8 (-11.4)	3117.5 (-5.8)	2976.2 (-10.1)	2043.4 (-38.3)	2622.4 (-20.8)	2279.3 (-31.1)	2592.5 (-21.7)	2400.9 (-27.5)	2631.1 (-20.5)	2223.2 (-32.8)
	EC	2156.0 (-34.9)	555.6 (-83.2)	560.7 (-83.1)	91.7 (-97.2)	2635.2 (-20.4)	2443.0 (-26.2)	1382.9 (-58.2)	344.3 (-89.6)	2335.3 (-29.4)	1885.0 (-43.0)	1511.5 (-54.3)	518.3 (-84.3)	2345.7 (-29.1)	1196.9 (-63.8)	1118.0 (-66.2)	417.1 (-87.4)
155	MC	741.1 (-77.6)	2014.3 (-39.1)	2411.1 (-27.2)	1616.2 (-51.2)	3042.6 (-8.1)	3158.5 (-4.6)	3007.9 (-9.1)	3197.0 (-3.4)	3055.8 (-7.7)	2097.3 (-36.6)	2690.6 (-18.7)	2339.0 (-29.3)	2660.8 (-19.6)	2459.9 (-25.7)	2698.4 (-18.5)	2279.6 (-31.1)
	EC	2209.0 (-33.3)	570.6 (-82.8)	575.7 (-82.6)	94.1 (-97.2)	2679.1 (-19.1)	2500.9 (-24.4)	1412.7 (-57.3)	352.5 (-89.3)	2398.8 (-27.5)	1927.8 (-41.8)	1544.3 (-53.3)	532.9 (-83.9)	2403.5 (-27.4)	1227.7 (-62.9)	1148.6 (-65.3)	426.0 (-87.1)
165	MC	759.8 (-77.0)	2063.2 (-32.7)	2473.5 (-25.3)	1653.9 (-50.0)	3117.3 (-5.8)	3233.2 (-2.3)	3084.0 (-6.8)	3279.5 (-0.9)	3137.6 (-5.2)	2154.6 (-34.9)	2762.4 (-16.5)	2402.8 (-27.4)	2729.2 (-17.6)	2519.4 (-23.9)	2766.3 (-16.4)	2336.0 (-29.4)
	EC	2261.7 (-31.7)	586.5 (-82.3)	591.7 (-82.1)	96.2 (-97.1)	2722.7 (-17.8)	2559.2 (-22.7)	1443.5 (-56.4)	361.1 (-89.1)	2467.9 (-25.4)	1976.7 (-40.3)	1576.1 (-52.4)	546.4 (-83.5)	2459.8 (-25.7)	1258.8 (-62.0)	1178.2 (-64.4)	435.8 (-86.8)
175	MC	778.4 (-76.5)	2110.5 (-36.2)	2536.4 (-23.4)	1695.1 (-48.8)	3192.1 (-3.6)	3307.8 (-0.1)	3160.0 (-4.5)	3361.9 (+1.6)	3219.7 (-23.4)	2211.4 (-33.2)	2833.9 (-14.4)	2465.6 (-25.5)	2796.8 (-15.5)	2578.8 (-22.1)	2834.2 (-14.4)	2391.5 (-27.8)
	EC	2307.9 (-30.3)	602.1 (-81.8)	607.6 (-81.6)	98.4 (-97.0)	2764.0 (-16.5)	2676.0 (-19.2)	1474.4 (-55.5)	369.5 (-88.8)	2536.8 (-23.4)	2024.2 (-38.9)	1607.3 (-51.4)	559.9 (-83.1)	2516.6 (-24.0)	1289.6 (-61.0)	1208.9 (-63.5)	446.6 (-86.5)
185	MC	796.6 (-75.9)	2154.6 (-34.9)	2593.3 (-21.7)	1734.4 (-47.6)	3267.4 (-1.3)	3381.0 (+2.1)	3235.2 (-2.3)	3442.9 (+4.0)	3300.1 (-0.3)	2264.6 (-31.6)	2903.9 (-12.3)	2523.7 (-23.8)	2863.0 (-13.5)	2636.7 (-20.3)	2901.9 (-12.3)	2445.3 (-26.1)
	EC	1063.2 (-67.2)	616.4 (-81.4)	622.2 (-81.2)	100.7 (-97.0)	2804.3 (-15.3)	2736.6 (-17.3)	1504.2 (-54.6)	378.5 (-88.6)	2598.6 (-21.5)	2065.3 (-37.6)	1635.5 (-50.6)	574.0 (-82.7)	2572.2 (-22.3)	1323.5 (-60.0)	1239.4 (-62.6)	455.1 (-86.2)

