

**EFFECT OF WEATHER PARAMETERS ON GROWTH
AND YIELD OF SCENTED RICE UNDER DIFFERENT
GROWING ENVIRONMENT**

M.Sc. (Ag.) THESIS

by

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**DEPARTMENT OF AGROMETEOROLOGY
COLLEGE OF AGRICULTURE, RAIPUR
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INDIRA GANDHI KRISHI VISHWAVIDYALAYA
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**EFFECT OF WEATHER PARAMETERS ON GROWTH
AND YIELD OF SCENTED RICE UNDER DIFFERENT
GROWING ENVIRONMENT**

Thesis

Submitted to the

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Jeetendra Kumar Netam

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REQUIREMENTS FOR THE DEGREE OF**

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CERTIFICATE – I

This is to certify that the thesis entitled “**Effect of weather parameters on growth and yield of scented rice under different growing environment**” submitted in partial fulfillment of the requirements for the degree of **Master Of Science In Agriculture** of the Indira Gandhi Krishi Vishwavidyalaya, Raipur, is a record of the bonafide research work carried out by **Jeetendra Kumar Netam** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee and the Director of Instructions.

No part of the thesis has been submitted for any other degree or diploma or has been published/ published part has been fully acknowledged. All the assistance and help received during the course of the investigations have been duly acknowledged by him.

Date: 21/7/17

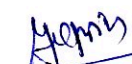

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CERTIFICATE – II

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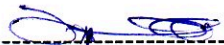
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Approved/Not approved

Director of Instructions

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“Words can hardly express my emotions as it is much more than express here.”

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LIST OF NOTATIONS/SYMBOLS

ABBREVIATIONS		FULL FORM
D₁	=	27 th June
D₂	=	12 th July
D₃	=	27 th July
V₁	=	Badshah Bhog Selection-1
V₂	=	Dubraj Selection – 1
V₃	=	Tarun Selection – 1
P₁	=	Sowing to panicle initiation
P₂	=	Panicle initiation to 50% flowering
P₃	=	50% flowering to maturity
mm	=	Millimeter
cm	=	Centimeter
g	=	Gram
kg	=	Kilogram
m	=	Meter
t	=	Tone
@	=	At the rate
T_b	=	Base temperature
⁰C	=	Degree Celsius
%	=	Per cent
a.i.	=	Active ingredient
Cv	=	Cultivar
ha	=	Hectare
*	=	Significant at 5% level of significance
**	=	Significant at 1% level of significance
SE_m±	=	Standard error due to mean
N	=	Maximum possible sunshine hour
n	=	Actual sunshine hour
L_c	=	Length of kernel after cooking
L_u	=	Length of kernel before cooking

Bc	=	Breadth of kernel after cooking
Bu	=	Breadth of kernel before cooking
Tmax	=	Maximum temperature
Tmin	=	Minimum temperature
RH₁	=	Relative humidity of morning
RH₂	=	Relative humidity of afternoon

LIST OF ABBREVIATIONS

ABBREVIATIONS	FULL FORM
DAT	= Days After Transplanting
GDD	= Growing Degree Days
PTU	= Photo Thermal Units
HTU	= Helio Thermal Units
HUE	= Heat Use Efficiency
RUE	= Radiation Use Efficiency
IPAR	= Intercepted Photo Synthetically Active Radiation
PCV	= Phenotypic Coefficient of Variation
GCV	= Genotypic Coefficient of Variation
LAI	= Leaf Area Index
RMSE	= Root Mean Square Error
BSH	= Bright Sunshine Hour
CGR	= Crop Growth Rate
RGR	= Relative Growth Rate
RCBD	= Randomized Complete Block Design
SSP	= Single Super Phosphate
MOP	= Murate of Potash
LS	= Long Slender
SS	= Short Slender
MS	= Medium Slender
SB	Short Bold
NS	= Non Significant
CD	= Critical Difference
CV	= Coefficient of Variance
SMW	= Standard Meteorological Week
Kmph	= Kilo meters per hour
KLAC	= Kernel Length After Cooking

THESIS ABSTRACT

- (a) Title of the Thesis : "Effect of weather parameters on growth and yield of scented rice under different growing environment"
- (b) Full Name of the student : Jeetendra Kumar Netam
- (c) Major subject : Department of Agrometeorology
- (d) Name and address of the : Shri J.L.Chaudhary
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- (e) Degree to be awarded : M.Sc. Agriculture



(Student)



(Major Advisor)

Date..... 21/7/17


Head of the department

ABSTRACT

The present investigation is entitled "Effect of weather parameters on growth and yield of scented rice under different growing environment" was carried out during *kharif* season 2016 at Research and Instructional Farm of Indira Gandhi Agricultural University, Raipur, Chhattisgarh with three scented rice varieties viz. Badshah bhog selection-1, Dubraj selection-1 and Tarun selection-1, sown under three different growing environments in factorial Randomized block design with three replications.

The results of phenological studies revealed that the days taken from sowing to seedling, tillering, panicle initiation, booting, panicle emergence, 50 percent flowering, milking, dough and maturity varied with different varieties.

Most of the weather parameters were highly significantly correlated with dry matter at P₃ stage (50% flowering-maturity) and also significantly affected the grain yield at P₂ stage ((Panicle initiation stage (PI)-50% flowering).

The results of growth characters revealed that plant height, total dry matter production, Crop growth rate, relative growth rate, test weight, grain yield, harvest index were recorded maximum in Dubraj selection-1 as compared to rest of the varieties. Whereas, the effective tillers, filled grain, straw yield, were recorded maximum in Tarun selection-1 and Badshah bhog selection-1, Dubraj selection-1 respectively while length of panicle and sterility percentage is maximum in Badshah bhog selection-1. With respect to the heat units viz., growing degree days, photo thermal and helio thermal units were recorded maximum in Dubraj selection-1 and Tarun selection-1 whereas, radiation use efficiency and heat use efficiency was maximum in Tarun selection-1. The results, crop growth rate and relative growth rate showed that these were maximum in Dubraj selection-1.

With regards to the different growing environments, the results revealed that the growing environments on 27th June (D₁) takes longer duration from sowing to maturity as compared to the growing environments on 12th July (D₂) and 27th July (D₃). The growth characters like plant height, total dry matter production, test weight, number of effective tillers per m², grain yield, harvest index were recorded maximum under growing environments on 27th June (D₁), while crop growth rate, sterility percentage, are maximum in growing environments on 27th July (D₃) and relative growth rate, filled grain per panicle, length of panicle, are maximum under 12th July (D₂) growing environments. With respect to the heat units viz. accumulated growing degree days, photo thermal unit, helio thermal unit, radiation use efficiency and heat use efficiency were recorded maximum in crop sown on 27th June (D₁) growing environment.

