PERFORMANCE OF *RABI* MAIZE (*Zea mays* L.) TO DIFFERENT DATE OF SOWING AND FERTILITY LEVELS

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IN

AGRONOMY

BY

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B.Sc. (Hons.) Agriculture





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ABSTRACT

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ABSTRACT

An experiment on "Performance of *rabi* maize (*Zea mays* L.) to different date of sowing and fertility levels" was carried out at the Cotton Research farm, Khedbhramha, Sardarkrushinagar Dantiwada Agricultural University, Khedbhramha during *rabi* season of 2015-16. The soil of the experimental field was loamy sand in texture with low in organic carbon and available nitrogen, medium in available phosphorus and potash having pH value of 7.5. Total twelve treatment combinations comprising four date of sowing in main plot *viz.*, 15th October (D_1), 1st November (D_2), 15th November (D_3) and 1st December (D_4) and three Fertility levels in sub plot *viz.*, 150-75-00 kg NPK per hectare (F_1), 175-87.5-00 kg NPK per hectare (F_2) and 200-100-00 kg NPK per hectare (F_3) were laid out in Split Plot Design with four replications.

Plant population at initial stage and at harvesting stage did not differ significantly due to different date of sowing and fertility levels. It means that the plant population was uniform during the course of investigation.

The plant height at 45 DAS and at harvest, basal girth, number of cobs per plant, cob length and seed index did not differ significantly due to different date of sowing. However, numerically higher plant height at 45 DAS and at harvest, basal girth, number of cobs per plant cob length and seed index were recorded by sowing the *rabi* maize crop on 1st November.

Significantly higher number of grains per cob and grain weight per cob were recorded by 1st November sowing but it was found at par with 15th October sowing. Significantly the lowest number of grains per cob and grain weight per cob were recorded by 1st December sowing.

Sowing the *rabi* maize on 15th October and 1st November were found equally effective with respect to grain and straw yield but found significantly superior over 15th November and 1st December sowing.

Harvest index of *rabi* maize did not differ significantly due to different date of sowing. However, numerically the maximum harvest index was noted by 1st November sowing.

Protein content by *rabi* maize crop did not differ significantly due to different date of sowing but protein yield was recorded significantly higher by 1st November sowing. However, it was found at par with 15th October and 15th November sowing.

The available nitrogen and potash in soil after harvest of *rabi* maize did not differ significantly due to different date of sowing while, sowing of *rabi* maize on 1st November recorded significantly the highest available phosphorus in soil after harvest of *rabi* maize.

The maximum net realization and benefit: cost ratio were recorded by 1st November sowing followed by 15th October sowing. The lowest net realization and benefit: cost ratio were observed with 1st December sowing.

The results on plant height at 45 DAS and at harvest, basal girth, cob length, number of grains per cob, grain weight per cob and seed index were significantly higher with application of 200-100-00 kg NPK per hectare and it was followed by application of 175-87.5-00 kg NPK per hectare at harvest.

Different fertility levels did not imparted their significant influence on number of cobs per plant and harvest index of *rabi* maize. However, the maximum number of cobs per plant and harvest index were noted under treatment F_3 (200-100-00 kg NPK /ha).

Fertilizing the *rabi* maize crop with 200-100-00 kg NPK / hectare being at par with the application of 175-87.5-00 kg NPK per hectare with respect to grain and straw yield and which were found significantly superior over treatment F_1 (150-75-00 kg NPK per ha). Significantly the lowest grain and straw yield were recorded by application of 150-75-00 kg NPK per hectare.

Significantly higher protein content and protein yield were recorded by application of 200-100-00 kg NPK per hectare. However in case of protein content it was found at par with application of 175-87.5-00 kg NPK per hectare. Significantly the lowest protein content and protein yield were recorded by application of 150-75-00 kg NPK per hectare.

Available nitrogen and potash in soil after harvest of *rabi* maize did not differ significantly due to different fertility levels. However, numerically the maximum available nitrogen and potash in soil after harvest of *rabi* maize were recorded by application of 200-100-00 kg NPK per hectare.

Available phosphorus in soil after harvesting of *rabi* maize crop was recorded significantly higher by application of 200-100-00 kg NPK per hectare. However, it remained at par with application of 175-87.5-00 kg NPK per hectare. Significantly the lowest available phosphorus in soil after harvest of *rabi* maize was recorded by application of 150-75-00 kg NPK per hectare.

The maximum net realization and benefit: cost ratio were recorded by application of 200-100-00 kg NPK per hectare followed by application of 175-87.5-00 kg NPK per hectare. The minimum net realization and benefit: cost ratio were observed by application of 150-75-00 kg NPK per hectare.

On the basis of one year experimentation, it can be concluded that the maximum grain yield, net realization and benefit: cost ratio can be achieved by sowing of *rabi* maize crop (HQPM-1) on 15th October to 1st November and fertilizing with 200-100-00 kg NPK per hectare.

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LIST OF ABBREVIATIONS

₹	: Rupees
%	: Percentage
@	: at the rate
B:C ratio	:Benefit: cost ratio
C.D.	: Critical difference
C.V.	: Coefficient of variation
°C	: Degree Celsius
cm	: Centimeter
DAP	: Di- ammonium phosphate
DAS	: Days after sowing
dSm^{-1}	: Decisimens per metre
EC	: Electrical conductivity
et al.	: et allii ; and other
etc	: Etcetera
Fig.	: Figure
G	: Gram
ha	: Hectare
hr	: Hour
i.e.	: That is
kg/ha	: Kilogram per hectare
kg	: Kilogram
km/hr	: kilometer per hour
max	: Maximum
min	: Minimum
mm	: Milimeter
NS	: Not- Significant
Q	: Quintal
R.H.	: Relative Humidity
S.Em. ±	: Standard error of mean
Temp.	: Temperature
viz.	: Namely

INTRODUCTION

I. INTRODUCTION

Among the cereals, maize (*Zea mays* L.) ranks third in total world food production after wheat and rice and it is the staple food in many countries, particularly in the tropics and sub-tropics. Maize is considered as the "Queen of Cereals". Being a C4 plant, it is capable to utilize solar radiation more efficiently even at higher radiation intensity.

It is one of the most versatile crops which can be grown in diverse environment and geographical range. The major maize producing countries in the world are USA, China, South and Central Africa, Argentina, Brazil and Mexico. In India, the important maize growing states are Utter Pradesh, Bihar, Rajasthan, Madhya Pradesh, Punjab, Karnataka, Himachal Pradesh and Andhra Pradesh.

Globally maize is cultivated in an area of 176.98 million hectares with annual production of 968.86 million tons of grain and productivity of 5470 kg ha^{-1}. In India, maize is cultivated in an area of 8.76 million hectares with annual production of 21.0 million tons of grain and productivity of 2400 kg ha^{-1}. India stands sixth in the world in maize production. Gujarat occupied an area of 0.50 million hectare with annual production of 0.82 million ton of grain and productivity of 1640 kg ha^{-1} (Anon., 2014-15). It is traditionally grown in tribal areas of Panchamahal, Dahod, Sabarkantha, Banaskantha, Vadodara, Bharuch, Surat, Anand and Kheda districts.

In India, 45 to 48 % of maize produced is consumed by human and the rest is used in cattle and poultry feed and by the starch and oil industries. Maize is utilized in many ways like other grain crops in food dishes including "Chapati".

Maize is also utilized for starch, oil, fuel, and feed. It is used as a major cereal in the form of processed foods for breakfast and snacks. In addition, green cobs are consumed as roasted form. Popping the corn is a method of starch cookery. Maize is used for number of products *viz* starch, glucose, dextrose, protein, high fructose syrup, maldextrin, meal fiber and gluten products which have application in industries such as alcohol, textile, paper, pharmaceuticals, organic chemicals, cosmetics and edible oil, so it is called as industrial crop.

Nutritionally maize grain contains about 10% protein, 4% oil, 70% carbohydrates, 2.3% crude fiber, 10.4% albuminoides and 1.4% ash. Maize grain has significant quantities of vitamin A, nicotinic acid, riboflavin, vitamin E and low in calcium but fairly high in phosphorus.

Traditionally maize has been widely cultivated as rain-fed crop during *kharif* season in the country but recent studies have shown that it can also be successfully grown during *rabi* season in many parts of the country. *Rabi* maize is becoming increasingly popular in irrigated areas due to higher productivity compared to *kharif* maize due to clear sky and less insect, pest and weed infestation. The yield level of maize during *rabi* season is considerably higher than that of *kharif* due to its higher water and fertilizer use efficiencies and comparatively more favourable weather condition. So, cultivation of *rabi* maize is also gaining popularity among the farmers of India.

Among the various agronomic factors determining the crop yield, nutrient management is considered as one of the basic factors. Judicious use of fertilizer is therefore considered to be vitally important to achieve high yield. Fertilizer is one of the most productive and costly inputs used in agriculture. The contribution of fertilizer in increasing agricultural production has been well demonstrated in India and elsewhere.

The most popular variety of quality protein maize HQPM-1 having slow initial growth and there after vigorous growth, It has high nitrogen requirements compared to other hybrids (Singh *et al.*, 2010).

To augment higher crop yield per unit area, proper sowing time and inter row spacing are the most important factors. The proper sowing time exerts a marked effect on the growth and eventually the yield of a crop. Sowing of the crop at right time ensures better plant growth and also inhibits weed growth. There are evidences that optimum time of sowing is one of the several cultural manipulations and play a vital role in boosting up the yield, particularly in India sub continent where the optimum time of sowing varies to great extent due to widely varying agro-climate conditions. Though, optimum time of sowing is decided by several factors, fluctuation in temperature during the growing season play a vital role.

Environmental factors could be governed possibly by sowing time which has great bearing on the realization of the yield potential of the crop. Besides weather parameters, management practices also influence the overall performance of the crop. There is need to understand the crop response to management practices in relation to weather factors, which will help in manipulating crop agronomic practices to suit in varying environmental conditions.

Among the primary nutrients, nitrogen is very important as it is intimately involved in the process of photosynthesis and directly reflected in the total dry matter production. It is also associated with vigorous vegetative growth, deep green colour and yield. An adequate supply of nitrogen is closely associated with growth and development of plants. Nitrogen is the most important input for realizing protein yield of any crop as requirement of nitrogen is the highest among all the essential plant nutrients are this nutrient is most limiting under Indian condition. It plays an important role in plant metabolism by virtue of being an essential constituent of structural component of the cell and much diverse type of metabolically active compounds. It is also a constituent of chlorophyll, which is important for the harvest of solar energy. Nitrogenous fertilizer, therefore, forms a basic input for obtaining high yield. Nitrogen, being an integral part of protoplasm and an essential constituent of plant tissues, its normal application quickly shows beneficial effect by increasing leaf greenness plant development. As an exhaustive crop maize requires a regulated and assured supply of nutrients particularly nitrogen throughout its growing period right from seedling stage to grain filling stage. Demand of plants for nitrogen is more than any other nutrient and it is noticed that its deficiency at any stage of growth, especially at tasseling and silking stage, may lead to small, shriveled grains and virtual crop failure. Nitrogen deficiency is characterized by stunted and spindly plant growth with yellowing of green foliage particularly the lower leaves. Hence higher yield of quality protein of maize can be obtained through judicious use of nitrogen as it can alone contribute 45-60 % of crop yield (Dass *et al.*, 2010)

Phosphorus is a fascinating plant nutrient. It is involved in a wide range of plant processes from permitting cell division to the development of a good root system and for ensuring timely and uniform ripening of the crop. It is most needed by young fast growing tissues and performs a numbers of functions related to growth, development, photosynthesis and utilization of carbohydrates. In maize crop,

phosphorus helps in development of all phases. It shows its deficiency mainly at the seedling stage, though it is needed most after flowering stage.

Considering the above facts in view, the present experiment entitled "Performance of *rabi* maize (*Zea mays* L.) to different date of sowing and fertility levels" was planned and conducted at Cotton Research Farm, Khedbramha, SDAU, Khedbramha with the following objectives:

OBJECTIVES

1. To study the effect of sowing dates on growth, yield and quality of *rabi* maize
2. To study the growth, yield and quality of *rabi* maize under different fertility levels
3. To ascertain interaction effects of sowing dates and fertility levels on growth and yield of *rabi* maize and
4. To work out the economics of different treatments

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

An attempt has been made to review the available literature on the "Performance of *rabi* maize (*Zea mays* L.) to different date of sowing and fertility levels". The work done on these aspects is very limited. Hence, an attempt has been made to review the work carried out in India and abroad of the related crops. The reviews of work are discussed under the following sub heads.

2.1 Effect of date of sowing

2.2 Effect of fertility levels

2.3 Interaction effect of sowing dates and fertility levels

2.1 Effect of date of sowing

Among the various agro-techniques, sowing time has been recognized as one of the most important non-monetary input affecting the yield potential of maize. Effect of sowing dates on growth, yield attributes, yield, quality, parameters and economics of maize and related crops are reviewed here under.

2.1.1 Effect on growth attributes

A field trial was conducted at Marathwada Agricultural University, Parbhani (Maharastra) on medium black clayey soils by Bainade *et al.,* (1987) to study the effect of sowing dates on biometric observation in maize. They evaluated five sowing dates (24th to 30th Sept., 8th to 14th Oct., 29th to 4th Nov., 12th to 18th Nov., and 26th to 2nd Dec.). They reported that maize sown between 24th to 30th September recorded more plant height, number of leaves plant^{-1} and dry matter accumulation plant^{-1} over other sowing dates. A field experiment was conducted at Chaudhary Charan Singh Haryana Agriculture University, Hisar (Haryana) on sandy loam soil by Singh *et al.*, (1990) to study the effect of sowing dates on *rabi* maize. They evaluated three dates of sowing (12th Dec., 24th Dec., and 5th Jan.). The results indicated that days to tasseling, silking and maturity decreased gradually with delay in sowing.

Nandal and Agrwal (1991) conducted an experiment at Chaudhary Charan Singh Haryana Agriculture University Hisar (Haryana) on sandy loam soil. They studied the response of winter maize to sowing dates. They evaluated two sowing

dates i.e., 2nd November and 30th November. The results showed that crop sown on 2nd November produced significantly higher dry matter, leaf area index and crop growth rate up to 30 DAS as compared to sowing on 30th November.

While evaluating three dates of sowing (viz., 1st October, 1st November and 1st December) on winter maize at Hudeiba (Northern Sudan) Rahman *et al.,* (2001) reported that sowing of maize on 1st October and 1st December produced taller plant than 1st November sowing.

A field experiment was conducted at ICRISAT, Patancheru (Andhra Pradesh) on vertisols to study the performance of sweet sorghum to six planting dates at monthly interval from July to December. From the results Reddy *et al.,* (2007) indicated that the October planting of sweet sorghum takes less time for 50 per cent flowering, however August sowing recorded the maximum plant height.

Adetayo *et al.,* (2008) conducted a field experiment at Research Farm of the Federal College of Agriculture, Ibadan, (Nigeria) on sandy loam soil. They studied the effect of planting dates (13th march, 27th march and 10th April) on growth and yield attributes of maize. They observed that sowing of maize on 27th march recorded non significant effect on stem girth of maize crop.

2.1.2 Effect on yield attributes and yield

Itnal *et al.,* (1978) carried out an experiment at bijapur (Karnataka) to study the response of sorghum to dates of planting. They evaluated five sowing dates (viz., 17th Aug., 27th Sept., 10th Oct., 19th Oct. and 2nd Nov.) and observed that sowing of sorghum on 27th September gave the maximum yield over other sowing dates while fodder yield was higher with 10th October sowing.

While studying the performance of *rabi* jowar under three sowing times (18th Oct., 29th Oct. and 8th Nov.) at Agricultural Research Institute, Rajendranagar (A. P.), Reddy and Rao (1978) observed that the maximum grain yield was registered in early sowing on 18th October. Substantial reduction in grain yield was observed by delayed sowing on 8th November.

Bhinder and Sawhney (1986) carried out an experiment to evaluate different sowing times (viz., 22nd Oct., 16th Nov., 11th Dec. and 7th Jan.) in winter maize at Punjab Agricultural University, Ludhiana (Punjab). They observed that crop sown on 22th October gave the highest grain yield but it was found statistically at par with 16th November and 7th January sowings, while the lowest yield was noted in December sowing.

Narwal *et al.*, (1986_a) studied the response of winter maize to sowing time at Chaudhary Charan Singh Haryana Agriculture University, Hisar (Haryana) on sandy loam soils. The results indicates that crop sown on 11th Nov. or 1st Dec., produced longer ears, higher grain yield plant^{-1} and grain yield ha^{-1} than maize crop shown on 21th Oct. However, test weight was greater when the crop was shown on 21th Oct. and 11th Nov. over 1st Dec sowing. Crop sown on 21th Oct. showed maximum number of ears ha^{-1} and decreased considerably with the delay in sowing.

A field experiment was laid out at Chaudhary Charan Singh Haryana Agriculture University, Hisar (Haryana) on sandy loam soils by Narwal *et al.*, (1987). They studied the performance of winter maize to sowing times. They reported that sowing of maize from 19th December to 8th January significantly improved the yield attributes like length of ear, number of ears and fully developed kernels, grain weight ear^{-1} and test weight, ultimately resulted in to higher grain yield over 18th January sowing.

Singh *et al.*, (1987) carried out an experiment at Chaudhary Charan Singh Haryana Agriculture University Hisar (Haryana) on alkaline soils. They evaluated three dates of sowing (12th, 24th Dec. and 5th Jan.) in winter maize. The results revealed that winter maize sown on 12th December recorded higher grain yield, ear length, number of ears ha^{-1}, number of grain ear^{-1} and test weight than late sowing on 24th December and 5th January.

Sawhney *et al.*, (1989) conducted an experiment at Punjab Agricultural University, Ludhiana (Punjab) on loamy sand soil to study the effect of sowing time on winter maize. They found that maize sown on 22nd October gave the maximum grain yield followed by 16th November. Both these dates were found statistically at par to each other but found significantly superior to 11th December and 7th January sowing.

Nandal and Agrwal (1991) conducted a field trial at Chaudhary Charan Singh Haryana Agriculture University Hisar (Haryana) on sandy loam soil during winter season of 1983-84 and 1984-85 to study the response of winter maize to sowing dates. The results indicated that significantly higher grain yield was obtained in 2nd November sowing as compared to 30th November sowing.

A field experiment was conducted at Godhara (Gujarat) on sandy loam to clay loam soil to study the effect of showing dates (1st, 3rd week of November and 1st week

of December) on yield of *rabi* maize. Patel *et al.*, (1994) observed that early showing i.e. 1st week of November recorded significantly the highest grain yield.

An investigation carried out at Anand (Gujarat) to study the crop weather relationship in *rabi* maize. Reddy (1994) evaluated three showing dates (October 5th, 20th and November 4th). They reported that the grain yield was significantly higher in the first date of sowing than rest of the treatments.

While evaluating different dates of showing viz., 15th, 25th Oct., 5th, 15th, 25th Nov. and 5th, 15th, 25th Dec. in winter maize varieties at Banswara (Rajasthan). Porwal and Jain (1999) found that showing of maize either on 5th or 15th November found equally good and recorded higher grain yield, stover yield and harvest index than October and December sowing dates.

While evaluating three date of showing viz., 1st October, 1st November and 1st December in winter maize at Hudeiba (Northern Sudan). Rahman *et al.*, (2001) reported that sowing of maize on 1st October gave significantly higher yield, number of cobs/m^2, cob yield and test weight over rest of the sowing dates.

A field experiment was carried out at ICRISAT, Patancheru (Andhra Pradesh) on vertisols to evaluate six planting dates at monthly interval from July to December in sweet sorghum. From the results Reddy *et al.*, (2007) indicated that October planting of sweet sorghum resulted in higher yield over other planting dates.

Rahman *et al.*, (2008) carried out a field experiment at Hudeiba (Northern Sudan) for two years to determine the appropriate sowing time for maize. They evaluated thirteen sowing dates from 17th July to 19th January at 25 days interval. They found that grain yield and yield component, like number of kernels ear^{-1}, test weight and ear weight were significantly improved when maize was sown between 17th September and 18th November. They also observed that sowing before third week of September or after first week of December resulted into substantial reduction in yield.