*%deviation from baseline value

Table 4.162: Simulation of changes in maize yield (kg ha⁻¹) of PMH2 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Abohar, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (3244.3 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	1501.8 (-53.7)*	1417.7 (-56.3)	1597.9 (-50.8)	1201.7 (-63.0)	1972.9 (-39.2)	2089.1 (-35.6)	1896.8 (-41.5)	2004.2 (-38.2)	1991.0 (-38.6)	1388.8 (-57.2)	1784.5 (-45.0)	1457.2 (-55.1)	1706.7 (-47.4)	1551.6 (-52.2)	1723.1 (-46.9)	1458.8 (-55.0)
	EC	670.0 (-79.3)	504.1 (-84.5)	507.4 (-84.4)	98.8 (-97.0)	1909.5 (-41.1)	1702.7 (-47.5)	1021.1 (-68.5)	277.5 (-91.4)	1524.8 (-53.0)	1142.4 (-64.8)	1108.3 (-65.8)	490.8 (-84.9)	1516.2 (-53.3)	966.0 (-70.2)	887.2 (-72.7)	413.4 (-87.3)
75	MC	1581.8 (-51.2)	1481.4 (-54.3)	1681.5 (-48.2)	1266.3 (-61.0)	2091.9 (-35.5)	2190.8 (-32.5)	2025.5 (-37.6)	2143.6 (-33.9)	2111.6 (-34.9)	1469.1 (-54.7)	1898.2 (-41.5)	1537.0 (-52.6)	1819.6 (-43.9)	1661.3 (-48.8)	1847.6 (-43.0)	1554.7 (-52.1)
	EC	700.0 (-78.4)	543.3 (-83.2)	546.0 (-83.2)	104.7 (-96.8)	1990.2 (-38.7)	1780.4 (-45.1)	1077.6 (-66.8)	286.9 (-91.2)	1615.1 (-50.2)	1229.9 (-62.1)	1170.1 (-63.9)	522.1 (-83.9)	1624.9 (-49.9)	1031.4 (-68.2)	937.0 (-71.1)	433.9 (-86.6)
85	MC	1651.9 (-49.1)	1541.3 (-52.5)	1756.2 (-45.9)	1319.7 (-59.3)	2171.8 (-33.1)	2266.5 (-30.1)	2112.0 (-34.9)	2240.5 (-30.9)	2208.7 (-31.9)	1535.1 (-52.7)	1975.9 (-39.1)	1636.4 (-49.6)	1888.1 (-41.8)	1731.3 (-46.6)	1922.3 (-40.8)	1616.1 (-50.2)
	EC	728.9 (-77.5)	574.0 (-82.3)	574.6 (-82.3)	109.7 (-96.6)	2062.4 (-36.4)	1847.5 (-43.0)	1121.3 (-65.4)	295.0 (-90.9)	1686.3 (-48.0)	1300.8 (-59.9)	1254.2 (-61.3)	552.6 (-83.0)	1687.7 (-48.0)	1072.4 (-67.0)	977.7 (-69.9)	453.7 (-86.0)
95	MC	1719.0 (-47.0)	1604.3 (-50.5)	1823.1 (-43.8)	1372.9 (-57.7)	2250.4 (-30.6)	2333.2 (-28.1)	2188.3 (-32.5)	2325.2 (-28.3)	2292.6 (-29.3)	1595.7 (-50.8)	2046.2 (-36.9)	1722.4 (-46.9)	1959.2 (-39.6)	1792.8 (-44.7)	1991.0 (-38.6)	1674.5 (-48.4)
	EC	775.6 (-76.1)	601.2 (-81.5)	599.7 (-81.5)	114.4 (-96.5)	2122.1 (-34.6)	1904.2 (-41.3)	1163.0 (-64.1)	302.1 (-90.7)	1762.7 (-45.7)	1358.8 (-58.1)	1308.5 (-59.7)	577.9 (-82.2)	1753.6 (-46.0)	1112.7 (-65.7)	1015.5 (-68.7)	473.2 (-85.4)
105	MC	1822.9 (-43.8)	1724.0 (-46.9)	1936.6 (-40.3)	1461.6 (-55.0)	2318.0 (-28.6)	2403.2 (-25.9)	2265.5 (-30.2)	2410.5 (-25.7)	2393.1 (-26.2)	1708.6 (-47.3)	2152.9 (-33.6)	1796.2 (-44.6)	2023.1 (-37.6)	1854.0 (-42.9)	2058.1 (-36.6)	1734.1 (-46.6)
	EC	819.3 (-74.8)	630.7 (-80.6)	629.1 (-80.6)	119.6 (-96.3)	2198.6 (-32.2)	1960.6 (-39.6)	1205.2 (-62.9)	311.9 (-90.4)	1871.6 (-42.3)	1422.9 (-56.1)	1369.4 (-57.8)	603.3 (-81.4)	1816.5 (-44.0)	1153.0 (-64.5)	1054.8 (-67.5)	492.1 (-84.8)
115	MC	1911.5 (-41.1)	1795.7 (-44.7)	2029.6 (-37.4)	1532.5 (-52.8)	2399.7 (-26.0)	2468.5 (-23.9)	2348.0 (-27.6)	2493.6 (-23.1)	2462.4 (-24.1)	1775.0 (-45.3)	2224.4 (-31.4)	1863.2 (-42.6)	2085.1 (-35.7)	1921.4 (-40.8)	2121.1 (-34.6)	1795.0 (-44.7)
	EC	851.9 (-73.7)	659.7 (-79.7)	658.1 (-79.7)	124.7 (-96.2)	2262.9 (-30.2)	2016.3 (-37.9)	1247.4 (-61.5)	319.3 (-90.2)	1932.4 (-40.4)	1489.1 (-54.1)	1426.2 (-56.0)	629.0 (-80.6)	1881.6 (-42.00)	1195.7 (-63.1)	1094.6 (-66.3)	515.0 (-84.1)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (3244.3 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	2041.5 (-37.1)	1918.3 (-40.9)	2161.5 (-33.4)	1640.9 (-49.4)	2517.3 (-22.4)	2593.9 (-20.0)	2480.6 (-23.5)	2639.0 (-18.7)	2601.9 (-19.8)	1891.5 (-41.7)	2355.5 (-27.4)	1993.1 (-38.6)	2218.6 (-31.6)	2041.6 (-37.1)	2242.7 (-30.9)	1917.5 (-40.9)
	EC	916.9 (-71.7)	715.6 (-77.9)	714.3 (-78.0)	134.7 (-95.9)	2367.6 (-27.0)	2119.1 (-34.7)	1287.6 (-60.3)	335.4 (-89.7)	2046.2 (-36.9)	1619.5 (-50.1)	1525.5 (-53.0)	672.8 (-79.3)	2009.0 (-38.1)	1274.0 (-60.7)	1173.0 (-63.8)	555.8 (-82.9)
145	MC	2109.6 (-35.0)	1983.9 (-38.9)	2228.4 (-31.3)	1695.5 (-47.7)	2578.7 (-20.5)	2659.7 (-18.0)	2480.6 (-23.5)	2716.3 (-16.3)	2670.5 (-17.7)	1952.4 (-39.8)	2420.4 (-25.4)	2061.3 (-36.5)	2285.2 (-29.6)	2105.7 (-35.1)	2308.1 (-28.9)	1980.4 (-39.0)
	EC	951.2 (-70.7)	740.6 (-77.2)	742.8 (-77.1)	139.0 (-95.7)	2416.6 (-25.5)	2230.6 (-31.2)	1287.6 (-60.3)	342.4 (-89.4)	2106.6 (-35.1)	1688.4 (-48.0)	1568.3 (-51.7)	692.7 (-78.7)	2079.4 (-35.9)	1316.4 (-59.4)	1215.7 (-62.5)	582.1 (-82.1)
155	MC	2165.7 (-33.2)	2039.4 (-37.1)	2286.2 (-29.5)	1743.0 (-46.3)	2637.8 (-18.7)	2719.8 (-16.2)	2480.6 (-23.5)	2781.2 (-14.3)	2735.5 (-15.7)	2004.9 (-38.2)	2480.1 (-23.6)	2119.3 (-34.7)	2347.4 (-27.7)	2170.9 (-33.1)	2368.4 (-27.0)	2041.0 (-37.1)
	EC	982.5 (-69.7)	763.6 (-76.5)	768.3 (-76.3)	142.9 (-95.6)	2460.0 (-24.2)	2286.5 (-29.5)	1328.4 (-59.1)	351.5 (-89.2)	2158.1 (-33.5)	1752.0 (-46.0)	1606.3 (-50.5)	711.7 (-78.1)	2149.3 (-33.8)	1359.8 (-58.1)	1255.2 (-61.3)	598.4 (-81.6)
165	MC	2226.5 (-31.4)	2098.9 (-35.3)	2350.9 (-27.5)	1794.8 (-44.7)	2701.0 (-16.8)	2833.8 (-12.7)	2543.1 (-21.6)	2857.8 (-11.9)	2806.0 (-13.5)	2061.7 (-36.4)	2545.8 (-21.5)	2185.3 (-32.6)	2406.9 (-25.8)	2233.4 (-31.2)	2429.7 (-25.1)	2100.8 (-35.2)
	EC	1012.8 (-68.8)	785.5 (-75.8)	795.1 (-75.5)	146.7 (-95.5)	2585.5 (-20.3)	2341.2 (-27.8)	1368.1 (-57.8)	359.5 (-88.9)	2218.4 (-31.6)	1817.7 (-44.0)	1648.6 (-49.2)	729.2 (-77.5)	2220.6 (-31.5)	1405.1 (-56.7)	1317.6 (-59.4)	613.0 (-81.1)
175	MC	2287.2 (-29.5)	2157.9 (-33.5)	2415.5 (-25.5)	1844.7 (-43.1)	2797.4 (-13.8)	2928.5 (-9.7)	2604.1 (-19.7)	2994.8 (-7.7)	2877.4 (-11.3)	2117.8 (-34.7)	2611.3 (-19.5)	2248.6 (-30.7)	2468.1 (-23.9)	2299.4 (-29.1)	2489.9 (-23.2)	2223.6 (-31.5)
	EC	1039.5 (-68.0)	805.9 (-75.2)	819.1 (-74.8)	150.5 (-95.4)	2639.7 (-18.6)	2407.4 (-25.8)	1401.8 (-56.8)	367.5 (-88.7)	2278.3 (-29.8)	1885.4 (-41.9)	1690.6 (-47.9)	744.9 (-77.0)	2283.4 (-29.6)	1525.9 (-53.0)	1408.5 (-56.6)	626.9 (-80.7)
185	MC	2340.4 (-27.9)	2210.3 (-31.9)	2472.4 (-23.8)	1888.4 (-41.8)	2860.5 (-11.8)	2988.4 (-7.9)	2670.2 (-17.7)	3061.7 (-5.6)	2936.8 (-9.5)	2167.6 (-33.2)	2670.4 (-17.7)	2302.8 (-29.0)	2521.0 (-22.3)	2361.9 (-27.2)	2551.2 (-21.4)	2287.9 (-29.5)
	EC	1063.2 (-67.2)	825.4 (-74.6)	840.2 (-74.1)	154.2 (-95.2)	2677.8 (-17.5)	2461.4 (-24.1)	1445.3 (-55.4)	376.4 (-88.4)	2331.4 (-28.1)	1944.9 (-40.0)	1730.1 (-46.7)	759.6 (-76.6)	2404.7 (-25.9)	1568.1 (-51.7)	1449.7 (-55.3)	640.3 (-80.3)