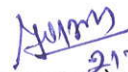
शोधग्रंथ सारांश

- (अ) शोध शीर्षक : अलग-अलग बढ़ते पर्यावरण के तहत अलग-अलग सुगंधित धान किस्मों के विकास और उपज पर मौसम मापदंडों का प्रभाव
- (आ) विद्यार्थी का पुरा नाम : जीतेन्द्र कुमार नेताम
- (इ) प्रमुख विषय : कृषि मौसम विज्ञान
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प्रमुख सलाहकार के हस्ताक्षर


छात्र के हस्ताक्षर

दिनांक..... 21/7/17


विभागाध्यक्ष के हस्ताक्षर

सारांश

खरीफ मौसम वर्ष-2016 के दौरान शोध एवं अनुदेशात्मक प्रक्षेत्र, इंदिरा गांधी कृषि विश्वविद्यालय रायपुर, छत्तीसगढ़ पर "अलग-अलग बढ़ते पर्यावरण के तहत अलग-अलग सुगंधित धान किस्मों के विकास और उपज पर मौसम मापदंडों का प्रभाव" विषय में वर्तमान परिक्षण तीन सुगंधित धान किस्मों जैसे बादशाह भोग चयन-1, दुबराज चयन-1 और तरुण चयन-1, को तीन अलग-अलग बढ़ते वातावरणों में बुआई कर कमगुणित यादृच्छिक खंड अभिकल्पना (फेक्टोरियल रैंडमाइज्ड ब्लॉक डिजाइन) में तीन प्रतिकृतियां के साथ किया गया।

फेनोलॉजिकल अध्ययन के परिणाम यह प्रकट करता है कि बीज बुआई से रोपाई, कल्ले निकलते समय, दाने का उदभव, 50 प्रतिशत पुष्पन, दुग्ध, दाने अवस्था और परिपक्वता अवस्था अलग-अलग धान किस्मों के साथ भिन्न होता है। अधिकतर मौसम मापदंड के साथ शुष्क पदार्थ पी-3 अवस्था (50 प्रतिशत पुष्पन-परिपक्वता) पर अत्यधिक सार्थक सहसंबद्ध एवं पी-2 अवस्था पर दाने के उपज में महत्वपूर्ण प्रभाव था।

पुष्पन-परिपक्वता) पर अत्यधिक सार्थक सहसंबद्ध एवं पी-2 अवस्था पर दाने के उपज में महत्वपूर्ण प्रभाव था।

वृद्धि विशेषता के परिणाम बताते हैं कि बाकी सभी किस्मों की तुलना में पौधे की ऊँचाई, कुल शुष्क पदार्थ उत्पादन, फसल वृद्धि दर, सापेक्ष वृद्धि दर, परीक्षण वजन, अनाज उपज, फसल सूचकांक को अधिकतम दुबराज चयन-1 में दर्ज किया गया था। जबकि प्रभावी कल्ले, भरा दाना, को अधिकतम तरुण चयन-1, बादशाह भोग चयन -1, दुबराज चयन -1 में क्रमशः दर्ज किया गया जबकि बाली की लंबाई और बांझ का प्रतिशत सबसे अधिक बादशाह भोग चयन-1 में था। उष्मीय इकाईयों के संबंध में, बढवार अंश दिवस, प्रकाशिय उष्मा इकाई और हेलियो उष्मीय इकाई को सबसे अधिक दुबराज चयन -1 और तरुण चयन -1 में दर्ज किया गया था, जबकि विकिरण उपयोग दक्षता और उष्मीय उपयोग दक्षता तरुण चयन -1 में अधिकतम थी। फसल विकास दर और सापेक्ष वृद्धि दर का परिणाम दिखाता है कि ये सबसे अधिक दुबराज चयन-1 में है।

विभिन्न बढ़ते वातावरणों के संबंध में, परिणाम बताते हैं कि 27 जून (डी 1) बढ़ते वातावरण पर 12 जुलाई (डी 2) और 27 जुलाई (डी 3) बढ़ते वातावरण की तुलना में बुवाई से परिपक्वता तक अधिक समय लेता है। पौधों की ऊँचाई, कुल शुष्क पदार्थ उत्पादन, परीक्षण वजन, प्रभावी कल्लों की संख्या, अनाज उपज, फसल सूचकांक 27 जून (डी 1) वातावरण में अधिकतम दर्ज की गई, जबकि फसल विकास दर, बांझपन प्रतिशत, 27 जुलाई (डी 3) और सापेक्ष वृद्धि दर, पुष्ट दाने प्रति बालिया, बालियो की लंबाई, 12 जुलाई (डी 2) के बढ़ते वातावरण में अधिकतम है। 27 जून (डी 1) पर बुवाई हुई फसल में संचयी बढवार अंश दिवस, प्रकाशिय उष्मा इकाई, हेलियो उष्मीय इकाई, विकिरण उपयोग दक्षता और गर्मी का उपयोग दक्षता को उष्मीय इकाई के संबंध में अधिकतम दर्ज किया गया था।

CHAPTER- I

INTRODUCTION

Rice (*Oryza sativa* L.) is the world's single most important food crop and a primary food source for more than a third of the world's population. More than 90% of the world's rice is grown and consumed in Asia where 60% of the earth's people live (Khush, 1997). Nowadays, rice is gradually representing as the main food regime among the many countries in the world. In South East Asian countries, it is the main staple food of about 3.5 billion people. Its daily demand is increasing and additional production for the future will be required due to increase in population by 2025. Rice is a unique crop among the major food crops by virtue of its extent and adaptability to wider range of edaphic, climatic and cultural conditions (Anonymous, 2013).

Rice is the most pre-dominant crop in India and it is an important centre of rice cultivation. The rice is cultivated on the largest areas in India. It is the second largest producer of rice after China having an area of over 44.10 million hectare with the production of 105.31 million tonnes (Anonymous, 2012). In India rice is grown under widely varying conditions of altitude and climate. Rice cultivation in India extends from 8° to 35° N latitude and from sea level to as high as 3000 meters. Rice crop needs a hot and humid climate. It is best suited to regions which have high humidity, prolonged sunshine hours and an assured supply of water. The average temperature required throughout the life period of the crop ranges from 21 to 37 °C. Maximum temperature which the crop can tolerate ranges between 40 °C to 42 °C.

The small and medium grain aromatic rice is being regarded as a separate class of non-Basmati aromatic rice. Although no concrete documentation exists, native areas of cultivation are known for most of the latter types, here referred to as indigenous scented rice. Almost every state of India has its own varieties of aromatic rice. These areas are identified from hundreds of years of experience of the farmers (Nene, 1998).

India has immense wealth of this small and medium grain aromatic rice. But a lot has already been lost as an aftermath of the green revolution where major emphasis was on yield rather than quality. This is despite the fact that some of the non-Basmati scented rice is much superior to Basmati types with respect to traits like aroma, kernel elongation after cooking, fluffiness, taste, etc. Nevertheless, due to the special attachment of the farmers with Basmati rice, a large number of them are still in existence (Singh *et al.*, 2000). Central India is well known for its native wealth of rice genetic resources and among these the large number of indigenous short grained, scented varieties are cultivated in different parts of the M.P. and C.G. states. These varieties in general are tall and photoperiod sensitive with aromatic short medium grains.

The Chhattisgarh state extends from 17° 46' N to 24° 5' N latitude and from 80° 15' E to 84° 20' E longitude. The general climate of Chhattisgarh state is sub-humid with a distinct and long dry season. The region receives rainfall mainly through the south-west monsoon. Chhattisgarh has a tremendous agricultural potential with a diversity of soil and climate, mountains, plateau, rivers, natural vegetation and forest. The rainfall ranges from 800 mm to 1700 mm in different years. Diversified crops and cropping systems are the typical characteristics of Chhattisgarh and rice is the major crop of the region. Chhattisgarh state popularly known as "Rice Bowl of India" occupies an area of around 3610.47 thousand hectare with the production of 5.48 million tons and productivity of the state ranging between 1.2 to 1.6 t/ha depending upon the rainfall (average 1517 kg per hectare). The state is comprised of three agro-climatic zones i.e. Chhattisgarh plain, Bastar plateau and Northern hill region of Surguja. These zones have huge variations in terms of soil topography, rainfall intensity and distribution, irrigation and adoption of agricultural production system and thus there are variations in the productivity of rice in these regions. The rainfall, which is major factor determining rice productivity is quite high in the region and ranges between 1200-1400 mm the state has an irrigated area of nearly 28% approx. In spite of that state is well behind the average national productivity. In view of topographical structure prevailing in this part of the country, 20-30% of the rice is grown in low lying areas (Kanhari soil). The long duration rice varieties are generally grown by the

farmers in these lands. The upland areas where rice is grown constitute about 15-20% of the total cultivated area. Rice grown in these lands normally are not being irrigated through canal or other sources. The crops invariably suffer due to moisture stress in one stage or the other. The substitution of crops in light soil in this region becomes more difficult due to continuous rains and development of perched water table at the surface of the soil for short duration during rice growing season. The farmers are growing rice either traditional varieties of long duration or highest yielding varieties of medium duration. These varieties are forced to go under moisture stress in one stage or the other even during normal years due to dry spells which is a recurring feature in Chhattisgarh state.