Reddy *et al.*, (2010) conducted field experiments during winter 2007-08 and 2008-09 on clay loam soil at Regional Agricultural Research Station, Warangal, Andhra Pradesh. They studied the performance of maize under different sowing dates, they revealed that crop sown on 15th December found higher number of kernels/ cob, kernel weight/ cob (g), dry weight at harvest (g/plant) and grain yield (kg/ha) during 2007-08. But during 2008-09, the maize sown on 15th November recorded higher yield attributes and yield than the other dates.

Singh *et al.,* (2015) conducted an experiment during *rabi* season of 2007-08 and 2008-09 on sandy loam soil at Crop Research Farm, Allahabad Agricultural institute, Deemed University, Allahabad (Andhra Pradesh). They studied that effect of three sowing dates (1st Oct., 30th Oct. and 29th Nov.) on sweet corn. They revealed that baby corn planted on 30th Oct. recorded significantly higher number of cobs/plant, corn yield and fodder yield over 1st October and 29th November sowing.

Shaheenuzzamn *et al.,* (2015) conducted an experiment during *rabi* season of 2010-11 and 2011-12 on acidic soil at Hill Tract Agricultural Research Station, Ramgarh, Khagrachari Hill (Bangaladesh). They studied the effect of five sowing dates (20th November, 30th November, 10th December, 20th December and 30th December) on sweet corn. They found that during 2010-11 the highest green cob as well as fodder yield were obtained from 20th November sowing, and during 2011-12 the maximum green cob yield was obtained from 20th November sowing.

2.1.3 Quality parameters

Pawade (2010) conducted an experiment at Agronomy Farm, Navsari Agricultural University (Navsari). He studied the effect of time of sowing (30th October, 10th November and 20th November) on *rabi* maize. He observed different sowing time failed to significant effect of protein content on maize grain.

A field experiment was carried out during *rabi* season of 2006-07 at Department of Agronomy, Brahmanand ahavidhyalaya, Rath (Hamirpur) by Verma *et al.,* (2012). The results revealed that the highest protein value was recorded in 25th Oct. sowing followed by 15th Oct and 5th Nov.

2.1.4 Economics

Patel *et al.,* (1994) conducted an experiment at Godhra (Gujarat) on sandy loam to clay loam soil to study the effect of three sowing dates (1st, 3rd week of November and 1st week of December) in *rabi* maize. The results indicated that the early sown crop (1st week Nov.) secured higher net returns (12214 ₹/ha) with CBR of 2.44 than delayed sowing.

While evaluating different dates of sowing viz. 15th, 25th Oct., 5th, 15th, 25th Nov. and 5th, 15th, 25th Dec. in winter maize varieties at Banswara (Rajasthan). Porwal and Jain (1999) revealed that sowing of maize either on 5th or 15th November found equally good and recorded higher net profit than October and December sowing.

Singh *et al.,* (2015) conducted an experiment during *rabi* season of 2007-08 and 2008-09 on sandy loam soil at Crop Research Farm, Allahabad Agricultural institute, Deemed University, Allahabad (Andhra Pradesh). They studied effect of three sowing dates (1st Oct., 30th Oct. and 29th Nov.) on sweet corn. They revealed that baby corn planted on 30th Oct. recorded the maximum gross return, net return and benefit cost ratio.

From the forgoing review it is seen that higher and economic production of winter maize can be achieved by sowing the crop during first fortnight of November under varying agro climatic conditions.

2.2 Effect of fertility levels

2.1.1 Effect on growth attributes

Gaur *et al.,* (1992) planned an experiment during winter season at Udaipur (Rajasthan) to study the effect of nitrogen levels (80 and 120 kg ha^{-1}) on yield of maize. The results revealed that an application of 80 kg N ha^{-1} increased dry matter accumulation in maize compared to other levels of nitrogen.

Paradkar and Sharma (1993) conducted an experiment at Zonal Agricultural Research Station, Chhindwara (Madhya Pradesh) on clay loam soil with four levels of nitrogen (0, 45, 90 and 135 kg N ha^{-1}). They observed that application of nitrogen @ 135 kg ha^{-1} significantly increased the plant height, but reduced days to silking as compared to rest of the nitrogen levels.

Patel *et al.,* (2000) carried out a field experiment at Main Maize Research Station, Gujarat Agricultural University, Godhra during *kharif* season of 1995, 1996 and 1997 under rainfed condition to study the response of phosphorus levels on growth and yield of maize. The treatments consisted of four levels of phosphorus (0, 20, 40 and 60 kg P_2O_5 ha^{-1}). The results revealed that the growth characters like plant height and dry matter production were significantly affected with the phosphorus application. Likewise, the highest dry matter production (3680 kg ha^{-1}) was obtained with application of 60 kg P_2O_5 ha^{-1}.

Singh *et al.,* (2000) conducted a field experiment during *kharif* season at R.A.U. Udaipur, (Rajasthan) with four levels of nitrogen. They reported that application of N up to 120 kg ha^{-1} significantly increased plant height, dry matter, leaf area index and chlorophyll content as compared to other levels of N (0, 40 and 80 kg ha^{-1}).

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Sarma *et al.*, (2000) conducted a field experiment on maize at Regional Agricultural Research Station, Diphu (Assam). They reported that plant height (1.49m) increased significantly with 60 kg phosphorus ha^{-1} than control.

While working at G. B.P. U. A. T., Pantnagar (Uttar Pradesh), Sharma and Singh (2000) studied the growth, yield and nitrogen uptake by maize as influence by nitrogen levels during *kharif* seasons of 1993 and 1994. They reported that plant height, leaf area index, dry matter accumulation and shelling percentage were significantly increased with nitrogen application up to 120 kg ha^{-1}.

Arya and Singh (2001) conducted an experiment on maize with different levels of phosphorus in rainy season at New Delhi. They found that application of phosphorus @ 39.6 kg ha^{-1} produced significantly taller plants (172. 83 cm), more LAI (3.78), decreased days to 50 per cent silking (56.27) and maximum dry matter accumulation (216.10 g) than other levels of phosphorus (0, 13.2 and 26.4 kg P ha^{-1}).

An experiment was conducted at Coimbatore (Tamil Nadu) on integrated nitrogen management on *rabi* maize by Vadivel *et al.*, (2001). They reported that increasing levels of nitrogen from 0 to 60 kg ha^{-1} significantly increased the plant height, leaf area index and dry matter accumulation over preceding levels.

Kumar and Singh (2002) laid out a field experiment on maize in *kharif* season during 2000 to study the growth and development of maize with different levels of nitrogen (0, 60, 120, and 180 kg ha^{-1}) and Phosphorus (0, 40 and 80 kg ha^{-1}) at School of Agricultural Science and Rural Development (S. A. S. R. D.), Nagaland (India). They reported that with increasing nitrogen levels, plant height, stem thickness, leaf area index and crop growth rate were increased.

Singh *et al.*, (2003) carried out an experiment with four levels of nitrogen (120, 150, 180 and 210 kg ha^{-1}) to maximize the yield potential of winter maize at Banaras Hindu University, Varanasi (Uttar Pradesh). The results revealed that plant height was significantly higher at nitrogen application @ 180 kg ha^{-1}.

Patel *et al.*, (2006) conducted an experiment to study the effect of nitrogen on maize at Regional Research Station, Anand Agricultural University, Anand (Gujarat). They showed that application of 175 kg N ha^{-1} recorded the highest number of leaves per plant, being at par with 150 kg N ha^{-1}. Both these levels of N were found significantly superior to lower levels.

Sepat and Kumar (2007a) conducted a field experiment during rainy season at Indian Agriculture Research Institute, New Delhi on sandy loam soil. They concluded

that LAI and dry weight per plant improved significantly with 120 kg N ha^{-1} as compared to control in maize.

A field experiment was carried out during *rabi* season of 2005-06 at Anand Agriculture University, Anand, (Gujarat) by Patel *et al.,* (2009). The results revealed that application of nitrogen up to 160 kg ha^{-1} significantly increased the plant height of maize.

A field experiment was conducted at Indian Agricultural Research Institute, New Delhi by Meena *et al.,*(2011) on maize. They found that taller plant with higher leaf area index were recorded with enhancement in N levels from 0 to 40, 40 to 80 and 80 to 120 kg N ha^{-1}.

Wasnik *et al.,* (2012) studied the influence of nitrogen levels on growth, yield and economic of cultivating hybrid winter maize at Hyderabad (Andhra Pradesh). They reported that plant height was increased significantly with increasing nitrogen levels from 150 to 250 kg ha^{-1}.

2.1.2 Effect on yield attributes and yields

Subbian *et al.,* (1991) conducted field experiments to study the effect of levels of Phosphorus (0, 40 and 80 kg ha^{-1}) on maize during winter season in the year 1980-81 and 1985-86 at Coimbatore (Tamil Nadu). The results revealed that the maize grain yield responded to phosphorus application up to 80 kg ha^{-1} during the year 1984-85 and up to 40 kg ha^{-1} during the year 1985-86.

While studying the effect of nitrogen levels (80 and 120 kg ha^{-1}) and their splits on yield of winter maize during 1987-88 at Rajasthan College of Agriculture, Udaipur (Rajasthan), Gaur *et al.,* (1992) observed that increasing levels of N from 80 to 120 kg ha^{-1} significantly increased the grain yield.

While studying the effect of nitrogen application on yield and quality of winter maize on sandy loam soil having poor availability of nitrogen during 1990-91 and 1991-92 at Narendra Deva University of Agriculture and Technology (N. D. U. A. T.), Bahraich (Uttar Pradesh), Misra *et al.,* (1994) reported that increasing levels of N from 100 to 200 kg ha^{-1} significantly increased number of rows per cob, number of cobs ha^{-1}, 1000 grain weight and grain yield of maize.

An experiment was conducted at H. A. U., Hissar (Haryana) during 1995 and 1996 to study the effect of nitrogen levels (0, 75, 150 and 225 kg ha^{-1}) on yield and yield attributes of spring maize, by Tyagi *et al.,* (1998). They observed that application of nitrogen @ 75, 150 and 225 kg ha^{-1} increased the grain yield by 60.77,

108.02, 137.0% and 57.18, 99.43 and 126.12% over no nitrogen during 1995 and 1996, respectively. Straw yield and harvest index also followed the same trend during both the years. Values of yield contributing characters increased at higher N application and corresponding production was more.

A field experiment was conducted on maize at Indian Agriculture Research Institute, New Delhi by Arya and Singh (2000). They observed that application of phosphorus @ 90 kg P_2O_5 ha^{-1} resulted in significantly more grain (58.58 q ha^{-1}) and straw (69. 50 q ha^{-1}) yields than the lower doses (30 and 60 kg P_2O_5 ha^{-1}).

Singh *et al.,* (2000) conducted a field experiment during winter maize at Lakhaoti (Uttar Pradesh). The results revealed that the grain yield increased with increasing nitrogen levels up to 200 kg ha^{-1}, though increased beyond 150 kg N ha^{-1} was found non significant.

Singh *et al.,* (2000) conducted a field experiment during *kharif* season at R.A.U., (Rajasthan) with four levels of nitrogen. They reported that application of N up to 120 kg ha^{-1} significantly increased cobs per plant, grain rows per cob, weight of cob, shelling percentage, test weight, grain yield, straw yield and biological yield of maize as compared to control.

While working at G. B. P. U. A. T., Pantnagar, Shivay and Singh (2000) studied the growth, yield and nitrogen uptake by maize as influenced by nitrogen levels during *kharif* seasons of 1992-93 and 1993-94. They reported that grain yield increased significantly with increasing nitrogen application up to 120 kg ha^{-1}.

An experiment was conducted at Coimbatore (Tamil Nadu) on integrated nitrogen management on *rabi* maize by Vadivel *et al.,* (2001). They suggested that increasing nitrogen levels from 0 to 60 kg ha^{-1} significantly increased the cob length, cob girth, cob weight and test weight.

Arya and Singh (2001) conducted a field experiment in rainy season of 1994 and 1995 at New Delhi. They revealed that application of phosphorus @ 39. 6 kg P ha^{-1} gave significantly higher grain (5. 84 and 4.24 t ha-1) and straw (6. 95 and 5. 74 t ha^{-1}) yields of maize compared to the other levels of phosphorus (0, 13.2 and 26.4 kg P ha^{-1}) during 1994 and 1995, respectively.

A field experiment was conducted on maize during rainy season (*Kharif*) at S.A.S.D.R., Mediphema (Nagaland) by Kumar and Singh (2003). They observed that interaction among different levels of nitrogen (0, 50, 100 and 150 kg N ha^{-1}) and

phosphorus (0, 40 and 80 kg P_2O_5 ha^{-1}) did not show any significant effect on stover and grain yields.

Singh *et al.,* (2003) carried out an experiment with four levels of nitrogen (120, 150, 180 and 210 kg ha^{-1}) to maximize the yield potential of winter maize at Banaras Hindu University, Varanasi (Uttar Pradesh). The results revealed that number of cobs per plant, girth of cob, length of cob, average shelling percent and 1000 grain weight were significantly higher at nitrogen application @ 180 kg ha^{-1}. Grain and straw yields were also significantly greater at this dose.

A field experiment was planned at Khalsa Collage, Amritsar (Punjab) on sandy loam soil to study the effect of five nitrogen levels (0, 80,100,120 and 140 kg ha^{-1}) on maize. Singh *et al.,* (2006) revealed that yield attributes of maize viz. cobs per plant, cob length, grain per cob and 1000 grain weight were greatly influenced by levels of nitrogen. Application of 80, 100, 120 and 140 kg N ha^{-1} recorded 36.14, 41.81, 43.36 and 44.36 q ha^{-1} of grain yield, respectively, but difference between 120 and 140 kg N ha^{-1} was found to be non significant.

Tank *et al.,* (2006) carried out a field experiment at Anand Agricultural University, Anand (Gujarat) during *rabi* season in the year 2001-02 on sandy loam soil to study the effect of four levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}). The results revealed that increasing nitrogen levels significantly increased yield and yield attributes. Application of 180 kg N ha^{-1} produced significantly the highest number of grains per cob and 1000 grain weight in maize.

A field experiment was conducted on maize at Indian Agriculture Research Institute, New Delhi by Sepat and Kumar (2007_b). They indicated that significantly the highest grain yield (4.88 t ha^{-1}) and straw yield (5.09 t ha^{-1}) were obtained with 120 kg N/ha as compared to control.

Siam *et al.,* (2008) laid out a field experiment during the two successive seasons of 2005 and 2006 at Demo, Fayoum Government (Egypt) to study the effect of different sources and application rates of nitrogen fertilizer on maize. They noted that the increasing levels of N up to 140 kg ha^{-1} significantly increased plant height, ear weight and 100 grain weight.

A field experiment was carried out during *rabi* season of 2005-06 at Anand (Gujarat) by Patel *et al.,* (2009). The results revealed that application of nitrogen up to 120 kg ha^{-1} significantly increased the grain yield of maize.

Paramasivam *et al.,* (2011) conducted a field experiment on maize at Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu) during 2006-2007 and 2007-08. They studied different phosphorus levels (0, 45, 60 and 75 kg ha^{-1}). The results revealed that the yield attributes like cob length, cob girth, grain rows per cob, 100 grain weight and grain and straw yields, were significantly increased with increasing levels of phosphorus up to 60 kg ha^{-1}.

A field experiment was conducted at Indian Agricultural Research Institute, New Delhi by Meena *et al.,* (2011). They reported that increasing N levels from 0 to 40, 40 to 80 and 80 to 120 kg N ha^{-1} markedly improved the number of grains per cob and test weight in maize.

Wasnik *et al.,* (2012) studied the influence of nitrogen levels on growth, yield and economic of cultivating hybrid winter maize at Hyderabad (Andhra Pradesh). They reported that cob length, cob girth, shelling percentage, test weight and cob weight were increased significantly with increasing nitrogen levels from 150 to 250 kg ha^{-1}.

Kalyani *et al.,* (2012) conducted field experiments during *rabi* 2008 and 2009 on sandy loam soil at S.V. Agricultural collage, Tirupati (Andhra Pradesh). They studied the effect of nutrients levels (80:40:40, 100:50:50 and 120:60:60 Kg NPK/ha) on popcorn. They revealed that the application of 120:60:60 kg NPK/ha recorded the highest grain yield, stover yield and test weight of pop corn in both the years.

Mathukiya *et al.,* (2014) conducted a field experiment during *rabi* season 2010 on clay soil of Junagadh (Gujarat). They studied the response of sweet corn to fertilizer (Control, 90-45, 120-60, 150-75 N, P_2O_5 kg/ha), they observed that application of 120-60 kg N-P_2O_5/ha improved growth and yield attributes and ultimately higher green cob and fodder yields

2.1.3 Effect on nutrient content, quality and nutrient status of soil

Gaur *et al.,* (1992) studied the effect of nitrogen level (80 and 20 kg ha^{-1} and their splits on yield of winter maize during the 1987-88 at Rajasthan College of Agriculture, Udaipur (Rajasthan). They observed that the N uptake by grain and straw (39. 0 and 32. 6% respectively) increased significantly with application of 120 kg N ha^{-1} compared to 80 kg N ha^{-1}.

A field experiment was conducted on maize at Indian Agriculture Research Institute, New Delhi by Arya and Singh (2000). They noted that application of

phosphorus@ 90 kg P_2O_5 ha^{-1}resulted significantly more protein yield (558 kg ha^{-1}) than the lower doses (30 and 60 kg P_2O_5 ha^{-1}).

Tank (2006) carried out a field experiment at Anand Agricultural University *et al.*, Anand (Gujarat) during *rabi* season 2001-02 on sandy loam soil to study the levels of nitrogen (0, 60, 120 and 180 kg N ha^{-1}). The results revealed that the increasing levels of nitrogen significantly increased protein content in grain of maize.

A field experiment was carried out during *rabi* season of 2005-06 at Anand (Gujarat) by Patel *et al.*, (2009). The results revealed that application of nitrogen from 100 to 160 kg ha^{-1} significantly increased the protein content (8.15 to 10.52%) of maize.

A field experiment was started by Tetarwal *et al.*, (2011) during 2008-09 at Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan). They concluded that application of 15 kg P ha^{-1} registered the maximum NPK uptake by maize and available N and P status was increased to the tune of 14.89 % P over initial status of soil fertility.

A field experiment was conducted on maize at Faculty of Agriculture, Sher-e-Kasmir University of Agricultural Sciences and Technology of Kasmir, Wadura, Sopore, (Jammu and Kashmir) by Singh *et al.*, (2012). They revealed that the nitrogen application significantly enhanced nitrogen uptake with successive increase up to 150 kg N ha^{-1}.

A field experiment was started by Tetarwal *et al.*, (2011) during 2008-09 at Maharana Pratap University of Agriculture and Technology, Udaipur (Rajasthan). They concluded that application of 40 kg N ha^{-1} registered maximum NPK uptake by maize and available N and P status was increased to the tune of 1.28% N over initial status of soil fertility.

Wasnik *et al.*, (2012) studied the influence of nitrogen levels on growth, yield and economic of cultivating hybrid winter maize at Hyderabad (Andhra Pradesh). They obtained 12.10 % protein content with 250 kg N ha^{-1}. This was found significantly superior over other nitrogen levels.

2.1.4 Effect on economics

A field experiment was conducted at Main Maize Research Station, Gujarat Agricultural University, Godhra (Gujarat) to study the effect of different phosphorus levels on economics by Patel *et al.*, (2000). Results revealed that the higher net profit

of ₹ 9772 ha^{-1} was obtained with 60 kg P_2O_5 ha^{-1} with a CBR of 1:2.58 followed by ₹ 8942 ha^{-1} with CBR of 1:2.55 in 40 kg P_2O_5 ha^{-1}.

A field experiment was conducted at Indian Agriculture Research Institute, New Delhi by Sepat and Kumar (2007_b). They reported that significantly highest benefit cost ratio (3.00), gross return (₹ 27,855 ha^{-1}) and net returns (₹ 18,607 ha^{-1}) in maize were obtained with 120 kg N ha^{-1} as compared to control.