*%deviation from baseline value

Table 4.163: Simulation of changes in maize yield (kg ha⁻¹) of PMH1 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Faridkot, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (5697.9 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	2859.4 (-49.8)*	2745.0 (-51.8)	3041.2 (-46.6)	2573.0 (-54.8)	3310.1 (-41.9)	3505.0 (-38.5)	3404.2 (-40.2)	3576.5 (-37.2)	3553.7 (-37.6)	2673.0 (-53.1)	3133.4 (-45.0)	2871.2 (-49.6)	3315.9 (-41.8)	3064.8 (-46.2)	3338.8 (-41.4)	2978.0 (-47.7)
	EC	2360.8 (-58.6)	666.7 (-88.3)	830.3 (-85.4)	334.2 (-94.1)	3373.7 (-40.8)	3230.5 (-43.3)	2565.6 (-55.0)	688.8 (-87.9)	3029.7 (-46.8)	2395.2 (-58.0)	2388.1 (-58.1)	683.8 (-88.0)	3257.8 (-42.8)	2442.2 (-57.1)	2373.9 (-58.3)	451.6 (-92.1)
75	MC	3279.9 (-42.4)	3157.1 (-44.6)	3503.2 (-38.5)	2962.8 (-48.0)	3817.6 (-33.0)	4029.7 (-29.3)	3911.4 (-31.3)	4116.7 (-27.8)	4073.9 (-28.5)	3093.0 (-45.7)	3606.1 (-36.7)	3306.5 (-42.0)	3830.0 (-32.8)	3518.3 (-38.2)	3828.9 (-32.8)	3425.7 (-39.9)
	EC	2726.0 (-52.2)	755.2 (-86.8)	949.0 (-83.3)	365.1 (-93.6)	3884.8 (-31.8)	3709.5 (-34.9)	2939.8 (-48.4)	786.3 (-86.2)	3476.2 (-39.0)	2756.7 (-51.6)	2753.0 (-51.7)	773.2 (-86.4)	3751.6 (-34.2)	2826.9 (-50.4)	2741.3 (-51.9)	515.9 (-91.0)
85	MC	3703.4 (-35.0)	3569.4 (-37.4)	3973.9 (-30.3)	3354.8 (-41.1)	4334.5 (-23.9)	4537.2 (-20.4)	4409.4 (-22.6)	4648.4 (-18.4)	4612.2 (-19.0)	3498.5 (-38.6)	4075.5 (-28.5)	3737.0 (-34.4)	4328.8 (-24.0)	3986.2 (-30.0)	4332.5 (-24.0)	3898.4 (-31.6)
	EC	3077.2 (-46.0)	829.9 (-85.4)	1054.9 (-81.5)	394.6 (-93.1)	4364.9 (-23.4)	4167.6 (-26.9)	3311.6 (-41.9)	877.3 (-84.6)	3946.7 (-30.7)	3098.4 (-45.6)	3088.7 (-45.8)	864.6 (-84.8)	4247.6 (-25.4)	3214.2 (-43.6)	3112.9 (-45.4)	574.1 (-89.9)
95	MC	3990.5 (-30.0)	3848.9 (-32.4)	4297.6 (-24.6)	3612.3 (-36.6)	4626.7 (-18.8)	4872.6 (-14.5)	4758.8 (-16.5)	5027.1 (-11.8)	4999.2 (-12.3)	3792.4 (-33.4)	4409.4 (-22.6)	4024.7 (-29.4)	4684.1 (-17.8)	4342.7 (-23.9)	4734.6 (-16.9)	4230.5 (-25.8)
	EC	3311.0 (-41.9)	885.8 (-84.4)	1129.5 (-80.2)	419.9 (-92.6)	4708.2 (-17.4)	4470.4 (-21.5)	3574.9 (-37.3)	944.0 (-83.4)	4268.5 (-25.1)	3335.2 (-41.5)	3326.0 (-41.6)	944.3 (-83.4)	4609.2 (-19.1)	3467.4 (-39.1)	3367.2 (-40.9)	619.9 (-89.1)
105	MC	4357.1 (-23.5)	4196.9 (-26.3)	4673.6 (-18.0)	3937.2 (-36.6)	5018.3 (-11.9)	5289.2 (-7.2)	5176.4 (-9.1)	5380.6 (-5.6)	5439.8 (-4.5)	4124.4 (-27.6)	4797.9 (-15.8)	4370.2 (-23.3)	5090.7 (-10.7)	4726.3 (-17.0)	5147.0 (-9.7)	4593.9 (-19.4)
	EC	3590.8 (-37.0)	957.0 (-83.2)	1226.5 (-78.5)	449.2 (-92.1)	5115.3 (-0.2)	4878.2 (-14.4)	3892.1 (-31.7)	1027.9 (-82.0)	4653.8 (-18.3)	3655.5 (-35.9)	3631.2 (-36.3)	1015.5 (-82.2)	5020.6 (-11.9)	3788.9 (-33.5)	3676.4 (-35.5)	680.0 (-88.1)
115	MC	4717.3 (-17.2)	4545.0 (-20.2)	5048.7 (-11.4)	4266.0 (-25.1)	5471.3 (-4.0)	5707.1 (+0.2)	5584.7 (-2.0)	5807.1 (+1.9)	5826.1 (+2.2)	4444.8 (-22.0)	5186.0 (-9.0)	4740.6 (-16.8)	5489.0 (-3.7)	5116.8 (-10.2)	5584.9 (-2.0)	4967.7 (-2.8)
	EC	3912.6 (-31.3)	1032.9 (-81.9)	1330.9 (-76.6)	476.6 (-91.6)	5543.3 (-2.7)	5237.9 (-8.1)	4187.6 (-26.5)	1117.8 (-80.4)	5030.1 (-11.7)	4041.4 (-29.1)	3931.6 (-31.0)	1068.2 (-81.2)	5415.2 (-5.0)	4107.0 (-27.9)	3988.9 (-30.0)	740.3 (-87.0)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (5697.9 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	5360.2 (-5.9)	5202.6 (-8.7)	5736.1 (+0.7)	4892.2 (-14.1)	6304.2 (+10.6)	6443.2 (+13.1)	6283.6 (+10.3)	6406.2 (+12.4)	6516.7 (+14.4)	5049.0 (-11.4)	5875.2 (+3.1)	5403.0 (-5.2)	6214.4 (+9.1)	5794.7 (+1.7)	6254.9 (+9.8)	5646.2 (-0.9)
	EC	4459.7 (-21.7)	1172.5 (-79.4)	1519.8 (-73.3)	505.2 (-91.1)	6373.6 (+11.9)	5948.4 (+4.4)	4729.0 (-17.0)	1259.7 (-77.9)	5733.8 (+0.6)	4692.7 (-17.6)	4513.3 (-20.8)	1128.8 (-80.2)	6132.8 (+7.6)	4714.2 (-17.3)	4577.2 (-19.7)	829.7 (-85.4)
145	MC	5816.7 (+2.1)	5607.1 (-1.6)	6175.8 (+8.4)	5271.2 (-7.5)	6781.6 (+19.0)	6797.7 (+19.3)	6591.4 (+15.7)	6780.1 (+19.0)	6879.2 (+20.7)	5395.4 (-5.3)	6264.7 (+10.0)	5822.2 (+2.2)	6578.8 (+15.5)	6204.4 (+8.9)	6581.4 (-15.5)	6031.5 (+5.9)
	EC	4791.6 (-15.9)	1214.2 (-78.7)	1603.1 (-71.9)	514.3 (-91.0)	6750.2 (+18.5)	6338.8 (+11.2)	5048.3 (-11.4)	1320.9 (-76.8)	6121.8 (+7.4)	4893.6 (-14.1)	4803.0 (-25.7)	1148.0 (-79.9)	6564.0 (+15.2)	5067.0 (-11.1)	4537.2 (-20.4)	856.4 (-85.0)
155	MC	6095.9 (+7.0)	5895.7 (+3.5)	6473.4 (+13.6)	5516.1 (-3.2)	7123.8 (+25.0)	7099.4 (+24.6)	6894.6 (+21.0)	7047.6 (+23.7)	7202.9 (+26.4)	5669.1 (-0.5)	6592.3 (+15.7)	6117.6 (+7.4)	6801.5 (+19.4)	6520.5 (+14.4)	6919.2 (+21.4)	6332.1 (+11.1)
	EC	5034.8 (-11.6)	1240.1 (-78.2)	1647.2 (-71.1)	521.7 (-90.8)	6950.8 (+22.0)	6635.9 (+16.5)	5309.1 (-6.8)	1350.4 (-76.3)	6429.7 (+12.8)	4992.9 (-12.4)	4956.4 (-13.0)	1161.9 (-79.6)	6844.5 (+20.1)	5369.7 (-5.8)	5201.3 (-8.7)	874.2 (-84.7)
165	MC	6354.7 (+11.5)	6150.2 (+7.9)	6788.8 (+19.1)	5745.7 (+0.8)	7306.7 (+28.2)	7256.5 (+27.3)	7169.0 (+25.8)	7308.2 (+28.3)	7507.4 (+31.8)	5990.6 (+5.1)	6908.0 (+21.2)	6367.2 (+11.8)	7166.8 (+25.8)	6866.8 (+20.5)	7230.0 (+26.9)	6644.6 (+16.6)
	EC	5234.5 (-8.1)	1265.7 (-77.8)	1683.0 (-70.5)	527.3 (-90.8)	7150.6 (+25.5)	6966.9 (+22.3)	5478.2 (-3.9)	1378.7 (-75.8)	6742.5 (+18.3)	5106.5 (-10.4)	5105.3 (-10.4)	1170.5 (-79.5)	7057.6 (+23.9)	5542.8 (-2.7)	5393.5 (-5.3)	890.9 (-84.4)
175	MC	6496.2 (+14.0)	6303.4 (+10.6)	6972.8 (+22.4)	5877.2 (+3.1)	7477.7 (+31.2)	7514.1 (+31.9)	7395.8 (-29.8)	7548.3 (+32.5)	7769.0 (+36.3)	6147.2 (+7.9)	7079.0 (+24.2)	6519.3 (+14.4)	7401.5 (+29.9)	7082.1 (+24.3)	7460.5 (+30.9)	6853.6 (+20.3)
	EC	5352.4 (-6.1)	1290.0 (-77.4)	1718.3 (-69.8)	530.7 (-90.7)	7272.4 (+27.6)	7132.5 (+25.2)	5576.2 (-2.1)	1406.2 (-75.3)	6899.0 (+21.1)	5216.5 (-8.4)	5226.3 (-8.3)	1175.1 (-79.4)	7317.1 (+28.4)	5669.5 (-0.5)	5520.6 (-3.1)	904.8 (-84.1)
185	MC	6616.7 (+16.1)	6563.3 (-15.2)	7088.0 (+24.4)	5979.7 (+5.0)	7624.4 (+33.8)	7779.2 (+36.5)	7619.8 (-33.7)	7740.9 (+35.9)	7977.2 (+40.0)	6257.6 (+9.8)	7243.4 (+27.1)	6638.8 (+16.5)	7533.7 (+32.2)	7229.7 (+26.9)	7649.6 (+34.2)	6992.8 (+22.7)
	EC	5445.7 (-4.4)	1329.6 (-76.7)	1747.4 (-69.3)	533.0 (-90.7)	7340.4 (+28.8)	7265.5 (+27.5)	5674.8 (-0.4)	1428.2 (-74.9)	7044.6 (+23.6)	5303.4 (-6.9)	5330.8 (-6.4)	1177.9 (-79.3)	7494.7 (+31.5)	5771.0 (+1.3)	5621.3 (-1.3)	915.0 (-83.7)