The onset of the monsoon reaches the southernmost tip of Bastar district around 10th June and covers the entire state by around 20th June. Rainfall during July and August is usually high (about 350-400 mm) in the whole region and remains stable till mid September. Rainfall in October occurs mostly due to cyclonic activity in the Bay of Bengal and is less stable. In the recent past a decreasing trend has been observed. This has considerable consequences for rice farming because the most popular traditional varieties of the state are Javaphool, Dubraj, Badshahbhog, Kalanamak etc. These varieties are planted between 15th to 25th July for higher productivity. The 30-40 days old seedlings produced higher yield and quality. The harvesting of rice at 30% moisture gave higher head rice recovery and milling percentage. The weeds may be controlled by application of pre-emergence herbicide followed by post-emergence herbicide or hand weeding or both. As regards to water management practices, these varieties are normally grown in low lying areas, where drainage is more essential. However, it must be done at 40-45 days after planting and shallow submergence may be maintained during other stages of the crop growth. It has been observed that one or two irrigations during water shortage period are sufficient to obtain higher productivity from these varieties (Pandey *et al.*, 2009).

The rice plant usually takes 3–6 months from germination to maturity, depending on the variety and the environment under which it is grown. During this period, rice completes basically two distinct sequential growth stages: vegetative and reproductive. According to Jarrod *et al.* (2010), the experimental studies

indicate that increased temperature (1–4°C) and decreased radiation (1, 3, 5) can reduce yield, with the impacts varying across the plant's three growth phases (vegetative: establishment to panicle initiation; reproductive: panicle initiation to flowering; ripening: flowering to mature grain). Crop production is highly dependent on weather parameters and the change of meteorological parameters affects crop yields and productivity (Ananda kumar *et al.*, 2008). During the last two decades, night temperatures have increased at a much faster rate than day temperatures and global climate models predict further increase in both frequency and intensity. Such rapid increase during the crop growth stages particularly during extremely sensitive reproductive and early grain-filling stages of rice may lead to reduced biomass, grain yield and quality. Radiation however will have a positive influence on yield and grain quality (Pattanayak and Kavi Kumar 2013). Choosing optimum date of plantation occupies an important part of high production package. Sowing dates have been shown to provide differential growth conditions such as temperature, precipitation and growth periods. Although sowing dates affect paddy yield by providing various environmental conditions, yet temperature is the key factor affected by sowing dates in medium grain rice (Safdar *et al* 2013).

The production and productivity of any crop are mainly dependent upon its genetic makeup and environments, which includes weather, climate and managerial factors. We have no control over environment but can alter the genetic makeup of the crop up to some extent which needs more skill and sophisticated equipments and lab, but we can develop a suitable production technology considering the prevailing weather and climatic parameters of region. In our vishwavidyalaya some suitable rice varieties have been refined and released for cultivation in the state. Considering the above facts, the present investigation has been planned with the following objectives.

1. To study the effect of weather parameters on growth, phenophase and yield of different varieties of aromatic rice.
2. To study the effect of various growing environments on growth, phenophase and yields of different varieties of aromatic rice.
3. To find out the heat units for different varieties of aromatic rice under various growing environments.
4. To find out the interaction effect of varieties and growing environment.

CHAPTER - II

REVIEW OF LITERATURE

In Chhattisgarh state, *Kharif* rice is pre-dominant due to concentration of annual rainfall into monsoonal season and rice being high water requirement crop. Rice is cultivated in almost all types of soils with varying productivity. Under high temperature, high humidity with sufficient rainfall and irrigation facilities, rice can be grown in any type of soil but rice crop growth is a result of many physical and physiological processes, each of which is affected by environmental factors. The main factors which have strong influence on crop growth and yield are air temperature, duration and quantity of light, radiation from the sun, cloudiness and precipitation. In Chhattisgarh, large number of indigenous short grain scented rice is mainly grown in low land under rainfed condition.

This chapter deals with the brief review of literature related to effect of weather parameters on growth and yield of scented rice under different growing environments has been discussed under following sections.

1. Effect of weather parameters on growth and yield of rice.
2. Heat units requirement and radiation use efficiency
3. Different growing environments.
4. Superior scented rice varieties and quality characters

A brief resume of work done in Chhattisgarh, India and abroad countries are according to following heads -

2.1 Effect of weather parameters on growth and yield of rice

Lalitha *et al.* (2000) reported that tiller number was measured at weekly intervals from the second week after sowing to 50% flowering stage. In *kharif*, the maximum tillering stage was at 32-36 days after sowing (DAS) in all cultivars

when the temperature was from 26.2 to 27.1°C. The tillering period increased to 55, 48 and 46 DAS during *Rabi* when the temperature was from 22.9 to 25.8°C. When mean temperature exceeded 26°C, the tiller production stopped abruptly by the fifth week. But when it fell below 26°C, the tiller production duration increased to 7-8 weeks. All 3 cultivars reached maximum tillering stage at 618 ± 54 degree days.

Khedikar *et al.* (2003) made a study on genetic variability for 9 characters (days to 50% flowering, plant height, effective tillers per plant, panicle length, test weight, sterility percentage, spikelet density, head rice recovery and grain yield per plant) was assessed in 20 scented rice genotypes grown in 3 different environments (Raipur, Ambikapur and Waraseoni) in Chhattisgarh and M.P., India during *Kharif*-1999/2000. Analysis of variance showed sufficient variation among genotypes in all environments for the different yield and yield contributing characters studied. The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all characters, indicating that the variation among them is not only due to genetic content but also due to the influence of environment. Days to 50% flowering followed by plant height and head rice recovery, recorded low GCV and PCV values in all environments. Considering these characters and grain yield plant⁻¹, the genotypes Jawaphool, Thurnbhog and Jeerashankar were selected for further cultivation or as parents in hybridization programme.

Khan and Bhagat (2005) carried out a field experiment at Madhya Pradesh, India during the *Kharif* season of 2002 to study the effects of sowing dates and weather on the growth and yield of rice cv. Annada. They found that leaf area index, crop growth rate and total dry matter were highest with 9th and 19th July sowing. Correlation coefficient was positive between leaf area index and crop growth rate and sunshine hours at the vegetative phase and rainfall at reproductive phase. Yield and yield attributes were positively correlated with rainfall and sunshine hours at reproductive and grain filling stages, while it was negatively correlated with maximum and minimum temperature at grain filling stage.

Jalota *et al.* (2009) reported from the field and simulation studies conducted are compared to any individual integrated management of transplanting date, cultivar and irrigation, sustained yield (6.3–7.5 t ha⁻¹) and saved substantial amount of water in rice. The total real water saving (wet saving) through reduction in evapotranspiration (ET) was 140 mm, which was almost double than managing the single, i.e. 66 mm by shifting transplanting or 71 mm by growing short duration hybrid variety. Shifting the transplanting date saved water through reduction in soil water evaporation component while growing of short duration variety through reduction in both evaporation and transpiration components of water balance.

Mohammed and Tarpley (2009) reported that the plants were subjected to ambient nighttime temperature (ANT) (27.8⁰C) or high nighttime temperatures (HNTs) (32.8⁰C) through use of continuously controlled infrared heaters, starting from 2000 h until 0600 h. The HNT did not affect leaf photosynthetic rates; however, profound effects on chlorophyll content, leaf nitrogen content, percent pollen germination and spikelet fertility were observed. In addition, HNT hastened plant development rates, as indicated by the panicle emergence date. Plants grown under HNT showed a 90% decrease in yield compared to plants grown under ANT.