A field experiment was conducted during north east monsoon season at Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu) by Lakshmi *et al.*, (2009). They recorded the maximum net returns (₹ 5777 ha^{-1}) and benefit cost ratio (1.94) of maize with application of 40 kg N ha^{-1} over other treatments.

A field experiment was conducted at Indian Agricultural Research Institute, New Delhi by Meena *et al.*, (2011). They reported that each successive increase in N levels from 0 to 120 kg N ha^{-1} improved the value of net return from maize.

A field experiment was conducted during winter season to study the influence of nitrogen levels on growth, yield and economic of winter hybrid maize by Wasnik *et al.*, (2012) at Hyderabad (Andhra Pradesh). They obtained significantly higher net return (₹ 48089 ha^{-1}) and benefit cost ratio (3.79) with 250 kg N ha^{-1}.

Mathukiya *et al.*, (2014) conducted a field experiment during *rabi* season 2010 on clay soil of Junagadh (Gujarat). They studied the response of sweet corn to fertilizer Control, 90-45, 120-60 and 150-75 kg/ha. They observed that application of 120-60 N-P_2O_5 kg/ha recorded highest net returns and B: C ratio over control and 90-45 kg N-P_2O_5/ha.

2.3 Interaction effect of date of sowing and fertility levels

2.3.1 Effect on growth parameters

Nandal and Agarwal (1991) conducted a field experiment at Haryana Agricultural University, Hisar during winter season of 1984-85 to study the effect of sowing dates (2nd Nov. and 30th Nov.) and nitrogen levels (0, 50, 100, 150, 200 kg N ha^{-1}) on maize. They found that sowing of maize 30th November along with application of 200 kg N ha^{-1} recorded significantly the highest dry matter accumulation, leaf area index and crop growth rate of winter maize.

Verma *et al.*, (2012) conducted a field experiment at Brahmanand Mahavidyalaya, Rath during *rabi* season of 2006-07 and 2007-08 to study the effect

of sowing dates (15th Oct, 25th Oct and 5th Nov) and nitrogen levels (50, 100 and 150 kg urea ha^{-1}) on maize. They observed that sowing of maize on 25th October along with 150 kg urea ha^{-1} significantly influenced plant height, number of leaves per plant, LAI and dry weight per plant of *rabi* maize.

Singh *et al.*, (2014) conducted field experiments at Crop Research Station, Bahraich (U.P.) during *rabi* season of 2011-12 and 2012-13 on sandy loam soil to study the effect of sowing time (20 Nov., 30 Nov. And 10 Dec.) and nitrogen levels (150, 200 and 250 kg N ha^{-1}) on growth attributes. They revealed that sowing time of *rabi* maize on 20 Nov. along with 250 kg N ha^{-1} significantly influenced plant height of *rabi* maize.

2.1.2 Yield attributes and yield

Nandal and Agarwal (1991) conducted a field experiment at Haryana Agricultural University, Hisar during winter season of 1984-85 to study the effect of sowing dates (2nd Nov. and 30th Nov.) and nitrogen levels (0, 50, 100, 150, 200 N kg ha^{-1}). They found that sowing of maize on 30th November along with 200 kg ha^{-1} recorded significantly the highest grain yield of winter maize.

Verma *et al.*, (2012) conducted a field experiment at Brahmanand Mahavidyalaya, Rath during *rabi* season of 2006-07 and 2007-08 to study the effect of sowing dates (15th Oct, 25th Oct and 5th Nov) and nitrogen levels (50, 100 and 150 kg urea ha^{-1}) on maize. They observed that sowing of maize on 25th October along with 150 kg urea ha^{-1} significantly influenced the weight of cob per plant and grain yield of *rabi* maize.

Singh *et al.*, (2014) conducted field experiments at Crop Research Station, Bahraich (U.P.) during *rabi* season of 2011-12 and 2012-13 on sandy loam soil to study the effect of sowing time (20 Nov., 30 Nov. And 10 Dec.) and nitrogen levels (150, 200 and 250 kg N ha^{-1}) on yield attributes and yield. They revealed that sowing time of *rabi* maize on 20 Nov. along with 250 kg N ha^{-1} significantly influenced the cob length, test weight, grain yield and stover yield of *rabi* maize.

2.1.3 Quality parameters

Verma *et al.*, (2012) conducted a field experiment at Brahmanand Mahavidyalaya, Rath during *rabi* season of 2006-07 and 2007-08 to study the effect of sowing dates (15th Oct, 25th Oct and 5th Nov) and nitrogen levels (50, 100 and 150

kg urea ha^{-1}). They observed that sowing of maize on 25th October along with 150 kg urea ha^{-1} recorded significantly higher value of protein (%) in grain of *rabi* maize.

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The details about materials used, experimental methods followed and techniques adopted during the course of investigation on "Performance of *rabi* maize (*Zea mays* L.) to different date of sowing and fertility levels" are given here.

3.1 Experimental site

A field experiment was laid out at Cotton Research Farm, Sardarkrushinagar Dantiwada Agricultural University, Khedbhrama, District: Sabarkantha (North Gujarat) during *rabi* season of 2015-16 at in plot no. C-1.

3.2 Climate and weather conditions

Geographically, Khedbhrahma is situated at 24°-00' North latitude and 72°-58' East longitude with an elevation of 203.81 metres from the mean sea level. It represents the North Gujarat Agro-climatic Zone.

This zone is characterized by semi-arid and sub-tropical climate. The weather conditions are quite favourable for normal growth and development of the crop. In general, monsoon is warm and moderately humid; winter is fairly cold and dry while summer is quite hot and dry. The monsoon commences by the third week of June and retreats by the middle of September with an average rainfall of 600 mm received in about 30 rainy days.

The regular winter season starts by the middle of October and it continues till the end of February. The temperature starts rising from February and reaches the maximum in the month of May. The wind velocity is very high during summer. The standard week wise mean maximum & minimum temperature data for the period under study varies from 24.3 to 36.2 °C and 7.8 to 22.9 °C, respectively. The standard week wise mean relative humidity varies from 47.0 to 82.1 per cent and 21.6 to 46.6 per cent, respectively in the morning and evening.

The standard week wise meteorological data for the period of the investigation as recorded at the observatory of the Cotton Research Sub-Station, Kedbhramha, Sardarkrushinagar Dantiwada Agricultural University, Khedbhrahma are presented in Table 3.1 and depicted in Fig. 3.1

Table 3.1 Standard week wise meteorological data recorded during crop season for the year 2015-16 at Khedbhrahma.

Months and Year	Std. Week	Temp. (0°C)		RH (%)		Wind velocity (km/hr)	Evapo ration (mm)	Rainfall (mm)
		Max.	Min.	A.M.	P.M.			
October – 2015	42	36.2	21.0	63.4	38.6	3.1	4.0	0.0
	43	35.2	21.8	82.1	28.6	2.7	3.7	0.0
	44	34.1	21.1	63.6	39.7	3.7	3.1	0.0
November - 2015	45	34.5	16.4	65.6	46.6	3.4	3.4	0.0
	46	34.3	15.1	65.7	36.9	2.4	2.5	0.0
	47	33.5	15.2	65.7	26.3	2.5	2.3	0.0
	48	32.0	13.7	60.6	45.7	2.4	2.0	0.0
December - 2015	49	31.3	12.8	64.4	41.0	2.7	2.4	0.0
	50	27.1	9.2	57.4	41.6	2.3	2.3	0.0
	51	25.7	7.9	56.7	42.6	2.5	2.0	0.0
	52	27.3	7.8	62.2	44.6	2.5	2.0	0.0
January - 2016	1	25.7	9.7	66.6	43.7	2.1	2.2	0.0
	2	27.9	9.1	67.0	40.7	3.3	2.5	0.0
	3	25.8	9.4	66.4	42.6	3.1	2.8	0.0
	4	24.3	11.2	66.1	44.0	2.8	2.5	0.0
	5	26.5	9.4	63.7	42.6	2.9	2.5	0.0
February - 2016	6	28.7	11.6	57.6	37.6	2.7	2.8	0.0
	7	30.8	13.6	62.3	34.6	3.7	2.7	0.0
	8	34.6	16.2	58.6	35.3	3.8	3.0	0.0
	9	27.2	13.0	48.9	21.6	3.4	3.3	0.0
March - 2016	10	31.0	19.2	53.1	27.6	4.3	3.4	0.0
	11	34.4	22.3	57.9	34.1	3.6	3.4	0.0
	12	31.2	21.4	65.8	36.6	6.1	4.2	0.0
	13	33.1	17.9	47.0	28.0	4.2	4.7	0.0
	14	31.2	22.9	65.7	27.7	3.9	4.3	0.0

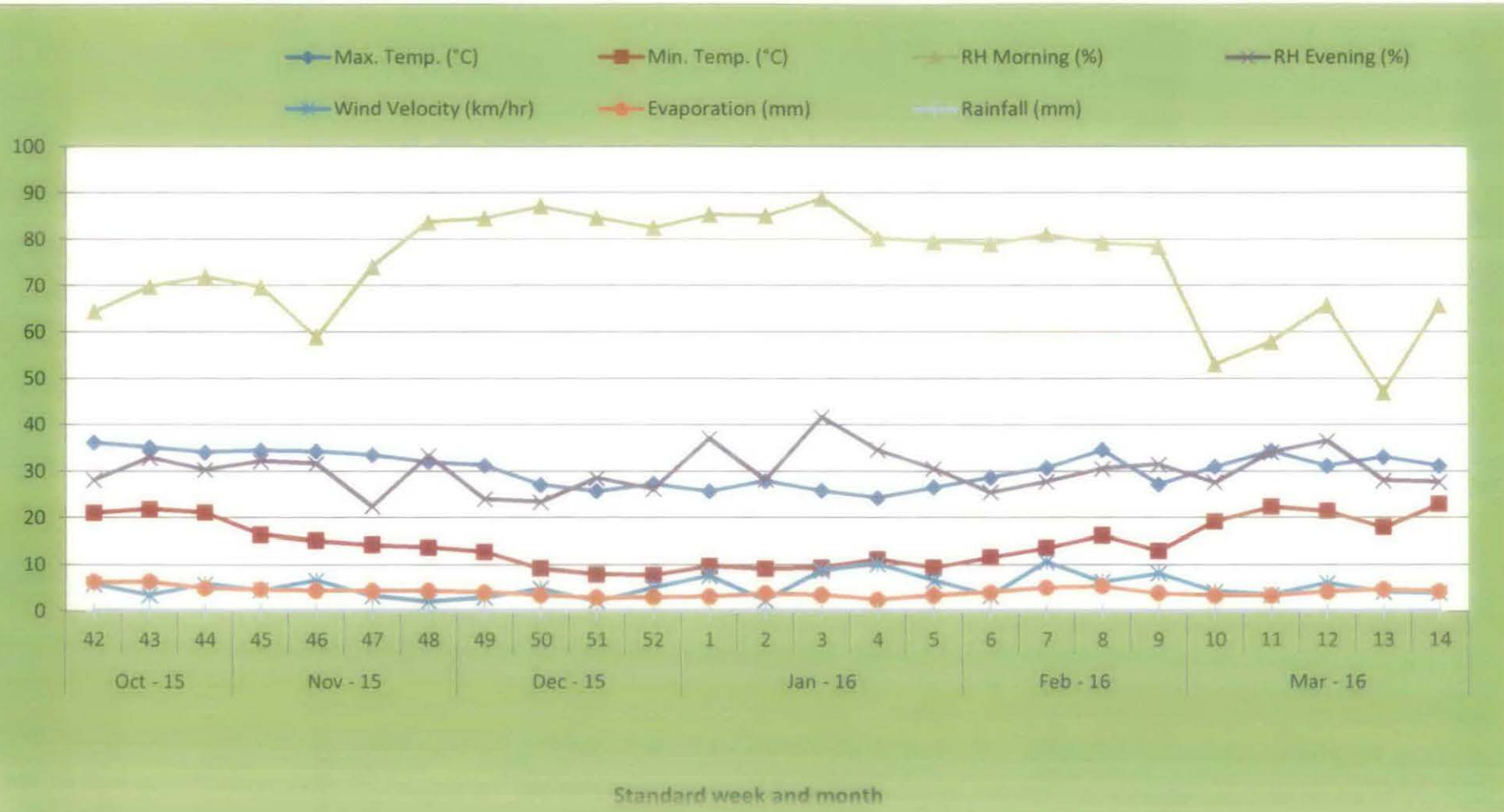


Fig. 3.1 Standard week wise meteorological data recorded during crop season for the year 2015-16 at khedbhrahma

These data indicated that the mean maximum temperature ranged between 24.3 to 36.2° C, while mean minimum temperature ranged between 7.8 to 22.9° C during the period of experimentation in the year 2015 - 16. The mean relative humidity recorded at morning and evening ranged from 47.0 to 82.1 and 21.6 to 46.6 per cent, respectively during crop period. There was no rainfall recorded in meteorological week during crop period.

The overall climatologically data indicated that the weather conditions were observed normal and favourable for the satisfactory growth and development of the maize crop during *rabi* season of 2015-16.

3.3 Physico-chemical properties of experimental soil

The experimental site had an even topography with a gentle slope. The type of soil is medium black. The soil is well drain and moisture retention characteristic of the experimental soil was also good. The ground water table was more than 15 m deep. Hence, there is no problem of high water table in the area.

Table 3.2 Physico-chemical properties of the soil of experimental plot (C-1)

S. No.	Properties		Soil depth (cm)		Methods employed
			0-15	15-30	
[A]	**Physical properties**				
	(a)	Sand (%)	59.81	59.96	International Pipette Method (Piper, 1966)
	(b)	Silt (%)	25.09	24.80	
	(c)	Clay (%)	14.59	14.69	
	(d)	Soil texture	Loamy sand		
[B]	**Chemical properties**				
	(a)	Soil pH (1:2.5, Soil: Water ratio)	7.40	7.45	Potentiometric method (Jackson, 1973)
	(b)	EC (dSm^{-1} at 25°C)	0.22	0.26	Schofield method (Jackson, 1973)
	(c)	Organic carbon (%)	0.31	0.27	Walkley and Black's rapid titration method (Jackson, 1973)
	(d)	Available Nitrogen (kg/ha)	178.50	164.03	Alkaline Permanganate method (Jackson, 1973)
	(e)	Available Phosphorus (kg/ha)	30.70	33.84	Spectrophotometric method (Olsen's 1954)
	(f)	Available Potash (kg/ha)	262.01	258.34	Flame photometer method (Jackson, 1973)

To find out physico-chemical properties of soil, soil samples were collected randomly before commencement of experiment from different spots in the field to a depth of 0-15 cm and 15-30 cm and composite soil sample was prepared and analyzed for physical and chemical properties of the soil. The values of these properties of the soil along with methods used to determine them are given in Table 3.2.

It is evident from the data (Table 3.2) that the soil of the experimental field was sandy loam in texture, low in organic carbon (0.31 %) and available nitrogen (178.50 kg/ha), and medium in available phosphorus (30.70 kg/ha) and available potash (262.01 kg/ha). Electrical conductivity was very low showing that the soil was free from salinity hazard.

3.4 Cropping history of the experimental field

The cropping history of the experimental site for the preceding three years prevailing fertilizer doze applied to each crop is presented in Table 3.3.

Table 3.3 Cropping history of the experimental field

Year	Season	Crop	Fertilizers applied (kg/ha)		
			N	P_2O_5	K_2O
2012-13	*Kharif*	Caster +	120	25	00
		black gram	20	40	00
	Rabi	Fallow	-	-	-
	Summer	Fallow	-	-	-
2013-14	*Kharif*	Caster +	120	25	00
		black gram	20	40	00
	Rabi	Wheat	120	60	00
	Summer	Fallow	-	-	-
2014-15	*Kharif*	BT Cotton	240	40	00
	Rabi	Fallow	-	-	-
	Summer	Fallow	-	-	-
2015-16	*Kharif*	Caster +	120	25	00
		black gram	20	40	00
	Rabi	Present experiment	As per treatment		

3.5 Selection of variety

Maize variety HQPM 1 hybrid has been identified for cultivation across the country. Developed by Haryana Agricultural University, this hybrid having quality protein given mean average yield of 6285 kg ha^{-1}. It is resistance to major disease like Maydis leaf blight (MLB) and turcicum leaf blight (TLB). The details of characteristics of the Variety are presented in table 3.5.1.

3.4 Salient features of the variety

Character	Description
Pedigree	HKI 193 X HKI 163
Year of release	2005
Day of maturity	88-90
Visual feature	Yellow dent
Plant: Ear placement	High
Ear: Length with husk	Long (>15 cm)
Plant height (cm)	175-200 cm (*Kharif*), 185-195 cm (*Rabi*)
Cobs length	18.5 to 19.5
Test weight	280-295 g/1000 grains
Protein percentage	9.36-10.25%
Grain yield (kg ha^{-1})	55-60 q ha^{-1}

3.6 Experimental details

The details of experimental techniques employed during the course of investigation are as under the experiment entitled "Performance of *rabi* maize (*Zea mays* L.) to different date of sowing and fertility levels" are described as under.

3.6.1 Treatment details:

Total twelve treatment combinations comprising four levels of sowing date and three fertility levels were tried. The details of treatments are as under.

(a) Treatments

A. Main plot treatments : Sowing dates (D)

D_1 : 15th October

D_2 : 1st November

D_3 : 15th November

D_4 : 1st December

B. Sub plot treatments : Fertility levels (F)

F_1 : 150-75-00 NPK kg/ha (RDF)

F_2 : 175-87.5-00 NPK kg/ha

F_3 : 200-100-00 NPK kg/ha

(b) Replications : 4 (four)

(c) Design : Split plot design

(d) Treatment combinations : 12

(e) Plot size **Gross** : 6.0 m X 4.5 m

Net : 4.4 m X 3.0 m

(f) No of rows in a plot **Gross** : 6

Net : 4

(g) Spacing (R X P) : 75 cm X 20 cm

(h) Seed rate : 20 kg/ha

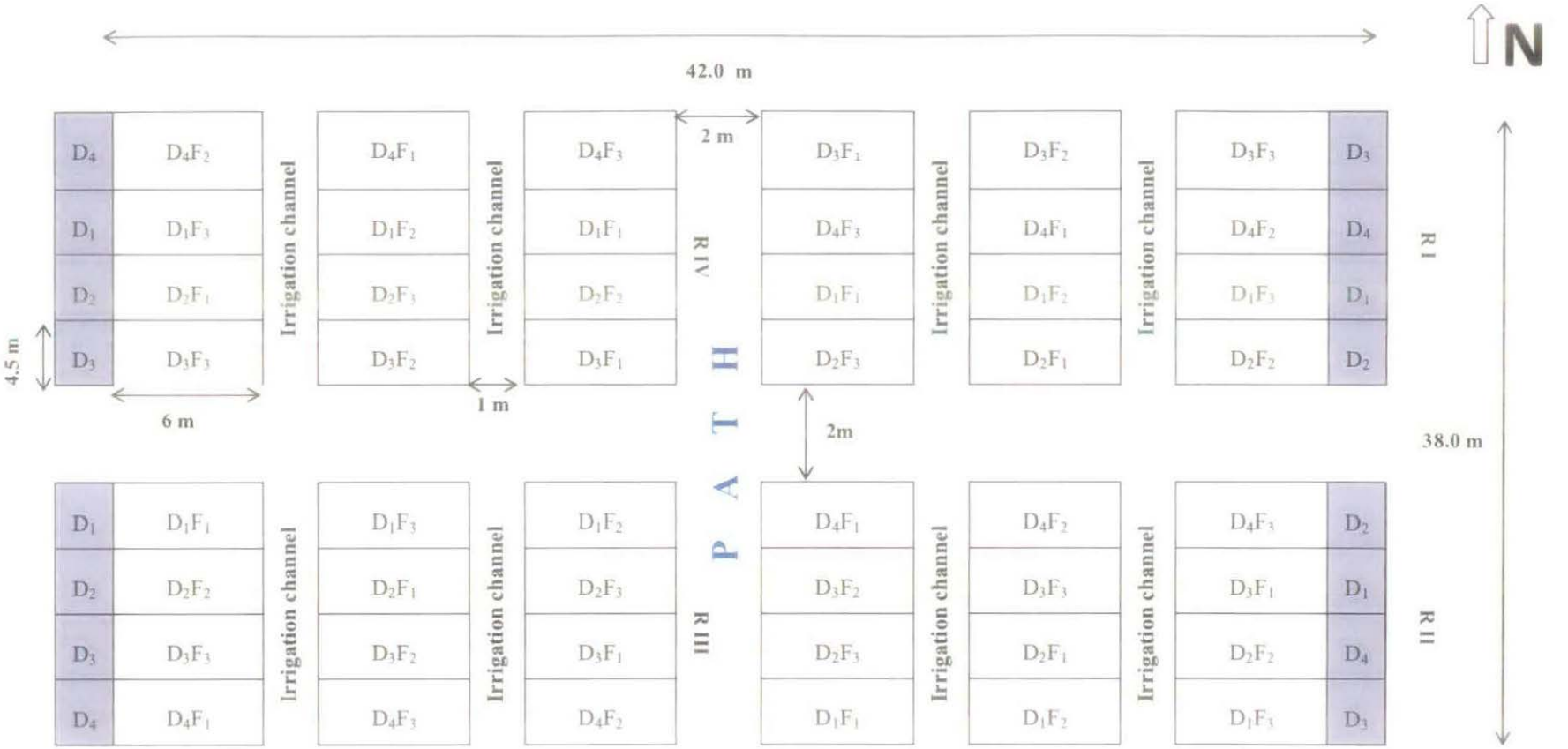
(i) Crop and variety : Maize (HQPM-1)

(j) RDF : As per treatments

The details of treatment combinations are presented in Table 3.5.