*%deviation from baseline value

Table 4.164: Simulation of changes in maize yield (kg ha⁻¹) of PMH2 variety by different models during 21st century (MC: Mid-century and EC: End-century) under optimized Nitrogen doses at Faridkot, Punjab

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (6242.9 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
65	MC	2840.4 (-54.5)*	2769.0 (-55.7)	2972.1 (-52.4)	2702.1 (-56.7)	3075.1 (-50.7)	3483.2 (-44.2)	3421.4 (-45.2)	3604.5 (-42.3)	3454.2 (-44.7)	2681.2 (-57.0)	3161.3 (-49.4)	2892.1 (-53.7)	3364.0 (-46.1)	2993.7 (-52.0)	3326.2 (-46.7)	2955.3 (-52.7)
	EC	2450.2 (-60.8)	1050.9 (-83.2)	1231.7 (-80.3)	448.5 (-92.8)	3156.4 (-49.4)	3002.9 (-51.9)	2552.9 (-59.1)	992.5 (-84.1)	2956.4 (-52.6)	2413.5 (-61.3)	2654.3 (-57.5)	1116.2 (-82.1)	3131.6 (-49.8)	2630.5 (-57.9)	2518.6 (-59.7)	765.0 (-87.8)
75	MC	3268.6 (-47.6)	3193.2 (-48.9)	3430.7 (-45.0)	3110.0 (-50.2)	3519.2 (-43.6)	4015.3 (-35.7)	3941.9 (-36.9)	4157.7 (-33.4)	3983.8 (-36.2)	3097.4 (-50.4)	3635.9 (-41.8)	3331.9 (-46.6)	3870.3 (-38.0)	3451.4 (-44.7)	3832.6 (-38.6)	3410.6 (-45.4)
	EC	2823.1 (-54.8)	1196.5 (-80.8)	1408.5 (-77.4)	497.2 (-92.0)	3624.8 (-41.9)	3462.5 (-44.5)	2939.2 (-52.9)	1116.1 (-82.1)	3411.1 (-45.4)	2781.9 (-55.4)	3052.8 (-51.1)	1256.6 (-79.9)	3606.4 (-42.2)	3030.5 (-51.5)	2908.4 (-53.4)	879.1 (-85.9)
85	MC	3697.8 (-40.8)	3617.2 (-42.1)	3890.7 (-37.7)	3513.2 (-43.7)	3974.9 (-36.3)	4562.8 (-26.9)	4480.5 (-28.2)	4726.2 (-24.3)	4528.4 (-27.5)	3519.4 (-43.6)	4127.3 (-33.9)	3778.7 (-39.5)	4399.2 (-29.5)	3929.7 (-37.0)	4361.3 (-30.1)	3872.8 (-38.0)
	EC	3194.0 (-48.8)	1320.5 (-78.9)	1560.0 (-75.0)	544.0 (-91.3)	4091.1 (-34.5)	3937.9 (-36.9)	3335.8 (-46.6)	1229.2 (-80.3)	3871.6 (-38.0)	3139.9 (-49.7)	3430.0 (-45.1)	1350.7 (-78.4)	4108.4 (-34.2)	3410.1 (-45.4)	3282.5 (-47.4)	983.6 (-84.2)
95	MC	4001.7 (-35.9)	3920.6 (-37.2)	4234.9 (-32.2)	3799.2 (-39.1)	4275.7 (-31.5)	4977.8 (-20.3)	4896.7 (-21.6)	5170.1 (-17.2)	4945.2 (-20.8)	3827.4 (-38.7)	4485.2 (-28.1)	4099.5 (-34.3)	4796.8 (-23.2)	4286.4 (-31.3)	4755.7 (-23.8)	4203.5 (-32.7)
	EC	3451.0 (-44.7)	1418.3 (-77.3)	1676.7 (-73.1)	581.7 (-90.7)	4403.0 (-29.5)	4290.6 (-31.3)	3625.2 (-41.9)	1320.3 (-78.9)	4214.8 (-32.5)	3367.5 (-46.1)	3703.5 (-40.7)	1422.6 (-77.2)	4480.4 (-28.2)	3650.7 (-41.5)	3525.3 (-43.5)	1064.2 (-83.0)
105	MC	4382.5 (-29.8)	4294.2 (-31.2)	4649.7 (-25.5)	4148.9 (-33.5)	4670.9 (-25.2)	5479.5 (-12.2)	5395.0 (-13.6)	5696.5 (-8.8)	5452.5 (-12.7)	4201.1 (-32.7)	4916.6 (-21.2)	4478.0 (-28.3)	5278.7 (-15.4)	4725.4 (-24.3)	5249.4 (-15.9)	4612.3 (-26.1)
	EC	3770.6 (-39.6)	1543.5 (-75.3)	1825.7 (-70.8)	608.3 (-90.3)	4773.8 (-23.5)	4730.7 (-24.2)	3960.1 (-36.6)	1432.9 (-77.0)	4634.8 (-25.8)	3680.6 (-41.0)	4038.8 (-35.3)	1473.8 (-76.4)	4942.5 (-20.8)	3984.1 (-36.2)	3855.4 (-38.2)	1150.5 (-81.6)
115	MC	4733.7 (-24.2)	4644.2 (-25.6)	5026.6 (-19.5)	4494.8 (-28.0)	5121.5 (-18.0)	5941.9 (-4.8)	5841.4 (-6.4)	6174.3 (-1.1)	5900.5 (-5.5)	4544.6 (-27.2)	5324.4 (-14.7)	4853.6 (-22.2)	5722.6 (-8.3)	5122.7 (-17.9)	5688.1 (-8.9)	5005.7 (-19.8)
	EC	4081.0 (-34.6)	1678.9 (-73.1)	1984.8 (-68.2)	620.9 (-90.0)	5171.0 (-17.2)	5138.0 (-17.7)	4271.3 (-31.6)	1536.6 (-75.4)	5010.0 (-19.8)	4025.1 (-35.5)	4384.9 (-29.8)	1505.7 (-75.9)	5361.2 (-14.1)	4346.9 (-30.4)	4207.8 (-32.6)	1219.9 (-80.5)