Cheng *et al.* (2009) made a study which was carried out on four controlled-environment chambers with two levels of [CO₂] (ambient, 380 ppm and elevated, 680 ppm) and two levels of night temperature (22 and 32 ⁰C). The day temperature was 32 ⁰C in all treatments. As far as results are summed the whole plant and stem dry weight were significantly increased by both elevated [CO₂] and high night temperature ($P < 0.01$), while the ear dry weight was significantly increased by elevated [CO₂] and decreased by high night temperature (both $P < 0.01$). The fertilized spikelet number was significantly decreased by high night temperature ($P < 0.01$), but not affected by elevated [CO₂] ($P = 0.18$). The individual grain weight was significantly increased by elevated [CO₂] ($P = 0.03$). Consequently, brown rice yield was significantly increased by elevated [CO₂] ($P < 0.01$) but decreased by high night temperature ($P < 0.01$), with a significant interaction of [CO₂] and night temperature ($P <$

0.05). The results indicate that high night temperature will reduce the stimulatory effect of elevated $[\text{CO}_2]$ on rice production in the future if both continue to increase.

Nagarajan *et al.* (2010) reported the field experiments and lab analyses in north India Delhi region were carried out using three Basmati and two non-Basmati cultivars to study the effect of a wide range of diurnal temperatures and radiation. Night temperature had a significant negative effect on grain yield ($P < 0.001$) and quality ($P < 0.01$) beyond 22°C . Reduced spikelet fertility followed by grain weight plant^{-1} accounted for the decline in yield. Radiation however had a positive influence on yield and grain quality. A definite relationship between maximum day temperature and grain yield could not be established as the temperatures were generally less than or equal to the critical temperature of 35°C during sensitive developmental stages.

Ogbuene (2010) reported the impacts of meteorological parameters on rice yields, poverty reduction, environmental resource sustainability and management. Data were generated through the use of multiple linear regressions and cross correlations analysis. The correlation variables results indicated that the tonnage of rice yield over the years was a function of meteorological conditions in the area. The consequences of continuous variation in meteorological condition were severe reduction and deterioration in annual tonnage of rice yield and environmental resource sustainability.

Larijani *et al.* (2011) reported the rice crop growth and yield in the north Iran are affected by crop duration and phenology. From evaluation, it has been concluded that ORYZA-2000 was sufficiently accurate in simulation of yield, Leaf area index (LAI) and biomass of crop organs over time. On an average, root-mean-square error values were 13%–15% for total biomass, 18%–21% for green leaf biomass, 17%–20% for stem biomass, 16%–23% for panicle biomass and 24%–26% for LAI. The RMSE values for final yield and biomass were 12%–16% and 6%–9%, respectively.

Rang *et al.* (2011) reported a strong relationship between spikelet fertility and the number of germinated pollen on stigmas. A cumulative linear decline in spikelet fertility with increasing duration of independent high-temperature stress and in combination with water stress was quantified. Better anther dehiscence, higher *in vivo* pollen germination and higher spikelet fertility were observed in both the N-22 accessions compared with IR-64, Apo and Moroberekan under high temperature, water stress and combined stress, indicating its ability to tolerate multiple abiotic stresses.

Yonemaru and Morita (2012) reported the effects of high temperatures during ripening and of cultivar on the crease depth (shrinkage stage) in field and growth chamber experiments. To avoid the influence of grain size, we calculated the inflection of the grain perimeter (from polar coordinates) at 50-60° away from the ventral ridge, which corresponded to the deepest crease. The mean inflection was used in this range ($Ir_{avg50-60}$) to evaluate the effect of high temperature on grain creases in the heat-tolerant rice cultivar 'Nikomaru' and heat-susceptible 'Hinohikari' at high and normal temperatures during ripening in a growth chamber and in the field in 2007 (hot summer) and 2008 (average summer). The grain creases were deeper under high temperature in the growth chamber and in the field ($P < 0.001$). Nikomaru had shallower grain creases than Hinohikari under both high and normal temperatures in the growth chamber and in hot weather in the field. $Ir_{avg50-60}$ was negatively correlated with final grain dry weight in both sets of experiments. These results confirm that $Ir_{avg50-60}$ is a suitable parameter for the evaluation of creasing on rice grains, which reflects grain filling under high temperatures during ripening.

Duan and Yang (2012) studied the continuous increase of the greenhouse and extreme weather effect, because high temperature occurs more frequently in China. To understand the mechanism involved in the effect of high temperature on rice growth and to put forward counter-measures to reduce damage of the stress to rice would have great significance in promoting rice production and ensuring food security. The effects of high temperature on rice yield and grain quality and its physiological mechanism involved from the aspects of

photosynthetic characteristics, stress resistance, proline hormones, polyamines, enzymatic activities and proteomics were studied.

Choi *et al.* (2013) reported that the warming predisposed rice plants that had experienced episodic lack of sunshine (ELS) to be more sensitive to spikelet sterility and spikelet number per panicle, accounting for most of the yield reductions. These findings provide evidence that an expected warming could further exacerbate rice productivity if ELS occurs simultaneously during reproductive stages. Our results collectively suggest that it might be critically important to consider extreme events for a holistic evaluation of the potential impact of warming and [CO₂] on crop productivity, when considering changing climate.

Chen *et al.* (2014) found that temperature and solar radiation had statistically significant impacts on rice yield during the vegetative and ripening stages, while the effects of rainfall on yield were not significant. In contrast to nearly all previous studies focusing on rice production in tropical/subtropical regions, they conclude that higher daily minimum temperature during the vegetative stage increased rice yield in China. Consistent with other studies, higher daily maximum temperature during the vegetative and ripening stages reduced rice yield in China, while the impacts of solar radiation on rice yield varied across the plant's growth stages.

Sridevi and Chellamuthu (2015) reported from experimental findings and the review is mainly confined to the influence of weather elements during different phenophases on growth, yield components and yield of rice. Rice is a sensitive crop that depends highly on weather conditions. Among the abiotic stresses, weather plays the dominant role in influencing the growth and yield of rice. If water is not the limiting factor, the most important weather parameters are temperature and solar radiation. Rainfall (spatial and temporal variation) is the direct critical weather parameter in rainfed ecologies. When considering the growth stages of rice, reproductive and ripening stages are the most sensitive stages to weather. Spikelet fertility is the most sensitive yield component when

rice is subjected to stress viz., low or high temperature, low solar radiation or water deficit (drought).

Kuthe *et al.* (2015) reported the case study of changes in meteorological parameters (viz. rainfall, temperature, relative humidity, evaporation rate etc.) which disturbed the crop physiology indirectly affecting the yield of rice. The combined effect of rainfall and temperature was on relative humidity that created conducive atmosphere for insect and pest attacks on crops. Due to changes in temperature and relative humidity, evaporative water demands would have further aggravated the watering needs of crop. The study concludes that erratic monsoon or delayed monsoon hampers crop physiology ultimately increasing in yield loss due to erratic weather conditions.

Modarresi *et al.* (2015) made a study by using a map of the rice plant phenology and meteorological data, which were obtained at the Rasht station in Gilan province. The cumulative rainfall in 2013 crop year was reduced compared with normal crop year. Moreover, the cumulative degree-day in 2013 crop year was reduced compared with normal crop year. The date occurrence of plant phenology in 2013 crop year was considerable delayed compared with normal crop year. Result of this study helped in anticipation of climate changes and used the appropriate management in rice crop.

Pandey *et al.* (2015) made a study which has been undertaken for rice crop in the districts of Faizabad, Uttar Pradesh, India. The present study is formulated to determine the individual and joint effect of weather variables on rice yield. On the basis of R^2 , we found that individually sun shine (hr) is more important with 67.57 followed by wind velocity and rainfall with 48.63 and 46.74% contribution respectively. The joint effect of weather variables is also playing an important role in case of rice crop. According to R^2 more important combination is rainfall & wind velocity with 82% followed by rainfall and sunshine hr 63% and wind velocity and sun shine hr 53.8% respectively.