Table 3.5 Details of treatment combinations along with time of sowing and nitrogen levels

Tr. No.	Treatment Combinations	Particular	
		Time of sowing	Fertility levels
T_1	D_1F_1	15th October 2015	150-75-00 NPK kg/ha
T_2	D_1F_2	15th October 2015	175-87.5-00 NPK kg/ha
T_3	D_1F_3	15th October 2015	200-100-00 NPK kg/ha
T_4	D_2F_1	1st November 2015	150-75-00 NPK kg/ha
T_5	D_2F_2	1st November 2015	175-87.5-00 NPK kg/ha
T_6	D_2F_3	1st November 2015	200-100-00 NPK kg/ha
T_7	D_3F_1	15th November 2015	150-75-00 NPK kg/ha
T_8	D_3F_2	15th November 2015	175-87.5-00 NPK kg/ha
T_9	D_3F_3	15th November 2015	200-100-00 NPK kg/ha
T_{10}	D_4F_1	1st December 2015	150-75-00 NPK kg/ha
T_{11}	D_4F_2	1st December 2015	175-87.5-00 NPK kg/ha
T_{12}	D_4F_3	1st December 2015	200-100-00 NPK kg/ha



Design : SPD (Split Plot Design)

Replication : 4 (Four)

Spacing : 75 cm × 20cm

Plot size **Gross**: 6.0m ×4.5 m (6 Rows) **Net plot**: 4.4 m× 3.0 m (4 Rows)

Fig. 3.2 Performance of *rabi* Maize (*Zea mays L.*) to different sowing dates and fertility levels



Plate I. General view of the experimental plot

3.6.2 Experimental layout

The present experiment was planned in Split Plot Design (SPD) with four replications. The layout of experiment is depicted in Fig. 3.2.

3.7 Calendar of cultural operations

All the essential cultural operations like cross cultivation by tractor, planking, opening of furrows etc. were carried out for the cultivation of experimental crop in the field where experiment was conducted. The sequences of operations carried out in the field during crop season are given in Table 3.6.

Table 3.6 Calendar of cultural operations

Sr. No.	Operations	D_1	D_2	D_3	D_4
A.	**Land preparation**				
1.	Cross cultivation by tractor	15/10/2015	30/10/2015	15/11/2015	30/11/2015
2.	Planking by tractor	15/10/2015	30/10/2015	15/11/2015	30/11/2015
3.	Layout preparation	15/10/2015	30/10/2015	15/11/2015	30/11/2015
4.	Preparation of beds and water channel	15/10/2015	30/10/2015	15/11/2015	30/11/2015
5.	Marking and opening of Furrows	15/10/2015	30/10/2015	15/11/2015	30/11/2015
B.	**Sowing and post sowing operation**				
6.	Basal application of Fertilizer	15/10/2015	30/10/2015	15/11/2015	30/11/2015
7.	Date of sowing	15/10/2015	1/11/2015	15/11/2015	1/12/2015
8.	Top dressing of urea	24/10/2015	21/11/2015	26/11/2015	18/12/2015
		16/12/2015	2/1/2016	19/1/2016	3/2/2016
9.	Interculturing	02/11/15	26/11/15	15/12/15	28/12/15
10.	Weeding	03/11/15	28/11/15	16/12/15	30/12/15
		28/11/15	16/12/15	30/12/16	28/1/16
11.	Irrigation				
	1	15/10/15	01/11/15	15/11/15	01/12/15
	2	20/10/15	6/11/15	20/11/15	6/12/15
	3	01/11/15	15/11/15	01/12/15	17/12/15
	4	15/11/15	01/12/15	17/12/15	02/01/16
	5	01/12/15	17/12/15	02/01/16	16/01/16
	6	17/12/15	02/01/16	16/01/16	03/02/16
	7	02/01/16	16/01/16	03/02/16	19/02/16
	8	16/01/16	03/02/16	19/02/16	05/03/16
12.	Date of harvesting	26/01/16	19/02/16	02/03/16	22/03/16

3.7.1 Land preparation

The experimental field was cross cultivated with tractor drawn cultivator followed by planking to level the field. The stubbles of the previous crops were also removed from the plot and finally land was prepared for sowing of seeds. The layout of the experiment was carried out as per layout plan and beds and irrigation channels were prepared with the help of bund former. Then after, all the beds were levelled manually and shallow furrows were opened at 75.0 cm apart with the help of the marker to dibble the seeds.

3.7.2 Fertilizer application

The crop was fertilized as per treatments, where the half dose of nitrogen and full dose of phosphorus in the form of di-amonium phosphate and urea were applied as basal dose in the previously opened furrow. After application of basal dose, the opened furrows were covered lightly with the soil. Remaining half dose of nitrogen was applied as top dressing in two equal split at 8 leaf stage and at tasseling stage.

3.7.3 Seed rate and spacing

HQPM-1 variety of maize was used for sowing with seed rate of 20 kg/ha. The crop was sown manually by dibbling the seed keeping 75 cm X 20 cm spacing.

3.7.4 Method of sowing

The crop was sown manually by dibbling the seeds to a depth of 2-3 cm in the previously opened furrows and lightly covered with the soil immediately.

3.7.5 Gap filling and thinning

After two weeks of sowing, gap filling and thinning operation were carried out wherever required for maintaining optimum plant stand in different treatments.

3.7.6 Inter culturing and weeding

The experimental field was kept weed free throughout the crop season. During investigation one interculturing and two hand weeding operations were carried out.

3.7.7 Irrigation

First irrigation was given immediately after sowing the seeds and second light irrigation was applied four days after first irrigation to ensure good germination and establishment of seedling. The subsequent irrigations were given as and when required at different growth stages of crop.

3.7.8 Plant protection measures

In general, the crop stand was satisfactory and there was no severe incidence of disease and pest attack, however crop was slightly infested by stem borer at initial stage. For effective control of this pest leaf whorls application of furadan 3G @ 2 kg ha^{-1} at 30 days after sowing was done.

3.7.9 Harvesting and threshing.

After the crop had attained physiological maturity the crop was harvested treatment wise manually prior to the finally harvest of crop five tagged plants from each plots were harvested for recording yield and yield attributes observations. The ring line of the gross plot was harvested first to eliminate the border effect and collected outside the experimental site. Then after, crop from the net plot area was harvested keeping 2-3 cm height from ground level. The harvested crop was tied into bundled, labelled carefully and allow for sun dry in respective plots. After complete drying the bundles were weighted just before threshing to record biological yield with the help of spring balance and then after plot wise threshing and cleaning were done manually. The grain yield from each net plot was weighed immediately and converted in to hectare basis by multiplying with the multiple factor.

3.8 Biometric observations

The various growth parameters, yield attributing characters and grain yield observations of maize crop were recorded during the course of investigation. The details of the techniques employed for recording the observations are described as under.

3.8.1 Pre harvest studies (growth parameters)

3.8.1.1 Plant population

The total number of plant from each net plot area was counted at 20 days after sowing and recorded as initial plant population per net plot area and just before harvesting of the crop the number of plant was counted from each net plot area and recorded separately as plant population at harvest of crop.

3.8.1.2 Plant height (cm)

The periodical plant height at 45 days after sowing as well as at harvest was measured from the ground level to the tip of the main shoot from the five randomly selected plants from each net plot and was tagged for recording the other parameters.

The average values of five plants from each plot at each stages were computed and recorded as different growth stages.

3.8.1.3 Basal girth

From each net plot, from the previously randomly selected five plants, basal girth was measured from middle portion of the plants with the help of vernier callipers and average was recorded and expressed as basal girth in centimetre.

3.8.2 Post harvest studies

3.8.2.1 Number of cobs per plant

Total number of cobs from previously selected each tagged plants were counted at harvest for respective treatments and mean values were recorded as a number of cobs per plant.

3.8.2.2 Length of cob (cm)

The five cobs from the previously tagged sample plants were collected and used for studying this character. Length of the five cobs was measured in centimetre from bottom to the end of the tip of the cob and mean values were recorded and expressed in length of cobs (cm).

3.8.2.3 Cob weight per plant (g)

The cobs which were previously collected from five tagged plant were used to compute the total weight of cobs. The average value of weight of cob per plant was worked out and recorded as cob weight per plant (g).

3.8.2.4 Number of grains per cob

Five cobs which were previously used for measuring cob weight were threshed and grains were cleaned manually. The number of grains was counted from all the previously collected five cobs from tagged plant and then average value was calculated and recorded separately for statistical analysis.

3.8.2.5 Seed index (g) (100 grain weight)

One hundred grains of maize were counted from composite sample randomly drawn from each net plot produce and weighed and recorded in gram for the respective treatments and expressed as seed index (g).

3.8.2.6 Grain yield (kg ha^{-1})

Cobs from all the plants of each net plot were harvested separately and allowed to sun-dry for about ten days. After complete drying of all cobs, the grains were separated manually from the cobs with the help of wooden sticks. The produce

so obtained was cleaned and weighed. The total grain weight kg per net plot was recorded after adding the grain weight of five sample plants of respective net plot and finally converted in to hectare basis by multiplying with multiple factor for each treatment.

3.8.2.7 Straw yield (kg ha^{-1})

After harvesting the cobs from the plants, the plants were harvested from the net plot separately and allowed to sun-dry for about ten days in the field. Then, it was tied into bundles of suitable size and straw yield kg per net plot was recorded. The total straw yield kg per net plot was recorded after adding the straw weight of five sample plants are taken from sample rows from each field and finally converted on hectare basis by multiplying with multiple factor for each treatment.

3.8.2.8 Harvest index (%)

Harvest index was calculated by using the formula suggested by Donald and hamblin (1976) and recorded separately for each treatment.

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Total biomass yield (kg ha}^{-1}\text{)}} \times 100$$

3.9 Quality parameters

Quality parameters studies pertaining to protein content and protein yield of maize were determined as per method described here under.

3.9.1 Protein content of grain (%)

The protein content was estimated in percentage by using NIR spectroscopy technique. NIR photo spectrometer instrument manufactured by Dicky John Company USA and measured the protein content of different sample.

The protein content of hybrid maize was estimated by using Near Infrared Reflectance Spectroscopy (NIR).

3.9.2 Protein yield (kg/ha)

The protein yield for each treatment was calculated by using following formula.

$$\text{Protein yield (kg/ha)} = \frac{\text{Protein content in the grain (\%) X Grain yield (kg/ha)}}{100}$$

3.10 Soil parameters

3.10.1 Available N, P_2O_5 and K_2O status of soil (Initial and after harvest of the crop)

To assess the initial status of chemical and physical properties of the soil, the representative soil samples (0-15 cm) from three spots of each plot before sowing of maize crop was collected, composited and air dried. To study the effect of different treatments on available nutrients status, treatments wise soil samples were collected from the net plot after harvest of the crop. The samples were powdered using a wooden mortar and pestle and passed through a 2 mm sieve to avoid metallic contamination. The soil samples were analyzed for available nitrogen, phosphorus and potash as per the methods given in Table 3.2.

3.11 Economics

3.11.1 Cost of cultivation (₹ ha^{-1})

The expenses incurred on all the cultural operations from preparatory tillage to harvesting and threshing including the cost of inputs *viz.*, seeds, fertilizers, irrigation, pesticides, *etc.* applied to each treatment was calculated on the basis of prevailing local charges.

3.11.2 Gross returns (₹ ha^{-1})

The gross returns in terms of rupees per hectare was worked out taking into consideration of the grain and straw yields of maize from each treatment on the basis of prevailing market prices during 2016.

3.11.3 Net return

The net return in term of rupees per hectare for each treatment was calculated by deducting the total cost of cultivation from the gross returns per hectare for respective treatments.

3.11.4 Benefit: Cost ratio (BCR)

The Benefit: Cost ratio (BCR) is the ratio of gross realization to total cost of cultivation and was calculated by using following formula.

$$\text{Benefit Cost Ratio} = \frac{\text{Gross realization (₹ ha}^{-1})}{\text{Total cost of cultivation (₹ ha}^{-1})}$$

3.12 Statistical analysis

The statistical analysis and interpretation of data of various characters studied in the present investigation was done by using the Fisher's method of analysis of variance technique as suggest by Panse and Sukhatme (1967). The experimental data on different aspect of maize ware subjected to statistical analysis by applying the technique of "Analysis of variance" and significance was tested by variance ratio i.e. F value at 5 percent level of significance. Standard error of means critical difference at 5% levels of significance and coefficient of variance were worked out to evaluated difference between means by following split plot design.

RESULTS

IV. RESULTS

The results of the field experiment entitled, "Performance of *rabi* maize (*Zea mays* L.) to different date of sowing and fertility levels" undertaken during *rabi* season of 2015-16 at the Cotton Research Farm, Khedbhramha, Sardarkrushinagar Dantiwada Agricultural University, Khedbhramha are presented in this chapter along with the statistical inferences in this chapter. The data pertaining to growth parameters, yield attributes, yields, quality parameters, economics and chemical study were subjected to statistical analysis and Analysis of Variance has been presented in appendix I to IV. The results have also been depicted graphically wherever felt necessary.

This chapter is mainly divided into following sub headings.

4.1 Effect of different treatments on plant population

4.2 Effect of different treatments on growth parameters

4.3 Effect of different treatments on yield attributes and yield

4.4 Effect of different treatments on quality parameters

4.5 Effect of different treatments on soil fertility status

4.6 Effect of different treatments on economics

4.1 Effect of different treatments on plant population

4.1.1 Plant population

The data regarding the effect of sowing dates and fertility levels on plant population at initial and at harvest of *rabi* maize are presented in Table 4.1.

The results indicated that the different sowing dates and fertility levels did not exert their significant effect on plant population at initial as well as at harvest of maize. This indicated that the plant population was uniform among all the treatments.

Table 4.1: Plant population of *rabi* maize as influenced by date of sowing and fertility levels

Treatments	Plant population/ net plot (13.2 m^2)	
	At 20 DAS	At harvest
Main plot : Date of sowing (D)		
D_1 : 15th October	82.30	69.4
D_2 : 1st November	83.10	69.8
D_3 : 15th November	81.60	68.9
D_4 : 1st December	80.60	68.4
S.Em.±	2.46	2.19
C.D. at 5 %	NS	NS
C. V. (%)	10.40	10.99
Sub plot : Fertility levels (NPK kg/ha) (F)		
F_1 : 150-75-00	79.69	66.9
F_2 : 175-87.5-00	81.96	68.9
F_3 : 200-100-00	84.06	71.5
S.Em.±	1.51	1.31
C.D. at 5 %	NS	NS
D x F (Interaction)	NS	NS
C. V. (%)	7.38	7.57

4.2 Effect of different treatments on growth parameters

4.2.1 Plant height (cm)

The data regarding the effect of sowing dates, fertility levels and their interaction effects on plant height of *rabi* maize recorded at 45 DAS and at harvest are presented in Table 4.2. Its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.2.

4.2.1.1 Plant height at 45 DAS

The plant height of maize measured at 45 DAS as influenced by date of sowing, fertility levels and their interaction effects are presented in Table 4.2 and also graphically depicted in Fig. 4.2.

4.2.1.1 Effect of date of sowing

Data presented in Table 4.2 revealed that the plant height of *rabi* maize measured at 45 DAS did not differed significantly due to different sowing dates. However, numerically taller plants (107.7 cm) were recorded by sowing on 1st November (D_2).

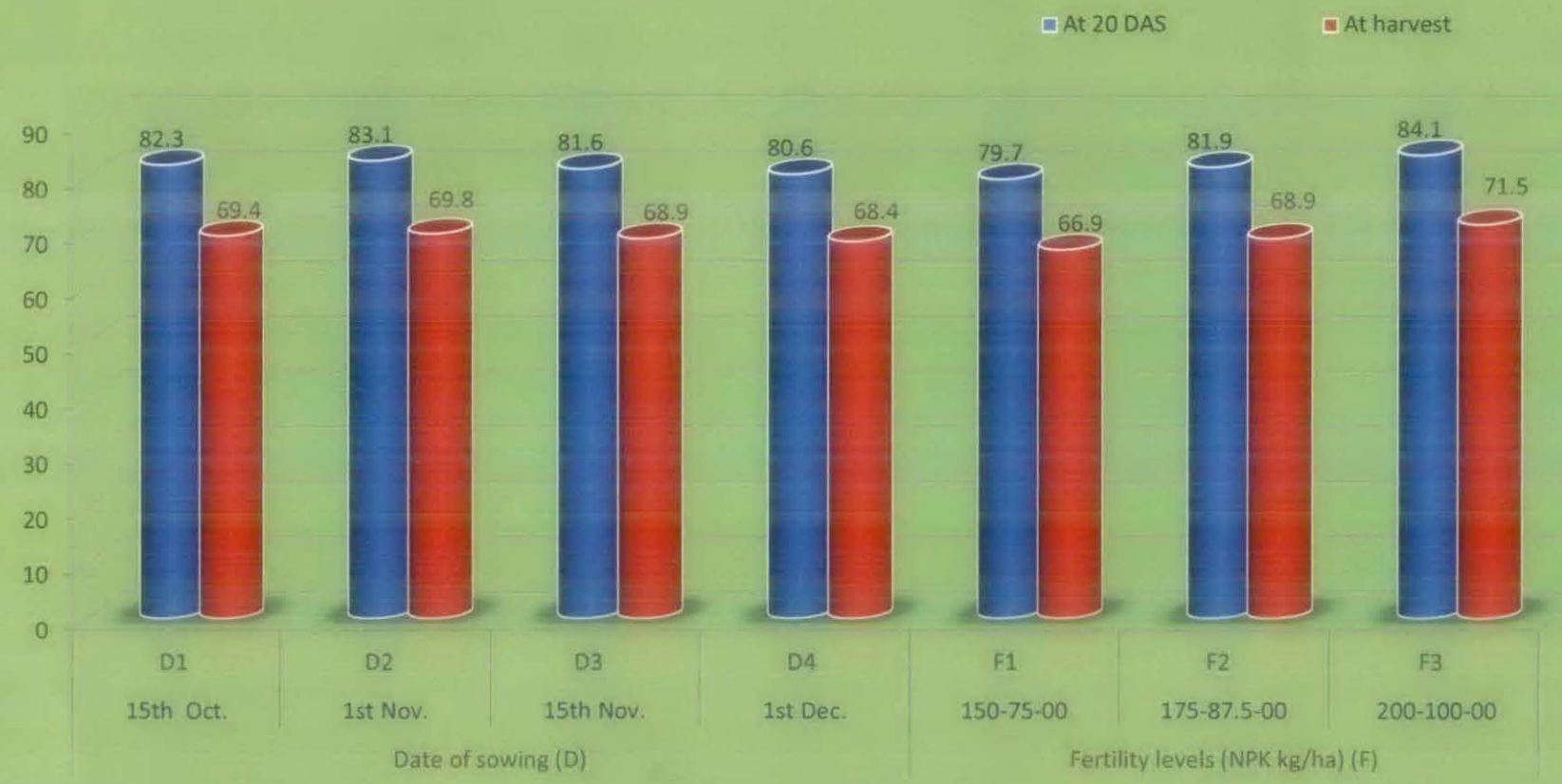


Fig. 4.1 Plant population at 20 DAS and at harvest of *rabi* maize crop influenced by date of sowing and fertility levels

Table 4.2: Plant height of *rabi* maize as influenced by date of sowing and fertility levels

Treatments	Plant height (cm)	
	At 45 DAS	At harvest
Main plot : Date of sowing (D)		
D_1 : 15th October	104.2	203.8
D_2 : 1st November	107.7	206.0
D_3 : 15th November	102.4	201.6
D_4 : 1st December	98.2	196.6
S.Em.±	3.90	7.44
C.D. at 5 %	NS	NS
C. V. (%)	13.08	12.76
Sub plot : Fertility levels NPK (kg/ha) (F)		
F_1 : 150-75-00	92.2	190.9
F_2 : 175-87.5-00	101.0	202.2
F_3 : 200-100-00	116.2	213.0
S.Em.±	2.18	4.27
C.D. at 5 %	6.37	12.47
D x F (Interaction)	NS	NS
C. V. (%)	8.46	8.46

4.2.1.2 Effect of fertility levels

Data presented in Table 4.2 indicated that different treatments of fertility levels had significant effect on plant height at 45 DAS. Significantly the tallest plant (116.2 cm) was recorded with application of 200-100-00 kg NPK per hectare (F_3). Significantly the smallest plant (92.2 cm) was recorded by application of 150-75-00 kg NPK per hectare.