Nitrogen Application (kg ha ⁻¹)	Time period	BASELINE: 4-June (6242.9 kg ha ⁻¹)															
		CSIRO-Mk-3-6-0				FIO-ESM				IPSL-CM5A-MR				Ensemble			
		RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5	RCP2.6	RCP4.5	RCP6.0	RCP8.5
135	MC	5392.0 (-13.6)	5317.7 (-14.8)	5696.0 (-8.8)	5143.9 (-17.6)	5925.2 (-5.1)	6763.5 (+8.3)	6638.6 (+6.3)	7013.3 (+12.3)	6682.3 (+7.0)	5154.5 (-17.4)	6020.7 (-3.6)	5518.0 (-11.6)	6464.2 (+3.6)	5779.3 (-7.43)	6408.5 (+2.7)	5686.2 (-8.9)
	EC	4627.6 (-25.9)	1815.2 (-70.9)	2198.1 (-64.8)	637.0 (-89.8)	5935.9 (-4.9)	5846.3 (-6.3)	4812.3 (-22.9)	1669.9 (-73.2)	5697.3 (-8.7)	4786.6 (-23.3)	4945.7 (-20.8)	1543.6 (-75.3)	6029.5 (-3.4)	5020.0 (-19.6)	4869.4 (-22.0)	1296.9 (-79.2)
145	MC	5783.9 (-7.3)	5716.5 (-8.4)	6100.4 (-2.3)	5456.0 (-12.6)	6396.2 (+2.5)	7223.8 (-15.7)	7071.6 (+13.3)	7465.2 (+19.6)	7134.7 (+14.3)	5508.3 (-11.8)	6443.7 (+3.2)	5911.5 (-5.3)	6897.1 (+10.5)	6171.9 (-1.1)	6833.7 (+9.5)	6104.5 (-2.2)
	EC	4945.4 (-20.8)	1847.7 (-70.4)	2252.3 (-63.9)	643.0 (-89.7)	6408.8 (+2.7)	6232.3 (-0.2)	5114.6 (-18.1)	1697.8 (-72.8)	6111.4 (-2.1)	5066.8 (-18.8)	5181.4 (-17.0)	1554.5 (-75.1)	6452.6 (+3.4)	5392.6 (-13.6)	5205.1 (-16.6)	1316.9 (-78.9)
155	MC	6177.4 (-1.0)	6027.6 (-3.4)	6443.4 (+3.2)	5736.7 (-8.1)	6773.8 (+8.5)	7548.6 (+20.9)	7379.7 (+18.2)	7808.9 (+25.1)	7469.3 (+19.6)	5762.1 (-7.7)	6759.5 (+8.3)	5911.5 (-5.3)	7192.4 (+15.2)	6484.4 (+3.9)	7134.5 (+14.3)	6398.2 (+2.5)
	EC	5258.8 (-15.8)	1878.8 (-69.9)	2297.2 (-63.2)	648.4 (-89.6)	6734.7 (+7.9)	6501.6 (+4.1)	5356.7 (-14.2)	1723.3 (-72.4)	6440.1 (+3.2)	5228.5 (-16.2)	5349.7 (-14.3)	1554.5 (-75.1)	6739.0 (+8.0)	5524.6 (-11.5)	5354.8 (-14.2)	1335.2 (-78.6)
165	MC	6532.1 (+4.6)	6338.2 (+1.5)	6872.7 (+10.1)	6012.4 (-3.7)	7057.6 (+13.0)	8010.8 (+28.3)	7801.5 (+25.0)	8127.6 (+30.2)	7866.9 (+26.0)	6141.8 (-1.6)	7187.7 (+15.1)	6545.2 (+4.8)	7610.0 (+21.9)	6918.9 (+10.8)	7634.1 (+22.3)	6742.6 (+8.0)
	EC	5498.3 (-11.9)	1901.7 (-69.5)	2337.0 (-62.6)	651.5 (-89.6)	6879.8 (+10.2)	6894.4 (+10.4)	5662.4 (-9.3)	1745.2 (-72.0)	6849.5 (+9.7)	5390.8 (-13.7)	5459.7 (-12.5)	1570.4 (-74.9)	7167.6 (+14.8)	5665.1 (-9.2)	5487.2 (-12.1)	1347.8 (-78.4)
175	MC	6690.0 (+7.2)	6536.8 (+4.7)	7158.7 (+14.7)	6164.3 (-1.3)	7242.9 (+16.0)	8341.8 (+33.6)	8183.7 (+31.1)	8425.2 (+35.0)	8272.9 (+32.5)	6381.9 (+2.2)	7517.7 (+20.4)	6731.7 (+7.8)	8056.1 (+29.0)	7345.4 (+17.7)	8033.7 (+28.7)	7053.2 (+13.0)
	EC	5604.4 (-10.2)	1920.5 (-69.2)	2370.0 (-62.0)	653.7 (-89.5)	7016.2 (+12.4)	7154.5 (+14.6)	5801.2 (-7.1)	1767.8 (-71.7)	7139.6 (+14.4)	5511.4 (-11.7)	5542.8 (-11.2)	1574.5 (-74.8)	7626.1 (+22.2)	5784.6 (-7.3)	5613.7 (-10.1)	1356.7 (-78.3)
185	MC	6823.5 (+9.3)	6665.9 (+6.8)	7293.1 (+16.8)	6286.3 (+0.7)	7365.3 (+18.0)	8468.5 (+35.7)	8378.7 (+34.2)	8585.8 (+37.5)	8501.4 (+36.2)	6502.4 (+4.2)	7697.3 (+23.3)	6862.7 (+9.9)	8288.2 (+32.8)	7516.5 (+20.4)	8240.9 (+32.0)	7214.1 (+15.6)
	EC	5691.0 (-8.8)	1935.9 (-69.0)	2394.2 (-61.7)	656.2 (-89.5)	7157.9 (+14.7)	7248.9 (+16.1)	5896.9 (-5.5)	1786.0 (-71.4)	7280.9 (+16.6)	5592.7 (-10.4)	5612.4 (-10.1)	1577.4 (-74.7)	7856.7 (+25.9)	5899.8 (-5.5)	5714.0 (-8.5)	1364.9 (-78.1)