Chen *et al.* (2016) reported that higher daily minimum temperature during the vegetative stage increased paddy rice yield; and found that higher daily

maximum temperature during the vegetative and ripening stages reduced paddy rice yield; the impacts of sunshine duration and rainfall on paddy rice yield differed across the plant's growth stages; and estimated weather effects on yield differed by rice variety. The most surprising finding is that T_{min} had a large and positive impact on paddy rice yield during the vegetative stage. Other findings are negative impact on paddy rice yield of higher T_{max} during the vegetative and ripening stages, a negative impact of increased sunshine duration during the vegetative stage, a positive impact of increased sunshine duration during the ripening stage and a negative impact of rainfall during the reproductive stage. Further analysis showed that the weather effects on yield differed by rice variety. The finding of the positive effect of higher T_{min} on yield only holds for Indica rice, while Japonica rice yield did not respond to changes in daily T_{min} . Higher T_{max} negatively affected Japonica and Indica varieties.

2.2 Heat unit requirement and radiation use efficiency

. Chopra and Chopra (2004) studied the phenology and growing degree days (GDD) and their subsequent effects on grain yield and quality of 'Pusa Basmati-1' rice (*Oryza sativa*) at Karnal, Haryana. The crop transplanted on 30th June took 109.5 calendar days and 3125.9 growing degree days from transplanting to maturity (total phenophases). The calendar days and growing degree days of vegetative and generative phase I and II were reduced by 7 to 9 days and 256.5, 393.5 and 427.6 growing degree days, respectively, with delay in transplanting on 4th August compared to 30th June. However, the calendar days and growing degree days required for physiological maturity significantly increased in delayed transplanting on 28th July and 4th August during ripening phase. The plant traits, 1000 grain weight, germination percentage, vigor and grain yield showed a significant decline with delay in transplanting. Increase in the growing degree days of any growth phase had differential effect on grain yield and electrical conductivity of grain. Adverse effects of late planting of 28th July and 4th August was reflected in lower yield and increased electrical conductivity values at ripening stage.

Katsura *et al.* (2010) studied the effect of radiation use efficiency (RUE) in the biomass production of rice crops in aerobic and flooded culture at experimental farm, graduate school of agriculture, Kyoto University, Osaka, Japan. They observed that, above ground biomass 17.2-18.5 t ha⁻¹ and N accumulation 194-233 kg N ha⁻¹ at maturity were significantly higher in aerobic culture than in flooded culture 14.7-15.8 t ha⁻¹ and 142-173 kg N ha⁻¹ respectively. RUE in aerobic culture was comparable to or higher than that in flooded culture 1.27-1.50 g MJ⁻¹ vs. 1.20-1.37 g MJ⁻¹.

Sreenivas *et al.* (2010) conducted a field experiment during *kharif* seasons at College farm, College of Agriculture, Rajendranagar, Hyderabad. Crop was sown on four different dates as main plot and two varieties as sub plot in split plot design and replicated twice. Results revealed that from emergence to physiological maturity, Jagtial Sannalu has accumulated mean growing degree days of 2017±55 and helio thermal units of 11526±817 with coefficient of variation of 3% and 7% respectively. While Polasa Prabha has accumulated 2102±33 mean growing degree days and 12031±716 helio thermal units from emergence to physiological maturity with coefficient of variation of 2% and 6% respectively.

Kashyapi *et al.* (2010) studied that the spatial and temporal distributions of heat unit and various agrometeorological indices for the rice crop they were selected from six rice growing zones, Eleven crop growth stages for this study, The revealed that for rice crop the total degree days requirement varied from 1706 degree-days (at Ranchi) to 2815 degree-days (at Shymakhunta). It showed primary peak (with 16.7 % of total requirement) at active tillering stage.

Praveen *et al.* (2013) reported that higher grain yield and straw yield along with the heat units viz. accumulated growing degree days, photo thermal unit, helio thermal unit, radiation use efficiency and heat use efficiency were recorded maximum in crop sown on 10th June as compared to on 20th June and 30th June sown crop at the Raipur. On the other hand it can be concluded that early sowing dates is better than delayed sowing. With respect to varieties Karma Mahsuri recorded maximum grain yield and straw yield along with heat units viz. growing

degree day, photo thermal and helio thermal units whereas, radiation use efficiency and heat use efficiency were maximum in Mahamaya.

Su *et al.* (2013) reported that the growth and development of crops is commonly regarded as a function of time alone. However, this approach can be inadequate due to temperatures which vary from year to year caused by global climate change. This prompted the development of the growing degree day concept, which incorporates information on both the passage of time and the temperature experienced by the crop plant during that time. Crop water requirements, which are estimated by multiplying reference evapotranspiration values by a crop-specific coefficient, play a crucial role in the management of hydrologic cycles on arable land. Consequently, it would be useful to identify the relationships between cumulative growing degree days and reference evapotranspiration in order to develop new methods for predicting crop growth and development periods and calculating reference evapotranspiration.

Khavse *et al.* (2015) reported from the field experiment at Raipur that higher grain yield was recorded with Mahamaya as compared to Karma Mahsuri and MTU-1010 under 10th June sowing. Also with respect to heat units the cumulative growing degree days at maturity stage (2410°C) days for Karma Mahsuri was followed by Mahamaya (2365°C) days and MTU-1010 (2161°C) days when sown on 10th June. Maximum growing degree days were observed in early sown crop (10th June) as compared to late sown crop (30th June). Similar results were found in the case of Photo Thermal Units and Helio Thermal Units also. At maturity stage, highest radiation use efficiency in 10th June early sown growing environment might be due to better conversion of light in to dry matter, better yield component and harvest index as compared to late growing environment.

Kumar *et al.* (2016) reported from field experiment about comparative performance of scented/basmati rice (CSR 30) under five different methods of planting in a RBD with three replications. The growth and agrometeorological indices during vegetative phase and post vegetative phase (0-60, 60-90 and 90-maturity DAS) of crop LAI, CGR, RGR, NAR, LAD, LWR, SLA, SLW, ULR,

LRGR, LAPF, AGDD, AHTU, APTU, RUE and HUE showed significantly positive correlation with yield and yield attributes. It was similar in all different methods of planting.

2.3 Different growing environments

Mandal and Ghosh (2003) conducted experiment in West Bengal, India; on rice cultivars Pro Agro 6210, PDSH 35, NARDI 111, CNHR-3 and ZR-36. The time taken for maturity ranged from 116.2 to 120.8 days for the different sowing dates and 105.0-127.3 days for different cultivars. The grain yield for each cultivar increased with delay in sowing. Correlation studies for summation of bright sunshine hour (BSH) and GDD had positive and negative effects respectively on grain yield during the ripening phase (flowering to maturity). In addition, grain yield was positively correlated with GDD, HTU, PTU and summation of BSH during the fourth leaf emergence and flowering stages during all sowing dates.

Yuan *et al.* (2004) made a study at Yangzhou, China and explained the effects of sowing date on the grain-filling property of rice cultivars Diantun 502 (indica) and Hexi 39 (japonica) using the Richards growth model. Compared with Hexi 39, Diantun 502 which had larger grains had a higher grain-filling rate, shorter filling time and larger difference in time taken to reach maximum filling rate between superior and inferior spikelets. Sowing date of rice not only had effects on the grain-filling parameters, but also on the difference of grain-filling parameters between the two cultivars and between superior and inferior spikelets.