2.1.3 Interaction effect

Interaction effects between date of sowing and fertility levels on plant height recorded at 45 DAS was found to be non significant.

4.2.2 Plant height at harvest

The plant height recorded at harvest as influenced by date of sowing, fertility levels and their interaction effects are presented in Table 4.2 and also graphically depicted in Fig. 4.2.

4.2.2.1 Effect of date of sowing

Data presented in Table 4.2 showed that the plant height of *rabi* maize measured at harvest did not differ significantly due to different date of sowing. However, numerically the taller plant (206.0 cm) was recorded by 1st November sowing (D_2).

4.2.2.2 Effect of fertility levels

An appraisal of data given in Table 4.2 revealed that the effect of different fertility levels on plant height of *rabi* maize recorded at harvest was found to be significant. Significantly the taller plant (213.0 cm) was found by application of 200-100-00 kg NPK per hectare (F_3) as compared to other treatments. However, it was found at par with application of 175-87.5-00 kg NPK per hectare (F_2). The smallest plant (190.9 cm) was recorded by application of 150-75-00 kg NPK per hectare (F_1).

4.2.2.3 Interaction effect

The interaction effects between date of sowing and fertility levels on plant height of *rabi* maize at harvest was found to be non significant.

4.2.3 Basal girth (cm)

The data regarding the effect of date of sowing, fertility levels and their interaction effects on basal girth of *rabi* maize crop recorded at harvest are presented in Table 4.3. Its analysis of variance is presented in appendix-I and the data are also graphically illustrated in Fig. 4.3.

Table 4.3: Basal girth, number of cobs per plant and cob length of *rabi* maize as influenced by date of sowing and fertility levels

Treatments	Basal girth (cm)	Number of cobs per plant	Cob length (cm)
Main plot : Date of sowing (D)			
D_1 : 15th October	6.7	1.51	18.8
D_2 : 1st November	6.8	1.57	19.3
D_3 : 15th November	6.6	1.45	18.5
D_4 : 1st December	6.3	1.42	17.8
S.Em.±	0.18	0.07	0.49
C.D. at 5 %	NS	NS	NS
C. V. (%)	9.46	16.31	9.20
Sub plot : Fertility levels (NPK kg/ha) (F)			
F_1 : 150-75-00	6.0	1.42	17.3
F_2 : 175-87.5-00	6.5	1.50	18.5
F_3 : 200-100-00	7.3	1.56	20.0
S.Em.±	0.11	0.04	0.27
C.D. at 5 %	0.33	NS	0.78
D x F (Interaction)	NS	NS	NS
C. V. (%)	6.90	10.71	5.75

4.2.3.1 Effect of date of sowing

Data regarding the effect of date of sowing on basal girth presented in Table 4.3 revealed that different date of sowing failed to exert their significant effect on the

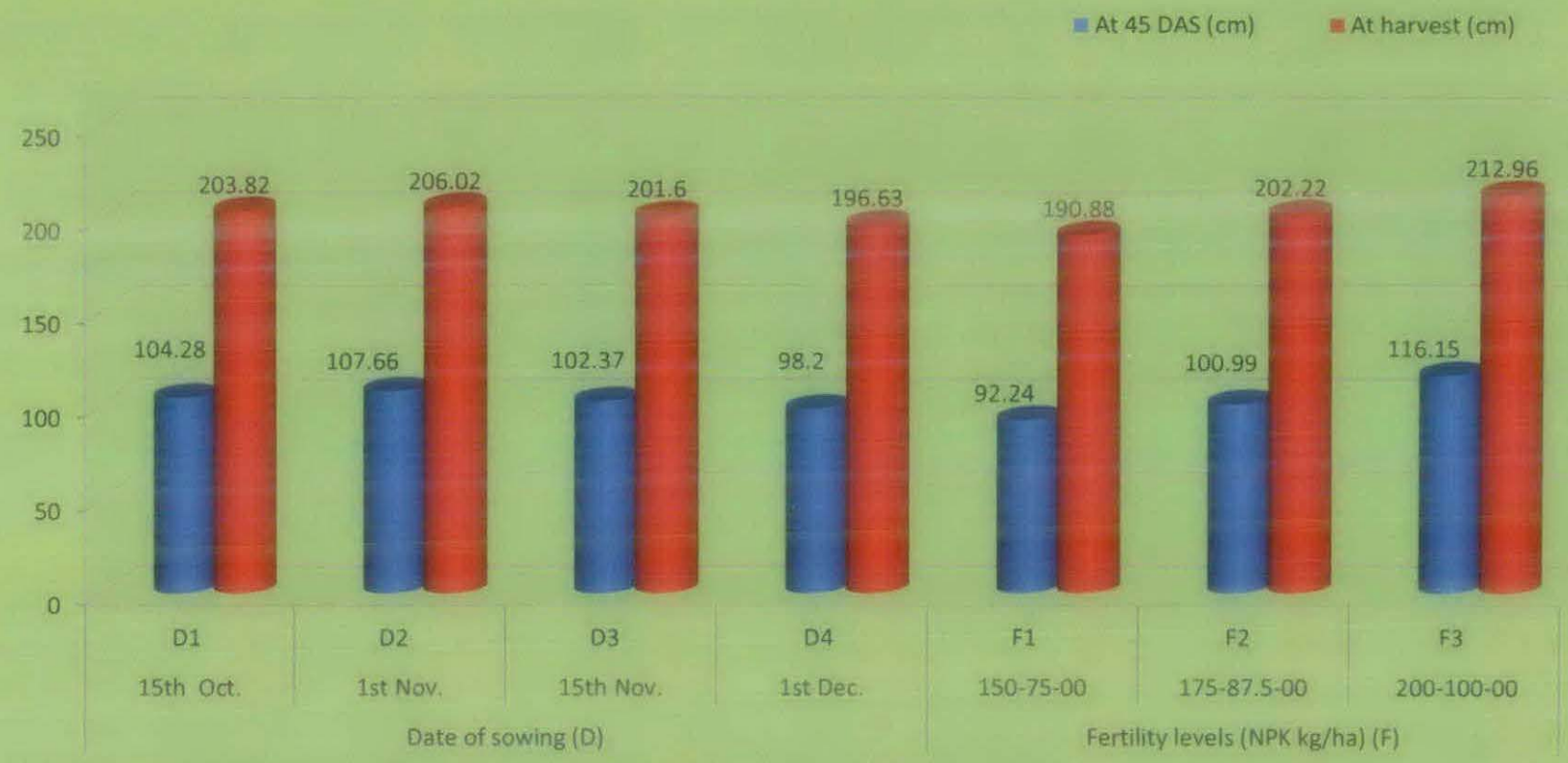


Fig. 4.2 Plant height at 45 DAS and at harvest of *rabi* maize crop influenced by date of sowing and fertility levels



Fig. 4.3 Basal girth, number of cob per plant and cob length of *rabi* maize crop influenced by date of sowing and fertility levels



Plate II: 1st November + 200-100-00 kg NPK / ha (D_2F_3)



Plate III: 1st November + 175-87.5-00 kg NPK / ha (D_2F_2)

basal girth of *rabi* maize measured at harvest. However, numerically the maximum basal girth of plant was recorded by 1st November sowing (D_2).

4.2.3.2 Effect of fertility levels

An examination of data on basal girth given in Table 4.3 showed that increasing levels of fertility significantly increased the basal girth at harvest. Significantly the maximum basal girth (7.3 cm) was recorded with application of 200-100-00 kg NPK per hectare (F_3), The lowest basal girth (6.0 cm) was recorded by application of 150-75-00 kg NPK per hectare (F_1).

4.2.3.3 Interaction effect

Interaction effects between date of sowing and fertility levels on basal girth of *rabi* maize crop at harvest was found to be non significant.

4.2.4 Number of cobs per plant

The data regarding the effect of date of sowing, fertility levels and their interaction effects on number of cobs per plant of *rabi* maize crop recorded at harvest are presented in Table 4.3. Its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.3.

4.2.4.1 Effect of date of sowing

Data presented in Table 4.3 revealed that the number of cobs per plant of *rabi* maize did not differ significantly due to different date of sowing. However, numerically the maximum number of cobs per plant (1.57) was recorded by 1st November sowing (D_2).

4.2.4.2 Effect of fertility levels

The data on number of cobs per plant presented in Table 4.3 showed that the effect of fertility levels on number of cobs per plant was found to be non significant. However, numerically the maximum number of cobs per plant (1.56) was recorded with application of 200-100-00 kg NPK per hectare (F_3).

4.2.4.3 Interaction effect

The interaction effects of date of sowing and fertility levels on number of cobs per plant of *rabi* maize was found to be non-significant.

4.2.5 Cob length (cm)

The data regarding the effect of date of sowing, fertility levels and their interaction effects on cob length of *rabi* maize crop recorded at harvest are presented

in Table 4.5 its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.3.

4.2.5.1 Effect of date of sowing

The data presented in Table 4.3 revealed that the different date of sowing treatments tried in the present experiment did not exert their significant effect on cob length of *rabi* maize. However, numerically the maximum cob length (19.3 cm) was recorded under treatment D_2 (1st November sowing).

4.2.5.2 Effect of fertility levels

An appraisal of the data presented in Table 4.3 indicated that the cob length was significantly influenced by different fertility levels. Significantly the highest cob length (20.0 cm) was observed under treatment F_3 (200-100-00 kg NPK per hectare). Treatment F_1 (150-75-00 NPK kg/ha) recorded the shortest cob (17.3 cm) of *rabi* maize.

4.2.5.3 Interaction effect

The interaction effects of date of sowing and a fertility level on cob length at harvest was found to be non-significant.

4.3 Effect of different treatments on yield attributes and yield

4.3.1 Number of grains per cob

The data pertaining to the effect of date of sowing, fertility levels and their interaction effects on number of grains per cob of *rabi* maize recorded at harvest are presented in Table 4.4. Its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.4.

4.3.1.1 Effect of date of sowing

The data presented in Table 4.4 showed that the number of grains per cob at harvest was influenced significantly by different date of sowing. Significantly higher number of grains per cob (376.81) was recorded by 1st November sowing (D_2) as compared to other treatments. But, it remained at par with treatment D_1 (15th October sowing). The lowest number of grains per cob (324.89) was recorded by treatment D_4 (1st December sowing).

4.3.1.2 Effect of fertility levels

An appraisal of data presented in Table 4.4 showed that the number of grains per cob at harvest influenced significantly due to different fertility levels. Increasing



Plate IV: 1st November + 150-75-00 kg NPK / ha (D_2F_1)



Plate V: 1st October + 200-100-00 kg NPK / ha (D_1F_3)

levels of fertility significantly increased the number of grains per cob. An application of 200-100-00 kg NPK per hectare (F_3) recorded significantly the maximum number of grains per cob (367.25). The lowest number of grains per cob (330.42) was recorded under treatment F_1 (150-75-00 kg NPK per hectare).

Table 4.4: Number of grains per cob, grain weight per cob and seed index of *rabi* maize as influenced by date of sowing and fertility levels

Treatments	Number of grains per cob	Grain weight per cob (g)	Seed index (g)
Main plot : Date of sowing (D)			
D_1 : 15th October	358.17	96.38	26.91
D_2 : 1st November	376.81	100.04	27.08
D_3 : 15thNovember	338.19	92.71	26.79
D_4 : 1st December	324.89	88.29	26.63
S.Em.±	11.18	2.61	0.99
C.D. at 5 %	35.76	8.34	NS
C. V. (%)	11.08	9.56	12.77
Sub plot : Fertility levels (NPK kg/ha) (F)			
F_1 : 150-75-00	330.42	87.52	25.86
F_2 : 175-87.5-00	350.88	94.66	27.02
F_3 : 200-100-00	367.25	101.13	27.67
S.Em.±	5.29	1.57	0.49
C.D. at 5 %	15.45	4.57	1.42
D x F	NS	NS	NS
C. V. (%)	6.06	6.64	7.25

4.3.1.3 Interaction effect

The interaction effect of date of sowing and fertility levels on number grains per cob was found to be non-significant.

4.3.2 Grain weight per cob (g)

The data regarding the effect of date of sowing, fertility levels and their interaction effects on grain weight per cob of *rabi* maize recorded at harvest are presented in Table 4.4. Its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.4.

4.3.2.1 Effect of date of sowing

The data presented in Table 4.4 indicated that the grain weight per cob was found to be significant due to different date of sowing. Significantly higher grain weight per cob (100.04 g) was recorded by 1st November sowing (D_2) than other date of sowing treatments. However it was found at par with 15th October (D_1) and 15th

November (D_3) sowing. The lowest grain weight per cob (88.29 g) was recorded by late sowing on 1st December (D_4).

4.3.2.2 Effect of fertility levels

An appraisal of data given in Table 4.4 indicated that different fertility levels had significant effect on grain weight per cob of *rabi* maize. Significantly the highest grain weight per cob (101.13 g) was found under treatment F_3 (200-100-00 kg NPK per hectare). Treatment F_1 (150-75-00 kg NPK /ha) recorded the lowest grain weight (63.51 g) per cob.

4.3.3.3 Interaction effect

The interaction effect of date of sowing and fertility levels on grain weight per cob was found to be non-significant.

4.3.4 Seed index (g)

The data regarding the effect of date of sowing, fertility levels and their interaction effects on seed index of *rabi* maize are presented in Table 4.4. Its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.6.

4.3.4.1 Effect of date of sowing

The data presented in Table 4.4 showed that seed index was not affected significantly due to different date of sowing treatments. However, numerically the maximum seed index (27.08 g) was recorded by 1st November sowing (D_2). The lowest seed index (26.63 g) was recorded by 1st December sowing (D_4).

4.3.4.2 Effect of fertility levels

It is evident from the data presented in Table 4.4 that the effect of different fertility levels on seed index was found to be significant. Significantly higher seed index (27.67 g) was recorded with application of 200-100-00 kg NPK per hectare (F_3) as compared to other treatments. However, it was found at par with treatment F_2 (175-87.5-00 kg NPK /ha). The lowest seed index (25.86 g) was found with application of 150-75-00 kg NPK per hectare (F_1).

4.3.4.3 Interaction effect

The interaction effect of date of sowing and fertility levels on seed index was found to be non-significant.

4.3.5 Grain yield (kg/ha)

The data regarding the effects of date of sowing and fertility levels on grain yield of *rabi* maize crop are presented in Table 4.5. Its analysis of variance is



Fig. 4.4 Number of grains per cob and grains per cob of *rabi* maize crop as influenced by date of sowing and fertility levels



Plate VI: 1st October + 175-87.5-00 kg NPK / ha (D_1F_2)



Plate VII: 1st October + 200-100-00 kg NPK / ha (D_1F_1)

presented in appendix-I and the data are also graphically depicted in Fig. 4.6.

4.3.5.1 Effect of date of sowing

Data presented in Table 4.5 showed that the grain yield of *rabi* maize was significantly influenced due to different date of sowing. Significantly higher (5125 kg/ha) grain yield was recorded by 1st November sowing (D_2) as compared to other treatments. However, it remained statistically at par with 15th October (D_1) sowing. Significantly the lower (4121 kg/ha) grain yield was recorded by 1st December sowing (D_4) than rest of the treatments.

Table 4.5: Grain yield, straw yield and harvest index of *rabi* maize as influenced by date of sowing and fertility levels

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
Main plot : Date of sowing (D)			
D_1 : 15th October	4790	5080	48.5
D_2 : 1st November	5125	5365	48.8
D_3 : 15th November	4590	4929	48.1
D_4 : 1st December	4121	4454	47.9
S.Em.±	162.64	130.32	1.31
C.D. at 5 %	520.32	416.93	NS
C. V. (%)	12.10	9.11	9.38
Sub plot : Fertility levels (NPK kg/ha) (F)			
F_1 : 150-75-00	4249	4700	47.4
F_2 : 175-87.5-00	4540	4817	48.4
F_3 : 200-100-00	5180	5355	49.1
S.Em.±	129.20	91.10	0.95
C.D. at 5 %	377.10	265.91	NS
D x F	NS	NS	NS
C. V. (%)	11.10	7.35	7.88

4.3.5.2 Effect of fertility levels

An examined of data on grain yield presented in Table 4.5 revealed that the effect of fertility levels on grain yield was found to be significant. Significantly the highest grain yield (5180 kg/ha) was produced with application of 200-100-00 kg NPK per hectare (F_3). The lowest grain yield (4249 kg/ha) was recorded by application of 150-75-00 kg NPK per hectare (F_1).

4.3.5.3 Interaction effect

The interaction effect of date of sowing and fertility levels on grain yield was found to be non-significant.

4.3.6 Straw yield (kg/ha)

The data regarding the effect of date of sowing, fertility levels and their interaction effects on straw yield of *rabi* maize are presented in Table 4.5. Its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.6.

4.3.6.1 Effect of date of sowing

The data presented in Table 4.5 showed that straw yield of *rabi* maize was significantly influenced due to different date of sowing. Significantly higher straw yield (5365 kg/ha) was noted by 1st November sowing (D_2) as compared to other treatments, but it was found at par with 15th October sowing (D_1). Significantly the lowest straw yield (4454 kg/ha) was recorded under 1st December sowing (D_4).

4.3.6.2 Effect of fertility levels

The straw yield of *rabi* maize was significantly influenced due to different fertility levels (Table 4.5). Significantly the highest straw yield (5355 kg/ha) was recorded by application of 200-100-00 kg NPK per hectare (F_3). Significantly lower straw yield (4700 kg/ha) was recorded with application of 150-75-00 kg NPK per hectare (F_1) as compared to other treatments.

4.3.6.3 Interaction effect

The interaction effects of date of sowing and fertility levels on straw yield of *rabi* maize was found to be non-significant.

4.3.7 Harvest index (%)

The data pertaining to the effect of date of sowing, fertility levels and their interaction effects on harvest index of *rabi* maize are presented in Table 4.5. Its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.5.

4.3.7.1 Effect of date of sowing

An appraisal of data presented in Table 4.5 showed that the effect of different dates of sowing on harvest index of *rabi* maize was found to be non-significant. However, numerically the highest harvest index (48.78 %) was recorded by 1st November sowing (D_2). While, the lowest harvest index (47.95 %) was recorded by 1st December sowing (D_4).