*%deviation from baseline value

CHAPTER V

SUMMARY

Climate change, a long occurring phenomenon has now become the biggest developmental challenge and its impact is unavoidable. The addition of GHGs to the atmosphere has degraded its quality and the rising temperatures are ultimately affecting the crop production. Maize being a major cereal crop requires attention under these changing conditions. The mitigation of climate change is only possible through suitable adaptation measures which if followed in future can save the crops (Tao and Zhang 2010). The negative impact of climate change is avoidable through adaptation measures like changing sowing dates, adjusting the nutrient and irrigation management and breeding new cultivars. Several GCMs provide data on meteorological parameters (temperature and precipitation) which can be used in the crop models for projecting changes in yield in future and how the changes in management practices can help in avoiding the adverse impact on yield and phenology of the crop. Punjab state is a major food grain producing state of India and so there is a need to study the impact of climate change on maize crop under future conditions. So, the present study entitled **“OPTIMIZING PRODUCTIVITY OF MAIZE UNDER EMISSION BASED CLIMATE SCENARIOS BY MID AND END OF 21ST CENTURY IN PUNJAB”** was carried out in the department of Climate Change and Agricultural Meteorology, Punjab Agricultural University, Ludhiana with the following objectives:

- To generate downscaled future climatic scenarios upto end 21st century in Punjab.
- To predict the changes in growth duration and yield of maize by the mid and end 21st century in Punjab.
- To evaluate the management practices in maize under changing climatic scenarios in Punjab.

The DSSAT CERES-Maize (v.4.7.5) model was calibrated and validated for the crop data collected on maize cultivars (cv PMH1 and PMH2) under the mandatory trial of the “All India Co-ordinated Research Project on Agrometeorology” operational in the Department of Climate Change and Agricultural Meteorology and further used to study the changes in yield and phenology. The four GCMs (CSIRO-Mk-3-6-0, FIO-ESM, IPSL-CM5A-MR and Ensemble model) output was downscaled and bias corrected by methodology reported by Kaur (2020) and were used to analyse the deviation of the maize yield and phenology at different agroclimatic zones of Punjab under the current as well as future conditions. The model used the GCMs output to simulate yield and phenology under optimized practices like shift in sowing dates and adjustment of the nitrogen doses at different zones of Punjab. The salient findings of the study are:

- The CERES-Maize model was sensitized towards the cultivar specific parameters for PMH1 and PMH2 and both mathematical and graphical approach showed that P5 was most sensitive to the grain yield
- The validation results showed the model to be in close agreement with the observed crop parameters with low NRMSE (%) for both the cultivars PMH1 (1, 0.8, 3, 11.7) PMH2 (0.9, 0.7, 2, 9) for anthesis, maturity, grain yield and LAI, respectively.
- The NRMSE showed good fit for LAI but with low model efficiency (-0.5 and 0) for PMH1 and PMH2, respectively.
- The yield and LAI showed a polynomial relationship with the date of sowing with high grain yield peaks/ LAI during 20 May to 7 June as 5200-6000 kg ha⁻¹/ 2.9-3.2 and 4200-5400 kg ha⁻¹/ 2.8-3.0 respectively for varieties PMH1 and PMH2.
- The deviation for the yield and HI varied between +14.36% to -18.28% and +20.40% to -15.05% respectively for PMH1 and the depreciation of grain yield and HI, respectively for PMH1 occurred after 9th June (-0.31%, -2.31%) and continued to depreciate till 30th June (-14.47%, -13.44%).
- The variety PMH2 showed a deviation of +19.75% to -21.66% and +14.71% to -11.20% for grain yield and HI respectively while for PMH2 a continuous decrease in grain yield and HI, respectively was observed after 12th June (-6.49%, -0.13%) till 30th June (-15.48%, -10.93%) while a sharp increase was detected after 20th May (-21.66%, -10.39%).
- Maize yield trend as per model projections at agroclimatic zone II
 - As per CSIRO-Mk-3-6-0 projections, the yield decline for the cultivar PMH1 ranged between -6.01 kg ha⁻¹ to -95.26 kg ha⁻¹ and for PMH2 between -4.68 kg ha⁻¹ to -59.20 kg ha⁻¹.
 - The FIO-ESM model simulated an increase in yield for PMH1 and PMH2 under RCP2.6 for all the four dates of sowing with fairly weak coefficient of determination. Under other three scenarios the yield decline ranged -2.03 kg ha⁻¹ to -84.61 kg ha⁻¹ and -2.47 kg ha⁻¹ to -75.55 kg ha⁻¹ for PMH1 and PMH2, respectively.
 - The IPSL-CM5A-MR model simulated reduction in yield ranging -1.60 kg ha⁻¹ to -70.40 kg ha⁻¹ and -7.81 kg ha⁻¹ to -54.86 kg ha⁻¹ for PMH1 and PMH2, respectively.
 - The projected yield trend for PMH1 by Ensemble model under RCP 2.6 indicated a slight increase on 6th June (+0.72 kg ha⁻¹) and 15th June (+3.00 kg ha⁻¹) and the range for yield decline was obtained between -2.32 kg ha⁻¹ to 61.92 kg ha⁻¹ and -1.72 kg ha⁻¹ to -61.99 kg ha⁻¹ for PMH1 and PMH2, respectively.