Khakwani *et al.* (2006) reported that the most of the yield and yield contributing parameters (days to 50% heading, leaf folder ,stem borer incidence, plant height, tillers per hill, 1000 grain weight, sterility % and harvest index %) were significantly affected by the two groups of date of rice transplanting. Highest paddy yield (4.53,4.03 and 4.53 t/ha.) were obtained in early transplanted rice group while seedlings transplanted late were heavily infested by stem borer thereby reducing yield to a larger extent(1.56, 1.94 and 2.24 t/ha.). It has been concluded that early sowing rice is a significant contributor towards farmer livelihood status by giving them increased paddy yield as compared to late transplanted rice.

Chahal *et al.* (2007) reported that the yield of rice is significantly influenced by temperature throughout the crop growth period at Indian Punjab and was more pronounced from flowering to anthesis period. Besides temperature, the number of showers during this period also affects the yield. With the shifting of transplanting dates of rice from higher (mid May) to lower (end of June onwards) evaporative demand, there is an increase in grain yield of rice while there is a reduction in evapotranspiration and irrigation water applied. The critical analysis of long-term weather reveals that weather conditions are favourable for growth and production in late transplanted rice under north India and if there is any reduction in yield, it will be due to factors other than the weather.

Watanabe *et al.* (2007) reported from the field experiment findings that the plant height stagnated in areas 3 and 4 due to rice blast although it recovered later. The highest number of stems was found in area 1 however, other areas showed better productive stem rates. The leaf colour in area 1 was inferior to that of other areas. The development of leaf age in areas 3 and 4 were faster than that of areas 1 and 2. The plant growth stages moved as the transplanting period moved and it proved that cold weather damage particularly during the meiotic cell division could be avoided by moving the transplanting period. The results also showed that the yields in areas 3 and 4 were significantly poor as the ripening rate was particularly low.

Maity and Khan (2007) found in an experiment conducted in Kalyani, West Bengal, India; during the 1998 and 1999 *kharif* rice (cultivars Kshitish, Lal Swarna and IR-36) as influenced by varied dates of transplanting (10th July, 24th July, 7th August and 21st August) and heat units. Results revealed that 10th July-transplanted crop produced the tallest plants, while 24th July-transplanted crop produced the highest dry matter and thereafter both plant height and dry matter decreased in the years. As compared to other varieties, plant height was highest in Kshitish, while dry matter was highest in Lal Swarna.

Mahajan *et al.* (2009) reported that the yield, irrigation, total water productivity and real crop water productivity of the photoperiod insensitive

cultivars were greater by transplanting early in mid-June because yields were significantly higher and irrigation water application was only slightly higher than for late transplanting. However, for the photoperiod sensitive cultivar, there was no yield advantage when planted early. The values for all the water productivity parameters were also lower because irrigation water application was much higher. Further results revealed that the delayed transplanting of the photoperiod insensitive cultivars after 15th June can cause significant reduction in grain yield but this will not be the same result for photoperiod sensitive cultivar.

Mannan *et al.* (2009) reported from field experiments conducted on fine rice genotypes viz. Basmati PNR, Basmati 370, Basmati 375, and Basmati-D were transplanted from 22th July and continued up to 7th October at an interval of 15 days. Thirty-day old seedlings were transplanted at a spacing of 20 x 15 cm. The tallest plant was found in the early-planted crop at maturity. Crop planted from 7th August to 7th September gave more number of tillers per m², panicles per m² and grains per panicle which resulted in higher grain yield. Among the genotypes, Basmati PNR gave maximum grain yield followed by Basmati-D due to more number of panicles and lower percentage of spikelet sterility. The lower grain yield was found in Basmati 370 irrespective of planting date due to lower number of panicles and high percentage of spikelet sterility. The Basmati PNR matured 5-12 days earlier than the rest of the test genotypes. Thus, fine rice Basmati PNR and Basmati-D were most suitable to obtain higher grain yield when planted within 17th -21st August.

Akbar *et al.* (2010) conducted an experiment at Faisalabad, Pakistan to study the response of yield and yield components of direct seeded fine rice (*Oryza sativa* L.) under different sowing dates. Experiment comprised of six different sowing dates ie. 31st May, 10th June, 20th June, 30th June, 10th July and 20th July. Result observed that yield components like tillers per meter square, number of kernel per panicle and 1000 kernel showed significant response to different sowing dates. The crop sown on 20th June (D₃) produced the maximum number of productive tillers per meter square (328.7), kernel per panicle (94.47). 1000 kernel weight (18.82 g) and paddy yield (4468 kg ha⁻¹). The results showed

that the direct seeding of super basmati on 20th June gave the best results in term of entire yield and yield components.

Lack *et al.* (2012) studied the effects of planting date on the grain yield and yield components of three rice cultivars. This research was conducted as a split plot using Randomized Complete Block Design (RCBD) with three replications in the research field of Khuzestan Agricultural Research and Natural Resources Center (Shavoor agricultural research station). They used 5 planting dates 5th May, 25th May and 15th June and three rice cultivars Hamar, Red Anbarbou and Danial. The results showed that the second planting date 25th May exhibited the highest grain yield with an average of 6018.3 kg ha⁻¹ and the first planting date 5th May assuming the lowest grain yield. The cultivars had a significant difference in terms of the above mentioned attributes. Danial and Hamar cultivars featured the highest grain yield with averages of 5591 and 5549.4 kg ha⁻¹ respectively; the lowest amount belonged to Red Anbarbou cultivar. The interaction effects of planting date and cultivar was significant on all attributes except for panicle length. The highest grain yield belonged to Danial cultivar in the second planting date with an average of 6902.6 kg ha⁻¹ while the lowest was obtained for Red Anbarbou cultivar on the first planting date. Both delayed and early planting resulted in the decline of grain yield of rice cultivars.

Dawadi and Chaudhary (2013) reported a case study of rice sown on June 13th at Chitwan (Nepal), produced significantly higher plant height, higher number of tillers per square meter, leaves per tiller, leaf area index and total dry matter. Significantly higher dry matter production, leaves per tillers, leaf area index and filled grains per panicle, heat use efficiency and lower sterility were recorded in 13th June sowing; hence they contributed to significantly higher grain yield (3.84 t ha⁻¹) Compared to Hardinath-1 (3.39 t ha⁻¹), Ram (3.07 t ha⁻¹) and Sabitri (2.76 t ha⁻¹). Hence for humid and sub-tropical condition June 13th can be used as the best sowing date to get higher yield of rice.

Hussain *et al.* (2013) reported that the optimum time of planting was 4th August compared to other dates of transplanting variety T. Aman rice gave higher yield with high quality of rice seed in comparison to early and late

planting, earlier planting of the variety was better as the late planted crops were severely affected by adverse environmental conditions during reproductive phase. The poor grain yield in early or late planting was due to higher percentage of spikelet sterility.

Moradpour *et al.* (2013) studied effect of planting date and planting density on important physiological traits that affected rice grain yield. A field experiment was carried out in split plot on basis of randomized completely block design with four replications in Islamic Azad University Chaloos, Iran. Main factor was planting date in 3 levels (May 30th, June 9th and June 19th) and sub-factor was planting density in 4 levels (17, 34, 51, 68 plant m⁻²). Results showed that grain yield would be increasing with increase in plant density. Maximum grain yield (6403 kg ha⁻¹) was obtained in treatment having 68 plants m⁻². Grain yield would be decreasing with delay in planting date. Maximum grain yield was related to May 30th and June 9th planting dates (6357 and 6264 kg ha⁻¹ respectively). Least grain yield was obtained in June 19th planting date (5576 kg ha⁻¹). It has been found that with planting density increasing, components of total dry matter, crop growth rate and leaf area index would be increasing. With planting date delaying, total plant dry matter, leaf area index and crop growth rate would be increasing.