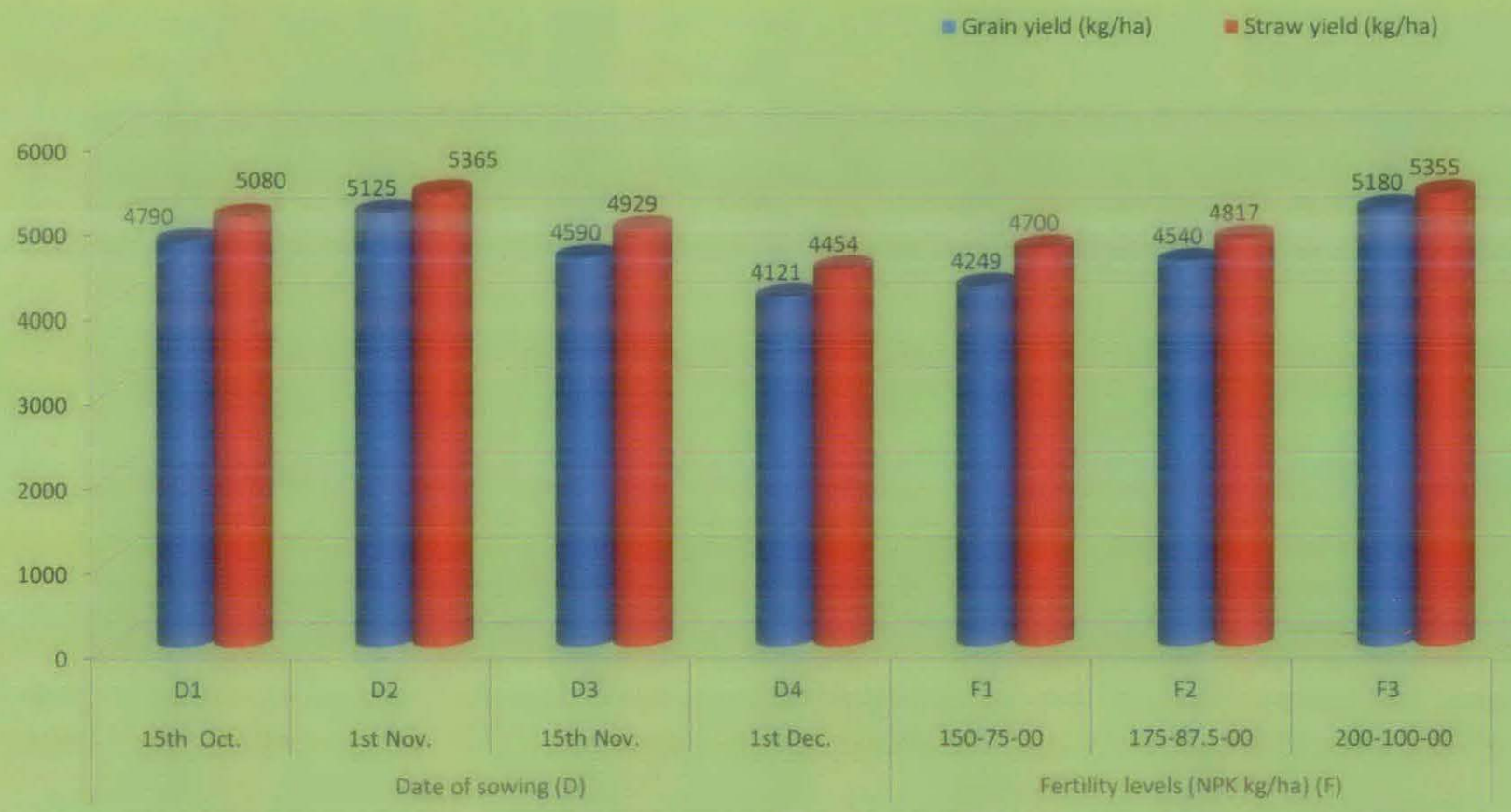


Fig. 4.5 Grain yield and straw yield of *rabi* maize crop influenced by date of sowing and fertility levels

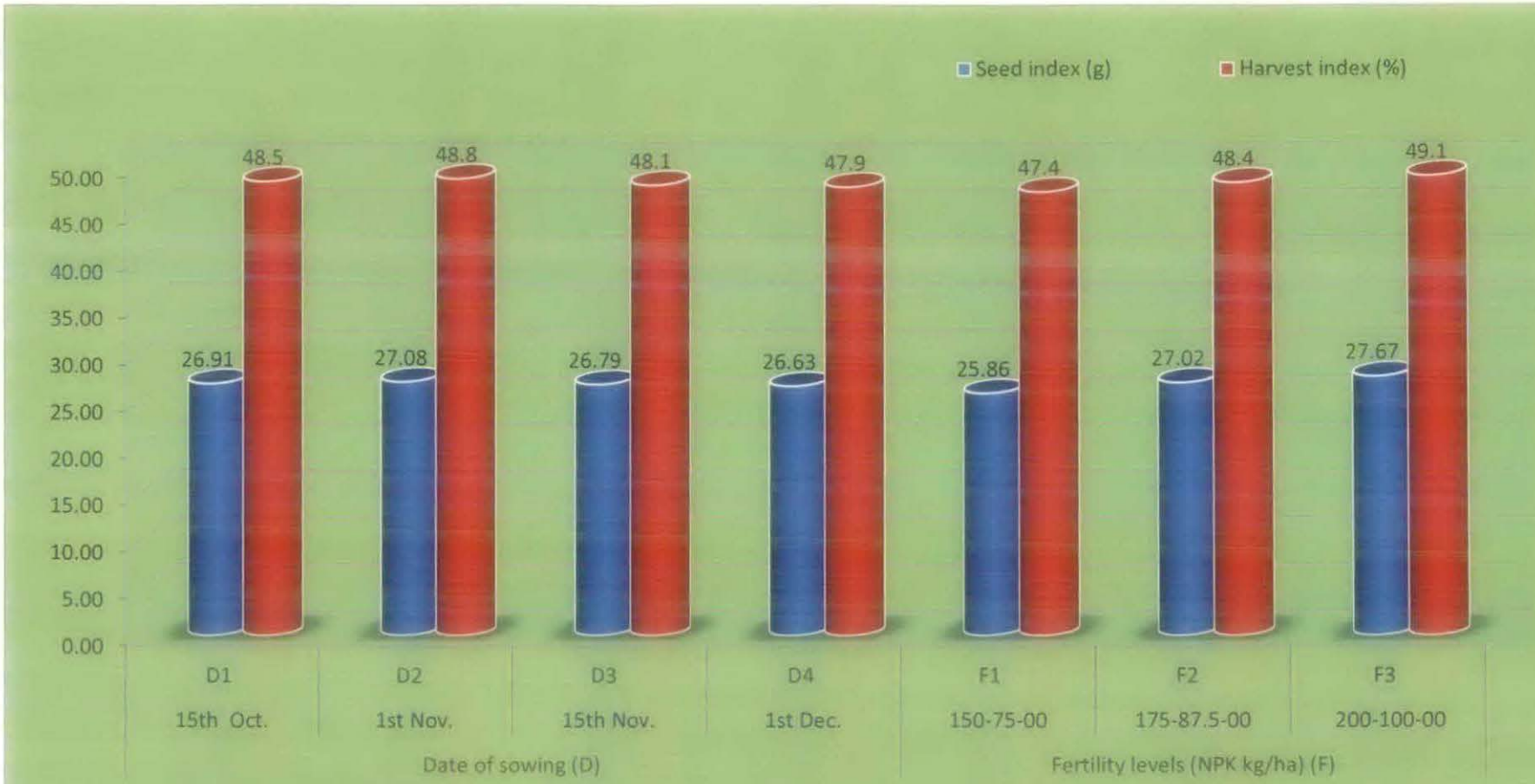


Fig. 4.6 Seed index and harvest index of *rabi* maize crop influenced by date of sowing and fertility levels



Plate VIII: 15th November + 200-100-00 kg NPK / ha (D_3F_3)



Plate IX: 1st December + 200-75-00 kg NPK / ha (D_4F_3)

4.3.7.2 Effect of fertility levels

The data presented in Table 4.5 revealed that the harvest index did not differ significantly due to different fertility levels. However, numerically the highest harvest index (49.14 %) was noted with application of 200-100-00 kg NPK per hectare (F_3). Fertilizing the *rabi* maize crop with 150-75-00 kg NPK per hectare (F_1) recorded the lowest harvest index (47.40 %).

4.3.7.3 Interaction effect

The interaction effect of date of sowing and fertility levels on harvest index was found to be non-significant.

4.4 Effect of different treatments on quality parameters

4.4.1 Protein content (%)

The data regarding the effect of date of sowing, fertility levels and their interaction effects on protein content of *rabi* maize are presented in Table 4.6. Its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.7.

Table 4.6 Protein content and protein yield of *rabi* maize as influenced by date of sowing and fertility levels

Treatments	Protein content (%)	Protein yield (kg/ha)
Main plot : Date of sowing (D)		
D_1 : 15th October	10.2	491
D_2 : 1st November	10.3	528
D_3 : 15th November	10.2	467
D_4 : 1st December	10.1	416
S.Em.±	0.30	19.79
C.D. at 5 %	NS	63.32
C. V. (%)	10.29	14.42
Sub plot : Fertility levels (NPK kg/ha) (F)		
F_1 : 150-75-00 kg/ha	10.0	422
F_2 : 175-87.5-00 kg/ha	10.1	461
F_3 : 200-100-00 kg/ha	10.5	544
S.Em.±	0.15	13.01
C.D. at 5 %	0.45	37.98
D x N	NS	NS
C. V. (%)	6.03	10.95

4.4.1.1 Effect of date of sowing

The data presented in Table 4.6 indicated that the effect of different date of sowing on protein content of maize was found to be non-significant. However,

numerically the highest protein content (10.32 %) was recorded by 1st November sowing (D_2). The lowest protein content (10.09 %) was noted under 1st December sowing (D_4).

4.4.1.2 Effect of fertility levels

The data presented in Table 4.6 showed that the different fertility levels had significant effect on protein content. Significantly higher protein content (10.51 %) was recorded by application of 200-100-00 kg NPK per hectare (F_3) than other fertility levels. However, it was found statistically at par with application of 175-87.5-00 kg NPK per hectare (F_2). The lowest protein content (9.95 %) was noted under treatment F_1 (150-75-00 NPK kg/ha)

4.4.1.3 Interaction effect

The interaction effect of date of sowing and fertility levels on protein content was found to be non-significant.

4.4.2 Protein yield

The data regarding the effects of date of sowing, fertility levels and their interaction effects on protein yield of *rabi* maize are presented in Table 4.6. Its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.7.

4.4.2.1 Effect of date of sowing

Data presented in Table 4.6 showed that the protein yield of *rabi* maize was significantly influenced due to different date of sowing. Significantly higher (528 kg/ha) protein yield was recorded by 1st November sowing (D_2) as compared to other treatments. However, it remained statistically at par with 15th October (D_1) and 15th November (F_3) sowing. The lowest (416 kg/ha) protein yield was recorded by 1st December sowing (D_4) than rest of the treatments.

4.4.2.2 Effect of fertility levels

An examined of data on protein yield presented in Table 4.6 revealed that the effect of fertility levels on protein yield was found to be significant. Significantly the highest protein yield (544 kg/ha) was produced with application of 200-100-00 kg NPK per hectare (F_3). Significantly the lowest protein yield (422 kg/ha) was recorded by application of 150-75-00 kg NPK per hectare (F_1).

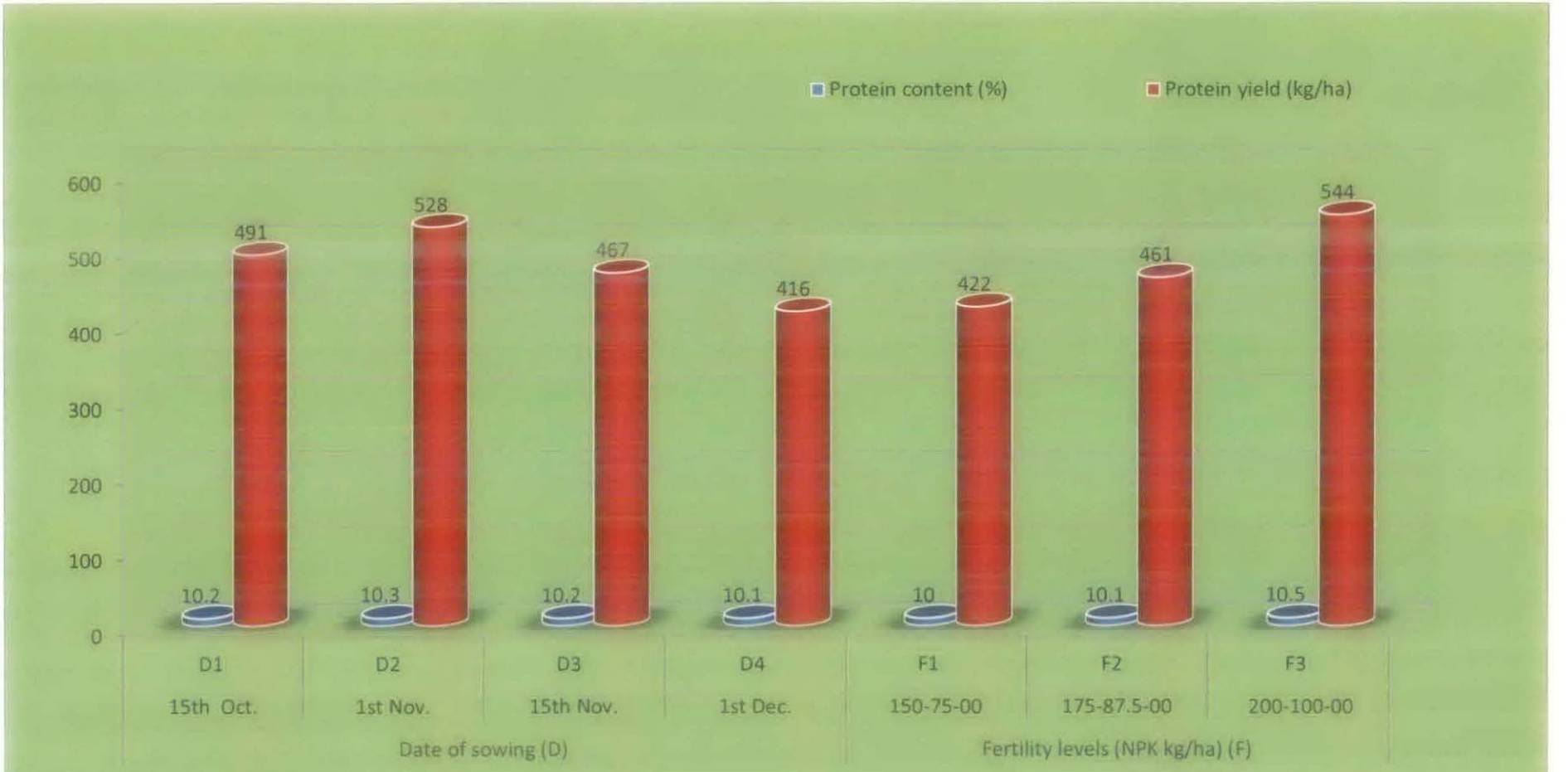


Fig. 4.7 Protein content and protein yield of *rabi* maize crop influenced by date of sowing and fertility levels



Plate X: 1st December + 150-75-00 kg NPK / ha (D_4F_1)

4.4.2.3 Interaction effect

The interaction effect of date of sowing and fertility levels on protein yield was found to be non-significant.

4.5 Effect of different treatments on soil fertility status

4.5.1. Available nitrogen content in soil (kg/ha)

The data regarding the effect of date of sowing, fertility levels and their interaction effects on available nitrogen in soil after harvest of *rabi* maize are presented in Table 4.7. Its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.8.

4.5.1.1. Effect of date of sowing

The data presented in Table 4.7 showed that the effect of different date of sowing on available nitrogen in soil after harvesting of the *rabi* maize crop was found to be non-significant. However, sowing the crop on 1st December (D_4) recorded numerically the maximum available nitrogen in soil (194.46 kg/ha) after harvest of *rabi* maize. Sowing the maize crop on 15th October recorded the minimum soil available nitrogen (173.21 kg/ha) after harvest of *rabi* maize.

4.5.1.2 Effect of fertility levels

An appraisal of data presented in Table 4.7 showed that the effect of different fertility levels on available nitrogen of the soil after harvest of *rabi* maize crop was found to be non-significant. However, numerically the maximum available nitrogen (189.92 kg/ha) in the soil after harvest of *rabi* maize was recorded by application of 200-100-00 kg NPK per hectare (F_3). The lowest available nitrogen (183.61 kg/ha) of the soil after harvest of *rabi* maize was recorded by application of 150-75-00 kg NPK per hectare (F_1).

4.5.1.3 Interaction effect

The interaction effects of date of sowing and fertility levels on available nitrogen of the soil after harvesting of *rabi* maize crop was found to be non-significant.

4.5.2 Available phosphorus (kg/ha) in soil

The data pertaining to the effect of different date of sowing, fertility levels and their interaction effects on available phosphorus of the soil after harvest of the *rabi* maize are presented in Table 4.7. Its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.8.

Table 4.7: Available N, P_2O_5, and K_2O in soil after harvest of *rabi* maize as influenced by date of sowing and fertility levels

Treatments	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Main plot : Date of sowing (D)			
D_1 : 15th October	179.21	34.26	238.84
D_2 : 1st November	185.22	35.42	245.20
D_3 : 15th November	189.70	36.31	249.61
D_4 : 1st December	194.46	37.83	254.64
S.Em.±	3.98	0.74	3.66
C.D. at 5 %	NS	2.36	NS
C. V. (%)	7.37	7.09	5.12
Sub plot : Fertility levels(NPK kg/ha) (F)			
F_1 : 150-75-00 kg/ha	183.61	34.84	243.45
F_2 : 175-87.5-00 kg/ha	187.92	36.14	247.80
F_3 : 200-100-00 kg/ha	189.92	36.93	249.96
S.Em.±	2.07	0.43	2.76
C.D. at 5 %	NS	1.26	NS
D x N (Interaction)	NS	NS	NS
C. V. (%)	3.94	4.80	4.48
Initial	178.50	30.70	262.01

4.5.2.1 Effect of date of sowing

The data presented in Table 4.7 indicated that the effect of date of sowing on available phosphorus in soil after harvest of the *rabi* maize was found to be significant. Significantly higher available phosphorus in soil (37.83 kg/ha) after harvest of *rabi* maize was recorded by 1st December sowing (D_4) than other treatments. However, it was found statistically at par with 15th November sowing (D_3). The lowest available phosphorus in soil (34.26 kg/ha) after harvest of *rabi* maize was recorded with sowing on 15th October (D_1).

4.5.2.2 Effect of fertility levels

The data presented in Table 4.7 showed that the effect of different fertility levels on available phosphorus of the soil after harvesting of *rabi* maize was found to be significant. Application of 200-100-00 kg NPK per hectare (F_3) recorded significantly higher available phosphorus (36.93 kg/ha) in soil after harvest of *rabi* maize as compared to other treatments. But it was found at par with application of 175-87.5-00 kg NPK /ha (F_2). Significantly the lowest available phosphorus in soil after harvest of *rabi* maize (34.84 kg/ha) was recorded under treatment F_1 (150-75-00 kg NPK per ha).



Fig. 4.8 Available N, P2O5 and K2O in soil after harvest of *rabi* maize crop influenced by date of sowing and fertility levels

4.5.2.3 Interaction effect

The interaction effects of date of sowing and fertility levels on available phosphorus of the soil after harvesting of *rabi* maize crop was found to be non significant.

4.5.3 Available potash (kg/ha) in soil

The data regarding the effect of different dates of sowing, fertility levels and their interaction effects on available potash of the soil after harvest of the *rabi* maize are presented in Table 4.7. Its analysis of variance is presented in appendix-I and the data are also graphically depicted in Fig. 4.8.

4.5.3.1 Effect of date of sowing

Available potash of the soil after harvest of the *rabi* maize did not differ significantly due to different date of sowing. However, sowing the crop on 1st December (D_4) recorded numerically the highest available potash (254.64 kg/ha) in the soil after harvest of *rabi* maize crop.