- Maize yield trend as per model projections at agroclimatic zone III
 - The CSIRO-Mk-3-6-0 model projected yield decline in the range -9.17 kg ha⁻¹ to -50.56 kg ha⁻¹ and -11.85 kg ha⁻¹ to -50.63 kg ha⁻¹ at Ludhiana, -0.13 kg ha⁻¹ to -103.39 kg ha⁻¹ and -1.2 kg ha⁻¹ to -81.31 kg ha⁻¹ at Amritsar and -16.7 kg ha⁻¹ to -114.4 kg ha⁻¹ and -12.1 kg ha⁻¹ to -86.4 kg ha⁻¹ at Patiala for PMH1 and PMH2, respectively.
 - The FIO-ESM model simulated slight increase in yield while the decline was ranging -7.36 kg ha⁻¹ to -74.46 kg ha⁻¹ and -1.54 kg ha⁻¹ to -57.83 kg ha⁻¹ at Ludhiana, -0.93 kg ha⁻¹ to -82.83 kg ha⁻¹ at Amritsar, 6.3 kg ha⁻¹ to -89.3 kg ha⁻¹ and -0.7 kg ha⁻¹ to -77.1 kg ha⁻¹ at Patiala for PMH1 and PMH2, respectively.
 - The IPSL-CM5A-MR model projected yield decline ranged between -5.97 kg ha⁻¹ to -84.62 kg ha⁻¹ and -2.69 kg ha⁻¹ to -65.77 kg ha⁻¹ at Ludhiana, -8.51 kg ha⁻¹ to -93.87 kg ha⁻¹ and -2.01 kg ha⁻¹ to -71.80 kg ha⁻¹ at Amritsar, -2.0 kg ha⁻¹ to -104.8 kg ha⁻¹ and -5.8 to -84.0 kg ha⁻¹ at Patiala for PMH1 and PMH2, respectively.
 - The Ensemble model projected the yield decline ranging -0.89 kg ha⁻¹ to -67.43 kg ha⁻¹ and -2.78 to 54.05 at Ludhiana, -0.94 kg ha⁻¹ to -78.79 kg ha⁻¹ and -3.41 kg ha⁻¹ to -54.88 kg ha⁻¹ at Amritsar, -9.7 kg ha⁻¹ to 89.4 kg ha⁻¹ and -5.8 kg ha⁻¹ to 84.0 kg ha⁻¹ at Patiala for PMH1 and PMH2, respectively.
- Maize yield trend as per model projections at agroclimatic zone IV
 - The CSIRO-Mk-3-6-0 model simulated yield decrease in the range -8.7 to -47.3 kg ha⁻¹ and -4.7 to -38.2 kg ha⁻¹ while FIO-ESM model projected this decline in the range -1.33 to -47.17 kg ha⁻¹ and -1.0 to -35.1 kg ha⁻¹ for PMH1 and PMH2, respectively.
 - The IPSL-CM5A-MR model projected yield decline ranging -1.6 to -25.6 kg ha⁻¹ and -1.2 to -29.2 kg ha⁻¹ and Ensemble model projected the decline in the range -0.2 to -21.0 kg ha⁻¹ and 0 to -28.5 kg ha⁻¹ for PMH1 and PMH2, respectively.
- Maize yield trend as per model projections at agroclimatic zone V
 - The CSIRO-Mk-3-6-0 model projected the yield decline in the range -3.13 to -97.00 kg ha⁻¹ and -9.8 to 92.1 kg ha⁻¹ while FIO-ESM model projected the decrease range -0.2 to -88.5 kg ha⁻¹ and -1.38 to -86.01 kg ha⁻¹, respectively for PMH1 and PMH2.
 - The IPSL-CM5A-MR model predicted the yield decrease in the range -3.54 to -79.92 kg ha⁻¹ and -1.55 to -72.74 kg ha⁻¹ while Ensemble model observed a decline in the range -9.30 to -96.49 kg ha⁻¹ and -2.7 kg ha⁻¹ to -91.3 kg ha⁻¹ for PMH1 and PMH2, respectively.
- Changes in phenological stages of maize as projected in agroclimatic zones of Punjab
 - At agroclimatic zone II the model predicted shortening of anthesis by 2-4 days and 2-6 days and maturity by 5-8 days and 5-25 days for PMH1 and by 2-5 days and 2-7 days

for anthesis and by 1-6 days and 5-25 days for maturity for PMH2 during mid and end-century, respectively.

- Agroclimatic zone III observed the shortening within the range of 0-5 days and 2-7 days for the anthesis and for maturity within the range 0-4 days and 3-25 days for PMH1 respectively during mid and end-century while PMH2 observed the shortening 1-2 days and 2-5 days for anthesis and 1-4 days and 3-25 days for maturity during respective centuries.
 - At agroclimatic zone IV the model predicted shortening of anthesis within the range 1-4 days and 1-5 days while maturity within the range 2-6 days and 4-25 days for PMH1 during mid and end-century and within the range of 0-3 days and 1-5 days for anthesis ; 0-4 days and 3-25days for maturity during respective centuries for PMH2.
 - At agroclimatic zone V the models projected the anthesis stage to shorten within the range 0-3 days and 1-5 days and maturity within the range 2-5 and 4-25 days for PMH1 and 0-4 and 1-4 days ; 0-4 and 1-25 days for PMH2 during mid and end-century, respectively.
- The optimized sowing dates for agroclimatic zone II :
- CSIRO-Mk-3-6-0 predicted the increase in the range 1.1% to 18.6% during mid and end-century for PMH1 on 14th and 19th June and 2.6 % to 10.1% during mid-century for PMH2.
 - FIO-ESM predicted the increase in the range 1.7% to 40.1% from 9th to 24th June under all the four RCPs during the mid-century for PMH1 and 10.7% to 38.7% under RCP2.6 and RCP4.5 on 9th to 29th June and 4th to 14th July during the end-century while PMH2 observed a slight increase ranging 1.9% to 26.7% during the mid-century for 25th May to 24th June under all the four RCPs and 11.9% to 39.7% under RCP2.6 for the respective dates of sowing.
 - The IPSL-CM5A-MR projected the increase ranging 4.0% to 24.6% during the mid-century under all the four RCPs for 14th to 24th June and the end-century observed the increase ranging 0.9% to 6.8% under RCP2.6 on the same dates for PMH1 while PMH2 observed the yield increase under RCP2.6 for the dates 14th June (1.7%), and 19th June (18.1%) during mid-century.
 - The Ensemble model projected a significant increase on 14th and 19th June ranging 2.4% to 17.5% during the mid-century and 7.9% to 12.5% during the end-century for PMH1 and slight increase on 19th June for PMH2.
 - The anthesis under the optimized sowing dates shortened in the range 2-8 days and 3-9 days during mid and end-century while maturity shortened by 5-13 days during mid-

century and 4-25 days during the end-century for all the four RCPs for PMH1 while PMH2 observed the shortening in the range 2-6 days and 3-9 days for anthesis and by 4-10 days and 8-30 days for maturity during the mid and end-century, respectively.