Mukesh *et al.* (2013) reported that early transplanting dates (25th June and 10th July) increased the grain yield (3.5 t/ha and 3.4 t/ha) and yield contributing characters of basmati rice (*Oryza sativa* L.) as compared to late planting (25th July). The late planting, improved the quality traits viz. hulling, milling and head rice recovery than early planting. 'Pusa Sugandha-4' recorded the highest grain yield, longest kernel and length breadth ratio. In interaction effect, 'Taraori Basmati' and 'CSR 30' recorded statistically similar yield across the dates of transplanting while 'Pusa Basmati' and 'Pusa Sugandha-4' yield declined markedly with late transplanting.

Sharif *et al.* (2014) observed that delaying sowing from 25th May/10th June to late June/early July usually resulted in 20-25% lower plant density and

lower uniformity of the plant stand as a result of rain shortly after sowing. For the late June/early July sowings, there was a strong positive relationship between plant density and yield, but this was not the case for earlier sowings. Thus, increasing seed rate compensated for the adverse effect of untimely rains after sowing on plant density and the shorter growth duration of the late sown crops. They also reported that the optimum date of sowing for dry seeded rice is late May to early June with a seed rate of 40 kg ha⁻¹. Planting can be delayed to late June/early July with no yield loss using a seed rate of 60 kg ha⁻¹.

Aghamolki *et al.* (2015) conducted a field experiment at rice research institute of Iran, Mazandaran on three seedling transplanting dates (1st May, 21st May and 10th June) and six rice cultivars (Neda, Hovaze, Hashemi, Domsiah, Tarom and Fajr). Among the studied cultivars, 'Neda' transplanted on 21st May recorded higher effective tillers, fertile spikelets, bolder grains with greater 1000-grain weight and grain yield. However panicle length, 1000-grain weight and fertile spikelets were equally greater with non-significant differences in 1st and 21st May except for plant height which declined in the early and mid transplanting. The suitability of early and mid transplanting was mainly due to favourable temperature during the growing phase.

Fayaz *et al.* (2015) made a study to determine the effect of different dates of sowing and spacing on growth and yield of scented rice (Pusa sugandh-3) under temperate condition of Kashmir. The growth parameters such as plant height, number of tillers hill⁻¹, SPAD and dry matter production was also observed significantly high in D₁S₂ (15th meteorological week 10th April). Grain yield (48.01 q ha⁻¹), straw yield (77.26 q ha⁻¹) were seen significantly higher in D₁S₂ compared to other treatments. The yield attributes like number of panicles m⁻², number of grains panicle⁻¹, 1000-grain weight (g) and harvest index (%) was seen significantly higher in D₁S₂. The economic analysis showed that treatment D₁S₂ showed maximum Benefit followed by D₁S₁ respectively.

Osman *et al.* (2015) made a study to find out that the sowing dates 1st July and 15th July produced the maximum grain yield of (2.9 t/ha⁻¹) and (2.8t/ha⁻¹),

respectively. It could be concluded that the period from the first of July to the mid July can be considered as the optimum sowing date for direct seeding of the upland rice (variety Nerica.4) at Sudan and under White Nile State condition.

2.4 Superior scented rice varieties and quality characters

Naik *et al.* (2006) reported through the cluster analysis that in the studied population high variability observed between the genotypes in different clusters for different characters. The genotypes Taraori Basmati, Jaiundhi, Krishnabhog, Samunderphool, Sansari, Amtma Shithal, Bhataphool, Ghodapunchi, Tulsimala, Dumerphool, Loktimachii and Elaychi can be used as potential donors for future hybridization programme to develop scented rice varieties with good grain yield and quality traits.

Marothia *et al.* (2007) reported a case study of scented rice of Chhattisgarh. In recent years there has been a serious concern among the farmers, scientists, policymakers and environmentalists regarding the continuous erosion of genetic biodiversity of rice cultivars in Chhattisgarh which has traditionally been known as bowl of scented rice in central India. In view of India's potential competitiveness in aromatic rice in the international market, it is imperative to understand the dynamics of domestic trade in aromatic rice.

Bisne and Sarawgi (2008) made a study which was carried out to characterize thirty two aromatic rice accessions of Badshah bhog group from IGKV, Raipur, Chhattisgarh. These germplasm accessions were evaluated for twenty-two morphological, six agronomical and eight quality characters. The specific genotypes B: 1340, B: 2039, B: 2495, B: 2816, B: 16930, B: 2354, B: 1639, B: 2094 were identified for quality and agronomical characteristics. These may be used in hybridization programme to achieve desired segregates for good grain quality with higher yield.

Nayak (2008) reported a case study of twenty nine scented rice genotypes including one non scented check Ratna were evaluated for their

stability parameters with respect to quality characters during four successive seasons. Significant of genotype x environment interactions were observed for all the quality characters studied. Varieties Kasturi, Basmatibahar, CR-689-424, CR-689-425 and Pusa basmati-1 possessed stability in general over seasons in most of the component quality characters.

Quyen and Sharma (2010) reported from field experiments on comparative effects of organic and conventional farming on scented rice. The yield obtained with this combination was significantly more than that obtained with $180 \text{ kg N} + 39 \text{ kg P}_2\text{O}_5 + 51 \text{ kg K}_2\text{O ha}^{-1}$. A similar trend was observed in N, P and K uptake of rice. Inorganic nutrients had no significant effect on grain quality parameters like head rice recovery (HRR), kernel length (KL), kernel breadth (KB) and KL:KB ratio, whereas organic manures and biofertilizers resulted in an increase in HRR, KL and KL : KB ratio. A combination of FYM + SGM + BGA + PSB also resulted in highest organic C and available N content in soil and thus holds a promise for sustainable production.

Kumari *et al.* (2013) studied twelve varieties/strains namely V₁, (NDR 6279), V₂ (NDR 6265), V₃ (Badshah Bhog), V₄ (NDR 6257), V₅ (Badshah Pasand), V₆ (Bhanta Phool A), V₇ (IET 19800), V₈ Kalanamak A, V₉ (Kanak Jeer), V₁₀ (Rambhog B), V₁₁ (Kalanamak Berdpur) and V₁₂ (Lalmati). Maximum kernel length was observed in (7.07 mm) NDR 6265 and kernel breadth was (1.81 mm) in NDR 625. Maximum elongation ratio was observed in (1.88 mm) Kankjeer and Banta Phool A and maximum kernel length after cooking was 11.4 mm in NDR 6265. Maximum carbohydrate content was found in Kalanamak Berdpur (79.4%). Maximum amylose content was found in variety Kalanamak Berdpur (19.8%). Highest total sugar content and non reducing sugar content was Badshah Pasonda 1.92 g /100 g and 1.72 g /100 g respectively whereas reducing sugar content was highest in Kalanamak Berdpur. On the basis of above parameters variety Kalanamak Berdpur, Badshah pasonda, NDR 6265 and NDR 625 were rated superior among the all varieties / accessions tested in the present investigation.

Rao *et al.* (2013) reported that, there was conspicuous difference among organic manures. Among organic manures supply of 60 kg N ha⁻¹ through Poultry manure found superior in terms of yield attributes, yield, root biomass nutrient uptake and returns. Noticeable varietal responses were observed under organic farming, among the varieties, RNR 18833 can be chosen for yield and in pest and disease endemic areas, Pusa Sugundh and Pusa Basmathi can be chosen for better grain quality.

CHAPTER - III

MATERIALS AND METHODS

The present experiment “**Effect of weather parameters on growth and yield of scented rice under different growing environment**” was conducted during the *Kharif* season of 2016. The experimental details, prevailing weather conditions, materials used and techniques adopted during the course of the investigation are briefly discussed in this chapter.

3.1 Location of Experimental site

The field experiment was carried out at Research and Instructional farm of Indira Gandhi Krishi Vishwavidyalaya; Raipur situated in Eastern Central part of Chhattisgarh at 21°16' N, longitude 81°36' E latitude and an altitude of 289.5 m above mean sea level.