4.6.3.2 Effect of fertility levels

The data presented in Table 4.7 showed that the effect of different fertility levels on available potash of the soil after harvest of the *rabi* maize was found to be non-significant. However, application of 200-100-00 kg NPK per hectare (F_3) recorded numerically the maximum available potash (249.96 kg/ha) in the soil after harvest of *rabi* maize.

4.6.3.3 Interaction effect

The interaction effects of date of sowing and fertility levels on available potash of the soil after harvest of *rabi* maize crop was found to be non significant.

4.7 Effect of different treatments on economics

The data regarding the economics of the different treatments are presented in Table 4.8 and are also illustrated in Fig. 4.9. The cost of cultivation and prices of produce are given in appendix E.

4.7.1 Effect of date of sowing

The data given in Table 4.8 revealed that the maximum gross realization of (₹110787 ha^{-1}), net realization of (₹73371 ha^{-1}) and BCR (1.96 %) values were noted by sowing the crop on 1st November (D_2) followed by 15th October sowing having net realization of (₹ 66302 ha^{-1})and BCR of (1.77%). The minimum gross realization (₹89440 ha^{-1}), net realization (₹ 52024 ha^{-1}) and BCR (1.39 %) values were observed under late sowing the *rabi* maize crop on 1st December (D_4). The

response of 15th October (D_1) and 15th November sowing (D_3) was found intermediate.

Table 4.8 Economics of *rabi* maize as influenced by date of sowing and fertility levels

Treatment	Yield (kg/ha)		Gross return (₹/ha)	Cost of cultivation (₹/ha)	Net realization (₹/ha)	BCR (%)
	Grain	Straw				
Main plot: Date of sowing (D)						
D_1 : 15th October	4790	5080	103718	37416	66302	1.77
D_2 : 1st November	5125	5365	110787	37416	73371	1.96
D_3 : 15th November	4590	4929	99533	37416	62117	1.66
D_4 : 1st December	4121	4454	89440	37416	52024	1.39
Sub plot : Fertility levels (NPK kg/ha) (F)						
F_1 : 150-75-00 kg/ha	4249	4700	92481	36467	56014	1.54
F_2 : 175-87.5-00 kg/ha	4540	4817	98303	37416	60887	1.63
F_3 : 200-100-00 kg/ha	5180	5355	111808	38365	73443	1.91

4.7.2 Effect of fertility levels

The data presenting in Table 4.8 indicated that application of 200-100-00 kg NPK per hectare (F_3) to *rabi* maize recorded the maximum gross realization (₹ 111808 ha^{-1}), net realization (₹ 73443 ha^{-1}), and benefit: cost ratio (1.91 %). Whereas, the minimum values of gross realization (₹ 92481 ha^{-1}), net realization (₹ 56014 ha^{-1}) and BCR (1.54 %) values were observed by application of 150-75-00 kg NPK per hectare (F_1) to *rabi* maize crop.

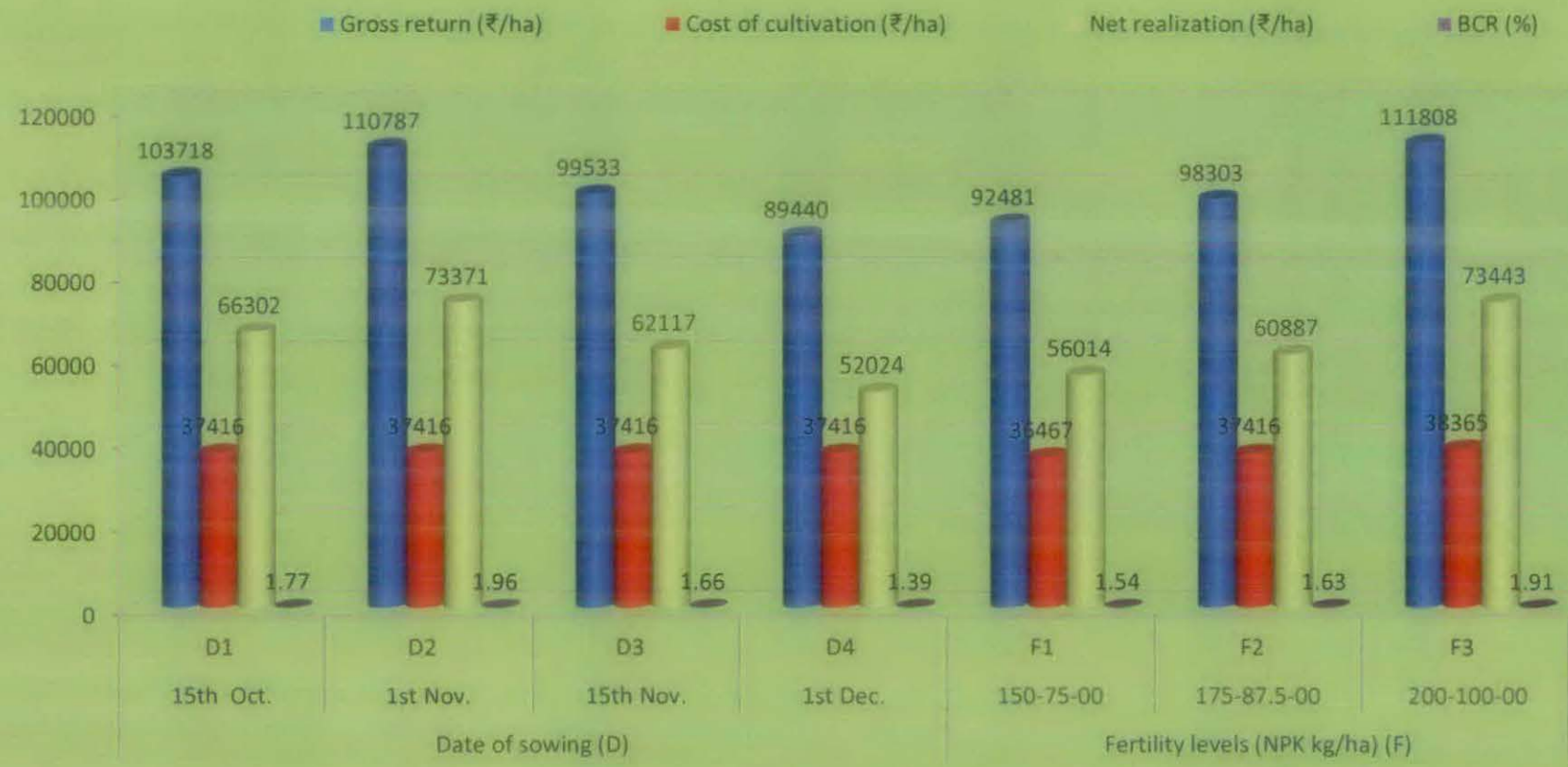


Fig. 4.9 Economics of *rabi* maize crop as influenced by date of sowing and fertility levels

DISCUSSION

V. DISCUSSION

During the course of presenting the results of the experiment entitled "Performance of *rabi* maize (*Zea mays* L.) to different date of sowing and fertility levels" carried out at the Cotton Research Farm, Khedbhramha, Sardarkrushinagar Dantiwada Agricultural University, Khedbhramha in the preceding chapter, many significant variations were obtained in growth characters, yield, yield attributes, quality and nutrient status after harvest of *rabi* maize under the influence of different treatments. Variations found significant or those assuming uniform trends are discussed in this chapter and duly supported by available evidences and relevant literature.

5.1 Effect of weather

The weather condition during *rabi* season of 2015-16 (Table.3.1, Fig.3.1) was favourable for the normal growth and development of *rabi* maize. There was no severe incidence of insect-pest and disease during the course of investigation. Moreover, the plant population was found uniform (Table 4.1). It is obvious from the foregoing information that, whatever variations observed in the present investigation are due to the effect of different treatments exercised in this experiment.

5.2 Effect of soil

The soil of the experimental field was loamy sand in texture. Fertility status of the soil evaluated before the commencement of investigation indicated that the soil was low in organic carbon (0.31%) and available nitrogen (178.50 kg/ha), medium in available phosphorus (30.70 kg/ha) and high in available potassium (262.01 kg/ha) having pH values of 7.4 (Table 3.2). Thus, soil of the experimental field had no any negative effect on the grain yield of the *rabi* maize crop.

5.3 Effect of plant population

The plant population per net plot recorded at initial and at harvesting stage was found to be non- significant due to different dates of sowing and fertility levels as well as their combined effects (Table 4.1). It means that the plant population in all the treatments was found uniform during the investigation which ultimately indicated that whatever variations observed in growth, yield attributes and yield were only due to the treatments effect but not due to plant population.

5.4 Effect of different treatments on plant growth parameters

5.4.1 Effect of date of sowing

The effect of date of sowing on growth parameters *viz,* plant height measured at 45 DAS and at harvest and basal girth were found to be non significant.

The plant height at 45 DAS and at harvest was found more or less equal under different dates of sowing. However, numerically higher plant height at 45 DAS and at harvest was noted by sowing the *rabi* maize on 1st November. The taller plant was recorded in the month of October and November sowing might be due to favourable temperature provided to maize crop in comparison to rest of the sowing time.

The basal girth did not differ significantly due to different date of sowing. However, numerically higher basal girth was recorded by 1st November sowing of *rabi* maize crop. The results are closely related with finding of Bainade *et al.,* (1987), Rahman *et al.,* (2001) and Adetayo *et al,* (2008).

5.4.2 Effect of fertility levels

The plant height recorded at 45 DAS and at harvest increased significantly with increasing fertility levels. Significantly higher plant height at 45 DAS and at harvest was recorded with the application of 200-100-00 kg NPK /ha (F_3) and it was to the tune of 15.01, 25.93 and 5.31, 11.56 percent higher than that of lower fertility levels of 175-87.5-00 kg NPK /ha (F_2) and 150-75-00 kg NPK /ha (F_1) at 45 DAS and at harvest, respectively, where as application of 175-87.5-00 kg NPK /ha increased 9.48 and 5.94 percent higher plant height than that of 150-75-00 kg NPK /ha at 45 DAS and at harvest, respectively (Table- 4.2)

The basal girth of *rabi* maize was significantly influenced due to different fertility levels. Application of 200-100-00 kg NPK /ha (F_3) recorded significantly the highest basal girth of *rabi* maize. The increase in basal girth of *rabi* maize under treatment F_3 (200-100-00 NPK kg/ha) was to the tune of 21.83 percent, respectively over treatment F_1 (150-75-00 kg NPK /ha).

The higher value of plant height (at 45 DAS and at harvest) and basal girth were recorded under treatment F_3 (200-100-00 NPK kg/ha) might be due to optimum levels of N and P_2O_5, a component of fertility management affected on crop growth seems to be due to maintaining congenial nutritional environment of plant system on account of their greater availability from soil media, which might have resulted in greater synthesis of amino acid, proteins and growth promoting substances, which seems to have enhance the meristematic activity and increased cell division and their

elongation. Further application of N & P might have increased interception, absorption and utilization of radiant energy which in turn increased photosynthesis and there by Plant height and basal girth. The present findings are within the close vicinity of these represented by Kumar and Singh (2002), Singh *et al.,* (2003) Patel *et al.,* (2009) and Wasnik *et al.,* (2012).

5.4.3 Interaction effect of date of sowing and fertility levels

The combined effect of date of sowing and fertility levels on different growth parameters *viz;* plant height at 45 DAS and at harvest and basal girth were found to be non significant. The results are in accordance with the findings of Verma *et al.,* (2012).

5.5 Effect of different treatments on yield attributes and yield

5.5.1 Effect of date of sowing

Various yield attributes *viz.,* number of grains per cob, grain weight per cob, grain and straw yield were significantly influenced under varying sowing dates (Table 4.6, 4.7 and 4.8). While, number of cobs per plant and cob length did not differ significantly due to different dates of sowing. (Table 4.3). However, numerically higher number of cobs per plant and cob length of *rabi* maize were recorded by 1st November (Table 4.4). It might be due to favourable temperature resulting the better growth and development of crop. The results are in close proximity with findings of Singh *et al.,* (1987) and Shaheenuzzamn *et al.,* (2015).

Sowing the *rabi* maize crop on 1st November produced significantly higher number of grains per cob at harvest over other date of sowing treatments which was 5.20, 11.41, and 15.98 per cent higher over 15th October, 15th November and 1st December sowing, respectively (Table 4.4). The higher number of grain per cob recorded under 1st November sowing might be due to more optimum temperature provided to maize crop in comparison to rest of the sowing dates which enhance rate of photosynthesis and also due to fact that good photosynthates accumulated in leaves and its transfer to economic part like grains, cobs etc. The results are closely related with findings of Singh *et al.,* (1987), Rahman *et al.,* (2008) and Reddy *et al.,* (2010).

Sowing the *rabi* maize crop on 1st November produced significantly higher grain weight per cob as compared to other date of sowing. The percent increased in grain weight per cob to the tune of 3.79, 7.90 and 13.30 over 15th October, 15th November and 1st December sowing, respectively (Table 4.4). Such significance

differences in grain weight per cob could be ascribed due to variation in climate characters especially relative humidity and maximum and minimum ambient temperature reported by Dass *et al.,* (2005). These findings are in close conformity with the finding of Reddy *et al.,* (2010).

Seed index of *rabi* maize did not differ significantly due to different date of sowing treatments. However, sowing the *rabi* maize crop on 1st November recorded numerically the maximum seed index. The lowest seed index was observed under late sowing on 1st December (Table 4.4). This might be due to optimum temperature provided to maize crop on 1st November in comparison to rest sowing dates. The experimental results also indicated that low temperature of atmosphere may be affect on crop growth. The results are closely related with finding of Singh *et al.,* (1981), Rahman *et al.,* (2001), Reddy *et al.,* (2010) and Singh *et al.,* (2014)

Significantly higher grain yield was produced by sowing the *rabi* maize crop on 1st November (Table 4.5) as compared to other treatments, but it was found at par with 15th October sowing. The percent increase in grain yield by 1st November sowing was to the tune of 6.53, 11.66 and 24.36 over 1st October, 15th November and 1st December sowing. The crop sown on 1st November gave 1004 kg higher grain yield than 1st December sowing. This might be due to optimum growth period favoured by 1st November sowing. The maximum yield recorded under 1st November sowing might be due to favourable temperature resulting in better growth and development of crop which increased yield attributes *viz;* number of grains per cob, grain weight per cob and seed index (Table 4.4) which led to better grain production efficiency by the crop. These yield attributes were also significantly decreased by early and delay in sowing (Table 4.4)., Moreover, the possible reason responsible for reduction in yield under advanced and delay sowing were temperature and length of growing periods. Further, differences of environmental condition during the growing period due to different sowing time may have reduced photoassimilate production during the lag phase of late sown maize because both temperature and incident solar radiation were low at that time which may affect on biomass production and perhaps sink activity. These findings are in close agreement with the results reported by Sawhney *et al.,* (1989), Nandal and Agarwal (1991), Rahman *et al.,* (2001), Rahman *et al.,* (2008), Reddy *et al.,* (2010) Singh *et al.,* (2015) and Shaheenuzzamn *et al.,* (2015).

Significantly higher straw yield was produced by sowing the *rabi* maize crop on 1st November (Table 4.5) as compared to other sowing dates. However, it remained

at par with 15th October sowing. Increased in straw yield of *rabi* maize under 1st November and 15th October sowing was to the tune of 9.02, 20.45 and 3.06, 14.05 percent over 15th November and 1st December sowing respectively. Higher straw yield obtained under these treatments might be due to environmental factors like temperature, solar radiation and day light gradually diminished during October to December and favoured the growth of early sown crop than that of late sown as evident from increased value of growth attributes *viz;* plant height and basal girth (Table 4.2 and 4.3). The results are in close vicinity with the findings of Bainade *et al.*, (1987), Porwal and Jain (1999), Singh *et al.*, (2015) and Shaheenuzzamn *et al.*, (2015).

As far as harvest index is concerned, various treatments of sowing date failed to express their significant effect; however, numerically the maximum value of harvest index (48.78 %) was noticed under 1st November sowing. The results are in consonance with those of Porwal and Jain (1999).

5.5.2 Effect of fertility levels

Yields attributes and yield viz., cob length, number of grains per cob, grain weight per cob and seed index (Table 4.3 and 4.4), were significantly influenced by various fertility levels. Whereas, number of cobs per plant did not differ significantly due to different fertility levels. However, numerically the maximum number of cobs per plant was noted under application of 200-100-00 kg NPK /ha (F_3). The results are closely related with findings of Tyagi *et al.*, (1998), Singh *et al.*, (2000), Singh *et al.*, (2003) and Tank *et al.*, (2006).

The cob length and number of grains per cob were significantly affected due to different fertility levels. Application of 200-100-00 kg NPK /ha recorded significantly the highest cob length and number of grains per cob of *rabi* maize (Table 4.3 and 4.4). The increased in cob length and number of grains per cob under higher fertility levels of treatment F_3 (200-100-00 kg NPK /ha) was to the tune of 15.18, 8.01 and 11.14, 4.66 percent respectively over treatments F_1 (150-75-00 kg NPK /ha) and F_2 (175-87.5-00 kg NPK /ha). The enhance cob length and number of grains per cob under higher fertility level might have been owing to significant improvement in the overall crop growth by virtue of increased photosynthetic efficiency. The greater availability of photosynthesis metabolites and nutrients to develop reproductive structures seems to have resulted in increased productive plants. The results are in

close conformity with the findings of Singh *et al.*, (2000), Singh *et al.*, (2003), Tank *et al.*, (2006) and Paramasivam *et al.*, (2011).

The grain weight per cob of *rabi* maize was significantly influenced due to different fertility levels. Application of 200-100-00 NPK kg/ha (F_3) recorded significantly the highest grain weight per cob of *rabi* maize (Table 4.4). The increased in grain weight per cob under treatment F_3 (200-100-00 kg NPK /ha) to the extent of 15.55 and 6.83 percent, respectively over lower fertility levels of F_1 (150-75-00 NPL kg/ha) and F_2 (175-87.5-00 NPK kg/ha). The variation in grain weight per cob under different fertility levels might be related to differences in size of photosynthate surface and to the relative efficiency of total sink activity. The results are closely related with the findings of Tyagi *et al.*, (1998), Singh *et al.*, (2000), Tank *et al.*, (2006) and Wasnik *et al.*, (2012).

The seed index of *rabi* maize was significantly influenced due to different fertility levels. Application of 200-100-00 kg NPK /ha (F_3) recorded significantly the highest seed index of *rabi* maize (Table 4.4). The better seed index under treatment F_3 (200-100-00 kg NPK /ha) might be due to adequate supply of nutrients with higher rate of fertility resulting in better growth and yield attributes of *rabi* maize (Table 4.2, 4.3 and 4.4). The increased in seed index of *rabi* maize under treatment 200-100-00 kg NPK /ha (F_3) was to the tune of 6.99 and 2.40 percent respectively over treatment F_1 (150-75-00 kg NPK /ha) and F_2 (175-87.5-00 kg NPK /ha). The present findings are within the close vicinity of those reported by Singh *et al.*, (2003), Tank *et al.*, (2006), Meena *et al.*, (2011), Paramasivam *et al.*, (2011), Wasnik *et al.*, (2012) and Mathukiya *et al.*, (2014).

Different fertility levels failed to express their significant effect on harvest index. However, numerically the maximum harvest index (49.14 %) was recorded under higher fertility level F_3 (200-100-00 kg NPK /ha). While the minimum harvest index (47.40 %) was recorded with lower fertility level of treatment F_1 (150-75-00 kg NPK /ha). The present findings are in close agreements with the results obtained by Tyagi *et al.*, (1998) and Singh *et al.*, (2000).