- The optimized sowing dates for agroclimatic zone III
 - CSIRO-Mk-3-6-0 predicted no increase in yield at any dates of sowing for both the cultivars.
 - FIO-ESM predicted the increase within 11.9% to 65.8% at Ludhiana, 3.2% to 13.0% at Amritsar and 13.5% to 22.4% at Patiala significantly on 14th and 19th June under all RCPs for PMH1 and 4.2% to 54.1% under RCP6.0 at Ludhiana from 14th June to 4th July and 0.9% to 63% under all the RCPs at Patiala on 14th and 19th June.
 - The IPSL-CM5A-MR projected the increase in the range 16.3% to 24.9% at Ludhiana; 4.6% at Amritsar and 4.3 to 19.3% at Patiala on 14th and 19th June during mid and end-century for PMH1 and 15.8% to 25.5% at Ludhiana on 19th and 24th June during mid-century for PMH2.
 - The Ensemble model projected the significant increase from 14th-29th June in the range 2.6% to 53.9% at Ludhiana and 39.1% to 53.9% at Patiala for PMH1 and from 19th to 29th June at Ludhiana under RCP4.5 and RCP6.0 ranging 2.9% to 40.9% during the mid-century for PMH2.
 - The PMH2 cultivar did not show any significant increment under any of the scenarios and sowing dates during any of the centuries at Amritsar and Patiala.
 - The models projected the shortening of anthesis by <7days and maturity by <25days for both the centuries and cultivar but Amritsar and Patiala observed the shortening by lesser days than Ludhiana during the end-century.
- The optimized sowing dates for agroclimatic zone IV observed no increase in yield under any of the scenarios and sowing dates while the anthesis was projected to shorten by 2-3 days and 4-5 days and maturity by 4-7 days and 5-25, respectively during mid and end-century for both the cultivars.
- The optimized sowing dates for agroclimatic zone V
 - CSIRO-Mk-3-6-0 model observed the yield to increase significantly on 10th, 15th and 25th May ranging 1.2% to 23.8% under the four scenarios for PMH1 and on 10th, 15th and 30th May ranging 0.2% to 12.6% under the four scenarios during the mid-century for PMH2.
 - FIO-ESM predicted the increase ranging 3.5% to 27.7% during the mid-century and 1.9% to 22.0% during the end-century for PMH1 from 5th May to 30th May and 3.9% to 16.5% during the mid-century and 1.2% to 4.2% during the end-century for PMH-2 on 10th, 15th and 30th May under the four RCPs.

- The IPSL-CM5A-MR projected the increase from 5th to 30th May within 1.5% to 28.2% during the mid-century for all the scenarios and within 5.4% to 17.0% under RCP2.6 during the end-century for PMH1 and 1.6% to 15.7% during mid-century for PMH2.
- The Ensemble model projected the significant increase from 5th-30th May in the range 5.1% to 28.2% for PMH1 and 1.6% to 16.3% for PMH2 during the mid-century.
- The models projected the shortening of anthesis by <5days and maturity by <25days for both the centuries and cultivar.
- The optimized nitrogen doses for agroclimatic zone II
 - At zone II for PMH1 cultivar the CSIRO-Mk-3-6-0 model didn't give good results but the other three models observed yield increment upto 62% and 35% during mid-century and upto 59% and 8% during the end-century under RCP2.6 and RCP4.5, respectively while RCP8.5 projected a yield decline upto 80%.
 - The PMH2 cultivar observed a yield decline upto 4.9% during mid-century; 7.8% and 12.5% during end-century under RCP2.6 and RCP4.5, respectively while under RCP6.0 and RCP8.5, the Ensemble model projected the yield decline upto 2.5% during the mid-century and 17.5%; 72.2%, respectively during the end-century.
- The optimized nitrogen doses for agroclimatic zone III
 - At Ludhiana the CSIRO-Mk-3-6-0 model projected yield decline under all the scenarios while Ensemble model projected yield increase for PMH1/PMH2 upto 22%/50%, 56%/67% during mid-century and upto 11%/34%, 36%/50% during end-century under RCP2.6, RCP4.5, respectively while under RCP8.5 the cultivar observed a yield decline upto 34%/7% and 95% /89% during the respective centuries at higher doses of nitrogen.
 - At Amritsar the CSIRO-Mk-3-6-0 gave same response as Ludhiana and the other models too predicted yield decline under all the scenarios for PMH1/PMH2 upto 20%/13%, 10%/19%, 2%/11% and 11%/21% during mid-century and upto 30%/16%, 34%/35%, 36%/39% and 83%/77% during end-century under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively.
 - At Patiala the CSIRO-Mk-3-6-0 model predicted yield decline under all the scenarios while the Ensemble model predicted yield increment at higher doses upto 7% during mid-century under RCP2.6 and yield decline for PMH1/PMH2 upto 3%/3%, 3%/4%, 1%/1% and 9%/9% during mid-century ; 1%/3% , 22%/16%, 24%/20% and 80%/73% during end-century under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively.
- The optimized nitrogen doses for agroclimatic zone IV
 - The zone observed yield decline for PMH1 under all the four scenarios and Ensemble projected the decline as 11%/15%, 13%/30%, 8%/44% and 18%/87% during mid/end-century under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively.

- The Ensemble model projected the yield decline for PMH2 upto 20%/26%, 21%/32%, 19%/45% and 25%/85% during mid/end-century under RCP2.6, RCP4.5, RCP6.0 and RCP8.5, respectively.
- The optimized nitrogen doses for agroclimatic zone V
 - The PMH1 cultivar performed well with increased nitrogen doses at Faridkot during the mid-century, the Ensemble model projected yield increase within 32%/31%, 27%/1% under RCP2.6, RCP4.5, respectively while increase upto 32%/23% during mid-century and decrease upto 1.3%/84% during end-century was observed under RCP2.6/RCP8.5, respectively.
 - The PMH2 cultivar was projected to increase upto 20%/32%/15.5% during mid-century and decrease upto 5%/9%/78% during end-century was observed under RCP4.5, RCP6.0, RCP8.5.

Conclusions:

1. 20th May -7th June is the appropriate sowing window of maize in Punjab for the cultivars PMH1 and PMH2.
2. The deviations of the maize yield from the baseline showed a significant yield decrease under RCP8.5 during the end-century when temperatures are projected to increase at higher rate.
3. The anthesis and maturity days are projected to shorten from the baseline period thus impacting the maize yield.
4. The optimizing practice of shifting the sowing dates observed late sowing for both the cultivars to give significant yield increase at all the agroclimatic zones except zone V (Faridkot) where early sowing was found to perform well under future scenarios.
5. The optimization of nitrogen doses depicted yield increase (11-30%) with the increase in N-doses (145 kg ha⁻¹ to 185 kg ha⁻¹) mostly during mid-century while the end-century showed no improvement with increasing doses of nitrogen.
6. Maize crop did not perform well at agroclimatic zone IV (Bathinda) and V (Abohar) where even under optimized practices no yield increment was observed.

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VITA

Name of the Student : Shivani Kothiyal
Father's name : Dr Vinod Prasad Kothiyal
Mother's name : Smt. Abha Kothiyal
Nationality : Indian
Date of birth : 24 August, 1992
Permanent home address : Shivani Kothiyal D/o Dr V. P. Kothiyal
V.P.O. Ajabpur, Tehsil and District Dehradun,
Uttarakhand
e-mail address : shivani.kothiyal41418@gmail.com

EDUCATIONAL QUALIFICATIONS

Bachelor degree : **B.Sc. Agriculture (Hons.)**
University : G.B. Pant University of Agriculture and Technology,
U.S. Nagar
Year of award : 2015
OCPA : 7.77/10.00
Master's degree : **M.Sc. Agricultural Meteorology**
University : G.B. Pant University of Agriculture and Technology,
U.S. Nagar
Year of award : 2017
OCPA : 8.45/10.00
Title of Master's Thesis : Analyzing the accuracy and usability of medium
range weather forecast in the Udham Singh Nagar
district of Uttarakhand
Ph.D. Degree : **Ph.D. (Agricultural Meteorology)**
University : Punjab Agricultural University, Ludhiana
Year of award : 2022
OCPA : 8.34/10.00
Title of Ph.D. Dissertation : Optimizing productivity of maize under emission
based climate scenarios by mid and end of 21st
century in Punjab
Awards/Distinctions/Scholarships : Research Assistantship during Master's Degree
Programme and ICAR-SRF during Ph.D. Degree
Programme