The grain yield of *rabi* maize was significantly influenced due to different fertility levels. Application of 200-100-00 kg NPK /ha (F_3) recorded significantly the highest grain yield of *rabi* maize. The lower fertility level of treatment F_1 (150-75-00 kg NPK /ha) recorded the minimum grain yield of *rabi* maize. The treatment F_1 (150-75-00 kg NPK /ha) and F_2 (175-87.5-00 kg NPK /ha) were found equally effective

with respect to grain yield. The increase in grain yield of *rabi* maize under treatment F_3 (200-100-00 kg NPK /ha) was to the tune of 21.91 and 14.09 percent respectively over treatments F_1 (150-75-00 kg NPK /ha) and F_2 (175-87.5-00 kg NPK /ha).

The straw yield of *rabi* maize was significantly influenced due to different fertility levels. Application of 200-100-00 kg NPK /ha (F_3) recorded significantly the highest straw yield of *rabi* maize. The increase in straw yield of *rabi* maize under treatment F_3 (200-100-00 kg NPK /ha) was to the tune of 13.93 and 11.16 percent, respectively over treatment F_1 (150-75-00 kg NPK /ha) and F_2 (175-87.5-00 kg NPK /ha). The increase in grain and straw yield under higher fertility level might be due to fact that higher level of nitrogen and phosphorus led to adequate supply of nutrients to the plant resulting in better growth and yield attributes (Table 4.2, 4.3 and 4.4) which in turn led to better physiological process and movement of photosynthates to sink which ultimately resulted in higher economic yield. The results are in close proximity with the findings of Subbian *et al.,* (1991), Mishra *et al.,* (1994), Tyagi *et al.,* (1998), Singh *et al.,* (2000), Tank *et al.,* (2006), Sepat and kumar (2007a), Paramasivam *et al.,* (2011) and Meena *et al.,*(2011) and Mathuliya *et al.,* (2014).

5.5.3 Interaction effect of date of sowing and fertility levels

The data of yield attributes and grain & straw yield (Table 4.3, 4.4 and 4.5) indicated that interaction effect of date of sowing and fertility levels did not express their significant effect on yield attributes *viz;* number of cobs per plant, cob length, number of grains per cob, grain weight, seed index and grain yield as well as straw yield. The results are in closely accordance with the findings of the Nandal and Agarwal, (1991) and Verma *et al.,* (2012).

5.7 Effect of different treatments on quality parameters

5.7.1 Effect of date of sowing

Varying sowing dates failed to produce its significant effect on grain quality in *rabi* maize in terms of protein content (Table 4.6). However numerically higher protein content in grain was observed in early sown crop *i.e.,* 1st November. Whereas the lower protein content was observed in late sown crop on 1st December.

Significantly higher protein yield was noted under treatment D_2 (1st November). However, it was found at par with sowing of *rabi* maize on 15th October and 15th November. The protein yield increased under 1st November, 15th October and 15th November to magnitude of 26.92, 18.02 and 12.25 percent over 1st December

sowing. This might be due to higher value of protein content and grain yield by 1st November, 15th October and 15th November sowing (Table 4.6). The results are in closely accordance with the findings of Verma *et al.*, (2012)

5.6.2 Effect of fertility levels

From the present study, it could be resulted that different fertility levels had significant effect on protein content and protein yield of *rabi* maize (Table 4.6). Significantly higher protein content and protein yield were recorded under treatment F_3 (200-100-00 kg NPK ha^{-1}) as compared to other treatments. However, it was found at par with treatment F_2 (175-87.5-00 kg NPK /ha). The protein yield increased under F_3 (200-100-00 kg NPK /ha) and F_2 (175-87.5-00 kg NPK /ha) treatment to the magnitude of 28.86 and 9.32 percent over treatment F_1 (150-75-00 kg NPK /ha). The higher protein content obtained by higher fertility levels might be due to optimum and regular supply of nitrogen nutrient to *rabi* maize crop for increasing growth and reproductive phase from soil and as it is integral part of protein the building blocks of plant. The higher protein yield recorded under higher fertility level F_3 (200-100-00 kg NPK /ha) might be due to higher protein content and grain yield of *rabi* maize (Table 4.6) as a results of higher growth and yield parameter due to higher availability of nutrients to the crop throughout the crop period. These findings are closely associated with those reported by Tank *et al.*, (2006), Arya and Singh (2001) Patel *et al.*, (2009) and Washnik *et al.*, (2012).

5.7.3 Interaction effect of date of sowing and fertility levels

The combined effect of date of sowing and fertility levels on quality parameters *viz.*, protein content and protein yield was found to be non significant.

5.8 Effect of different treatments on soil fertility status

5.8.1 Effect of date of sowing

The effect of date of sowing on the soil available nitrogen and potash did not show any nutrient mining effects after harvesting of the *rabi* maize crop (Table 4.7). However, numerically the maximum available nitrogen and potash in soil after harvest of *rabi* maize were recorded by 1st November sowing. The lowest available nitrogen and potash in soil after harvest of *rabi* maize was recorded under 1st December sowing.

While, available phosphorus in soil after harvest of *rabi* maize was significantly influenced due to different sowing dates (Table 4.7). Significantly higher

available phosphorus in soil after harvest of *rabi* maize was observed under 1st December sowing as compared to other sowing dates. But it was found at par with 1st November and 15th November sowing. This might be due to number of growing period was less as crop was sown on 15th November and 1st December due to a more fixation tendency of phosphorus, low phosphorus was utilize during later crop growing period, hence the remaining phosphorus is reserved in soil.

5.8.2 Effect of fertility levels

The available nitrogen in soil after harvest of *rabi* maize did not differ significantly due to different fertility levels. However, numerically the maximum available nitrogen in soil after harvest of *rabi* maize was recorded with application of 200-100-00 kg NPK /ha of *rabi* maize crop. Higher available nitrogen status in soil recorded under higher fertility level of 200-100-00 kg NPK /ha (F_3) be due to increase the activity of micro- organism leading to greater mineralization of applied and inherent nutrients and available nitrogen. The results are closely related with the findings of Tetarwal *et al.*, (2011).

Available phosphorus in soil after harvest of *rabi* maize was significantly affected due to different fertility levels (Table 4.7). Significantly higher available phosphorus in soil after harvest of *rabi* maize in soil was observed under treatment F_3 (200-100-00 kg NPK /ha) than all other fertility levels. However, it was found at par with treatment F_2 (175-87.5-00 kg NPK /ha). Higher available phosphorus after harvest of *rabi* maize recorded under treatment F_1 (150-75-00 kg NPK /ha) might be due to increase in the levels of fertility also assured the availability of this nutrient to the crop plant in adequate amount and remained in the soil in substantial quantity and after fulfilling the crop requirement that ultimately improved the soil fertility. It was confirmable by the findings of Saha and Mondal (2006).

The available potash in soil after harvest of *rabi* maize did not differ significantly due to different fertility levels. However, numerically the maximum available potash in soil after harvest of *rabi* maize was recorded by application of 200-100-00 kg NPK /ha (F_3).

5.8.3 Interaction effect of date of sowing and fertility levels

The interaction effect of date of sowing and fertility levels on soil fertility status after harvesting of *rabi* maize crop was found to be non significant.

5.9 Effect of different treatments on economics

5.9.1 Effect of date of sowing

Economics is the forecast consideration of the farmer's point of view while thinking a decision to adopt a new technology. The data in Table 4.8 indicated that the highest net realization of ₹ 73371 /ha was achieved under 1st November sowing, followed by 15th October sowing (₹ 66302 /ha). Both these treatments also recorded higher BCR (1.96 and 1.77) value over other treatments. The minimum net realization of ₹ 52024 /ha and benefit cost ratio of 1.39 were observed by 1st December sowing. This could be attributes to higher grain and straw yield recorded under early sown crop than late sown crop without any additional expenditure (Table 4.5). These findings are substantiated with those reported by Patel *et al.*, (1994), Porwal and Jain (1999) Singh *et al.*, (2015)

5.9.2 Effect of fertility levels

An application of 200-100-00 kg NPK per hectare recorded the maximum net realization of ₹ 73443 ha^{-1}, and benefit: cost ratio of 1.91% it was followed by treatment F_2 (175-87.5-00 kg NPK per hectare) having net realization of ₹ 60887 ha^{-1} and BCR of 1.63% (Table 4.8). The lowest net returns ₹ 350014 ha^{-1} and BCR value 1.54% were recorded by treatment F_1 (150-75-00 kg NPK /ha). This can be attributed due to the highest grain and straw yield recorded with the application of 200-100-00 kg NPK per hectare. These findings are in close conformity with those reported by sarma *et al.*, (2000), Patel *et al.*, (2000), Sepat and Kumar (2007_b), Lakshami *et al.*, (2009), Wasnik *et al.*, (2012) and Mathukiya *et al.*, (2014).

SUMMARY AND CONCLUSIONS

VI. SUMMARY AND CONCLUSIONS

A field experiment was conducted at Cotton Research Farm, Khedbhramha, Sardarkrushinagar Dantiwada Agricultural University, Khedbhramha to study the "Performance of *rabi* maize (*Zea mays* L.) to different date of sowing and fertility levels" during *rabi* season of 2015-16. The soil of experimental field was loamy sand in texture with low in organic carbon and available nitrogen, medium in available phosphorus and available potash having pH value of 7.40. Total twelve treatment combinations comprising four date of sowing in main plot *viz.*, 15th October (D_1), 1st November (D_2), 15th November (D_3) and 1st December (D_4) and three fertility levels in sub plot *viz.*, 150-75-00 kg NPK /ha (F_1), 175-87.5-00 kg NPK /ha (F_2) and 200-100-00 kg NPK /ha (N_3) were laid out in Split Plot Design with four replications.

The results presented and discussed in the preceding chapters are summarized here.

6.1 EFFECT OF DATE OF SOWING

6.1.1 Plant population recorded at initial stage and at the time of harvesting stage did not differ significantly due to different date of sowing.

6.1.2 The plant height recorded at 45 DAS as well as at harvesting time did not differ significantly due to different dates of sowing. However, numerically taller plant was recorded on 1st November sowing at 45 DAS as well as at harvesting time. While, the lowest plant height was recorded with late sowing on 1st December at 45 DAS and at harvest of maize.

6.1.3 The basal girth of *rabi* maize was not affected significantly due to different date of sowing. However, numerically the maximum basal girth was recorded by 1st November sowing.

6.1.4 The number of cobs per plant and cob length did not differ significantly due to different dates of sowing. However, numerically the maximum number of cobs per plant and cob length were recorded by 1st November sowing.

6.1.5 Sowing the *rabi* maize crop on 1st November recorded significantly higher number of grains per cob and grain weight per cob. However, it was found at par with 15th October sowing, in case of number of grains per cob while in case of grain weight per cob it remained at par with 15th October and 15th

November sowing. Significantly the lowest number of grains per cob and grain weight per cob were recorded by 1st December sowing.

1.6 Different dates of sowing failed to express their significant effects on seed index of *rabi* maize. However, the maximum seed index was noted under 1st November sowing. The lowest seed index was recorded under late sowing on 1st December.

1.7 Grain and straw yield of *rabi* maize were significantly influenced due to varying sowing dates. Crop sown on 1st November and 15th October were found equally good with respect to grain and straw yield of *rabi* maize. But these were found significantly superior over 15th November and 1st December sowing.

1.8 Various sowing dates failed to express its significant effect on harvest index in *rabi* maize. However, numerically the maximum harvest index was noted under 1st November sowing.

1.9 Quality parameters in terms of protein content in grain did not show any significant differences due to varying sowing dates. However, numerically the maximum protein content in grain was recorded by 1st November sowing.

1.10 Protein yield was significant affected by different date of sowing. The *rabi* maize crop sown on 1st November, 15th October and 15th November found equally effective with respect to protein yield, but found significantly superior over 1st December sowing.

1.11 Sowing the *rabi* maize crop on 1st December recorded significantly higher soil available phosphorus status after harvest of *rabi* maize. However, it remained at par with 15th October and 15th November sowing. While, the lowest soil available phosphorus status after harvest if *rabi* maize (34.26 kg/ha) was recorded by 15th October sowing (D_1). Different date of sowing did not impart their significant influence on available nitrogen and potash status of soil after harvest of *rabi* maize crop. However, numerically the maximum value of available nitrogen and potash in soil after harvest of *rabi* maize were recorded with 1st December sowing.

1.12 From economic point of view, sowing of *rabi* maize on 1st November secured the maximum net realization (₹73371/ha) and BCR (1.96%) followed by 15th October sowing.

6.2 EFFECT OF FERTILITY LEVELS

6.2.1 Plant population recorded at initial stage and at the time of harvesting of *rabi* maize did not differ significantly due to different fertility levels.

6.2.2 Application of 200-100-00 kg NPK /ha recorded significantly the highest basal girth. Whereas, the lowest basal girth was observed under treatment F_1 (150-75-00 kg NPK / ha)

6.2.3 Number of cobs per plant did not differ significantly due to different fertility levels. However numerically the maximum number of cobs per plant was recorded under treatment F_3 (200-100-00 kg NPK /ha).

6.2.4 Treatment F_3 (200-100-00 kg NPK /ha) recorded significantly the highest cob length, number of grains per cob and grain weight per cob. Significantly the lowest value of cob length, number of grains per cob and grain weight per cob were recorded under low fertility level of 150-75-00 kg NPK /ha (F_1).

6.2.5 Significantly the highest seed index was noted under application of 200-100-00 kg NPK /ha (F_3). While the lowest seed index was recorded with application of 150-75-00 kg NPK /ha (F_1).

6.2.6 Application of 200-100-00 kg NPK /ha (F_3) recorded significantly the highest grain (5180 kg/ha) and straw yield (5355 kg/ha). While, Significantly the lowest grain (4249 kg/ha) and straw yield (4700 kg/ha) were produced under treatment F_1 (150-75-00 kg NPK /ha).

6.2.7 Different fertility levels did not imparted their significant influence on harvest index. However, application of 200-100-00 kg NPK ha^{-1} (F_3) recorded numerically the maximum harvest index (49.14 %).

6.2.8 Application of 200-100-00 kg NPK ha^{-1} (F_3) recorded significantly higher protein content as compared to other treatments, but it was found at par with treatment F_2 (175-87.5-00 kg NPK /ha). While, the lowest protein content was recorded under treatment F_1 (150-75-00 kg NPK /ha).

6.2.9 Significantly the highest protein yield (544 kg/ha) was recorded with application of 200-100-00 kg NPK /ha (F_3). Significantly the lowest protein yield (422 kg/ha) was recorded by treatment F_1 (150-75-00 kg NPK /ha).

6.2.10 Application of 200-100-00 kg NPK /ha (F_3) recorded significantly the highest soil available phosphorus (36.39 kg/ha) after harvest of *rabi* maize. While, the lowest available phosphorus status (34.84 kg/ha) after harvest of *rabi* maize was recorded under treatment F_1 (150-75-00 kg NPK /ha). Different fertility

levels did not impart their significant influence on available nitrogen and potash status of soil after harvest of *rabi* maize crop. However numerically the maximum available nitrogen and potash status in soil after harvest of *rabi* maize were recorded by treatment F_3 (200-100-00 kg NPK /ha).

6.2.11 The maximum net return (₹73443/ha) and benefit cost ratio (1.91%) were recorded with application of 200-100-00 kg NPK/ha (F_3) followed by treatment F_2 (175-87.5-00 kg NPK/ha). While the minimum net return (₹ 56014/ha) and benefit cost ratio (1.54%) observed with application of 150-75-00 kg NPK/ha (F_1).

6.3 INTERACTION EFFECT

The interaction effect of date of sowing and fertility levels were found non significant with respect to growth, yield attributes and grain and straw yield as well as quality parameters (protein content and protein yield).

CONCLUSION

On the basis of one year experimentation, it can be concluded that the maximum grain yield, net realization and benefit: cost ratio in *rabi* maize crop (HQPM 1) can be achieved by sowing on 15th October to 1st November and fertilizing with 200-100-00 kg NPK per hectare.

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APPENDICES

Appendix-A

Analysis of variance for plant population at initial and at harvest and plant height at 45 DAS and at harvest

Source of variation	DF	Mean sum of square				
		Plant population per hectare		Plant height (cm)		Basal girth (cm)
		Initial	At harvest	45 DAS	At harvest	
Replications	3	59..48	24.52	69.50	128.46	0.29
Date of sowing	3	13.52	4.05	186.64	193.25	0.56
Error (a)	9	78.48	57.77	182.48	663.68	0.38
Fertility levels	2	76.39	85.12	2342.53	1953.03	7.11
D x F	6	1.17	1.45	16.01	27.44	0.03
Error (b)	24	36.53	27.37	76.14	291.58	0.21

Appendix-B

Analysis of variance for number of cobs per plant, cob length and number of grains per cob at harvest

Source of variation	DF	Mean sum of square			
		Number of cobs per plant	Cob length (cm)	Number of grains per cob	Grain weight per cob (g)
Replications	3	0.18	4.53	2681.76	107.62
Date of sowing	3	0.07	4.62	6218.40	315.51
Error (a)	9	0.05	2.92	1499.23	81.53
Fertility levels	2	0.00	28.23	5448.17	741.06
D x F	6	0.00	0.35	371.43	12.45
Error (b)	24	0.02	1.17	448.04	39.29

Appendix-C

Analysis of variance for seed index, grain yield, straw yield and harvest index

Source of variation	DF	Mean sum of square			
		Seed index (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
Replications	3	45.26	306786.19	206928.63	17.09
Date of sowing	3	0.43	2113540.69	1744093.91	1.76
Error (a)	9	11.76	317446.69	203838.24	20.55
Fertility levels	2	13.79	3632180.65	1954667.65	12.20
D x F	6	0.00	50216.98	85765.70	2.05
Error (b)	24	3.79	267111.06	132805.47	14.48

Appendix-D

Analysis of variance for protein content, protein yield and available N, P_2O_5, K_2O in soil

Source of variation	DF	Mean sum of square				
		Protein content (%)	Protein yield (kg/ha)	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Replications	3	0.31	6412.26	18.58	0.15	67.67
Date of sowing	3	0.10	26576.83	506.76	26.90	536.02
Error (a)	9	1.11	4701.61	189.79	6.51	160.26
Fertility levels	2	1.34	61779.56	166.52	18.21	178.08
D x F	6	0.00	593.60	2.33	0.53	2.23
Error (b)	24	0.37	2709.68	68.79	2.98	122.30

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Appendix-E

Details of cost of cultivation of *rabi* maize crop per hectare

Sr. No.	Particulars	Application		Frequency	Cost (₹/ha)
		Pair of bullock	Labour		
A	**Pre sowing operation**				
1	Tractor ploughing (2.0 hrs)	-	-	2	1800
2	Harrowing and planking by tractor (1.5 hrs)	-	-	1	675
B	**Sowing operation and fertilizer application**				
1	Preparation of beds, bunds, irrigation channels	1	3	1	900
2	Sowing of seeds and Fertilizer application by tractor (2.0 hrs)		1	1	1050
3	Seed 20 kg/ha		-	1	3000
4	Fertilizer	-	-	-	6644
5	Irrigation		8	8	7600
C	**Post sowing operation**				
1	Interculturing	1	1	1	600
2	Fertilizer application cost		1	3	450
3	Weeding		20	2	3000
4	Harvesting cost		25	1	3750
D	Total (A+B+C) =				30669
E	Suspension & land revenue (10 %)				3067
F	Interest on working capital (12 %)				3680
G	Total cost (D+E+F) =				37416

Fertility levels (F)	DAP (kg/ha)	Urea (kg/ha)	Fertilizer cost (₹)	Common cost (₹)	Total cost (₹)
150-75-00 NPK	162.75 Price: 4052.48 ₹	261.92 Price: 1642.64 ₹	5695	30772	36467
175-87.5-00 NPK	189.88 Price: 4727.89 ₹	305.58 Price: 1915.99 ₹	6644	30772	37416
200-100-00 NPK	217 Price: 5403.30 ₹	349.23 Price: 2189.67 ₹	7593	30772	38365

Note:-

Labour charges	: ₹150/hr	Bullock charges	: ₹ 450
Tractor charges	: ₹ 450/hr	Seed price of maize (HQPM-1)	: ₹150/kg
Urea	: ₹ 6.27/kg	Selling price of maize grain	: ₹ 19/kg
DAP	: ₹24.90/kg	Selling price of maize straw	: ₹ 2.50/kg
Irrigation	: ₹ 800/ha		

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CERTIFICATE

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