3.2 Climate

The general climatic condition of Raipur is classified as sub humid with mean annual rainfall of about 1175 mm out of which 87 percent (1023.0 mm) rainfall is received during monsoon (June to September). During *Rabi*, (December to February) only 33.8 rainfall is received and hence rice is mostly grown under rainfed conditions. Maximum and minimum temperature ranges between 24.4 °C to 42.6 °C and 10.0 °C to 27.5 °C. Atmospheric humidity is normally higher during June to September. Thereafter, humidity decreases during *Rabi* with increased sunshine hours.

3.3 Weather condition during crop period

During the crop growth period the maximum temperature ranged from 26.5°C to 35.0°C whereas minimum temperature ranged from 11.3°C to 28.8°C. The total rainfall recorded 1029.4 mm, the morning relative humidity varied from 85 to 97 per cent whereas; in afternoon it varied from 25 to 89 per cent, the wind velocity ranged from 0.9 km/h to 11.2 km/h and sunshine duration varied from 0.9 – 10 hours.

3.4 Soil

The soil of the experimental field was sandy loam with moderately coarse texture of inceptisol group locally known as “*Matasi*.” The soil was neutral in reaction and had low phosphorous medium nitrogen and potassium content.

3.5 Cropping History of the Field

Prior to the present experiment, the field was cropped with rice (*Oryza sativa* L.) during *Kharif* and wheat (*Triticum aestivum* L.) during *Rabi* in the preceeding three years.

3.6 Experimental Detail

The details of the treatments are given below and experimental layout is shown in Fig.

Season	: <i>Kharif</i> -2016
Crop	: Rice (<i>Oryza sativa</i> L.)
Dates of sowing	: Three
	D ₁ -27 th June 2016
	D ₂ -12 th July 2016
	D ₃ -27 th July 2016
Varieties	: Three
	V ₁ Badshah Bhog selection-1
	V ₂ Dubraj Selection-1
	V ₃ Tarun Selection-1
Date of transplanting	: D ₁ - 15 th July 2016
	D ₂ - 30 th July 2016
	D ₃ - 15 th August 2016
Row spacing	: 20 cm
Seed Rate	: 40 Kg/ha
Plot size	: 7.5 m x 5.6 m = 42 m ²
Total No. of plot	: 27
Replication to replication distance	: 1.0 m
Treatment to Treatment distance	: 0.5 m

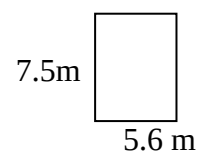
Net plot size : 36 m² (7.5x4.8 m)
 Fertilizer dose : 100:60:40 NPK, kg/ ha.

Treatment Details

Design : Factorial Randomized block design (RBD)
 Replication : Three (03)
 Treatment : Nine (9)

Replicated layout of experiments

Replication-I	Replication-II	Replication-III
D ₂ D ₁ D ₃	D ₁ D ₃ D ₂	D ₃ D ₂ D ₁
V 1 V 1 V 1	V 4 V 4 V 4	V 1 V 1 V 1
V 2 V 2 V 2	V 3 V 3 V 3	V 2 V 2 V 2
V 3 V 3 V 3	V 2 V 2 V 2	V 3 V 3 V 3



Layout of Scented Rice Experiment 2016-17

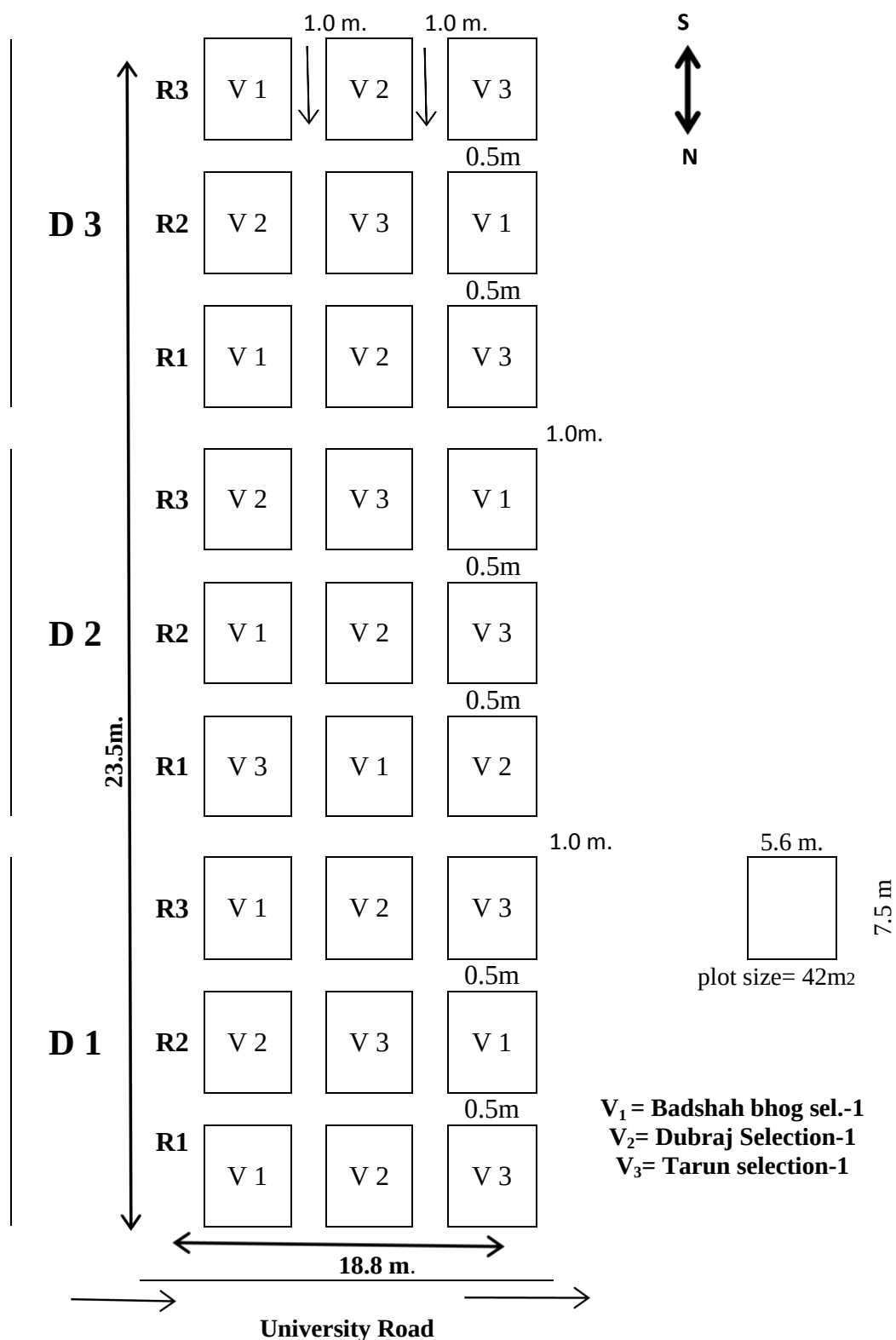


Fig:- 3.1 Location layout of scented rice experiment 2016-17

3.7 Calendar of Operations

3.7.1. Field Preparation

The field was prepared by giving three criss-cross ploughing using power operated cultivator. Thereafter, the field was completely flooded with 10-12 cm standing water for two days. Finally, puddling was done with the help of tractor mounted paddy puddler cum leveler. Few centimeters of standing water was kept in the field, so as to avoid drying and hardening of upper surface of the soil. Afterwards, the experiment was laid out in the field as per plan with the help of tape, rope and bamboo pegs.

3.7.2. Nursery Preparation

Well pulverized raised nursery beds were prepared. The size of each nursery beds were 1 m wide and drainage channel of 30 cm width was provided between the beds. The seeds were sown in the raised nursery bed by hand drilling methods in rows, using 40 g seeds per meter square. Light and frequent irrigation was given until the seedlings were ready for transplanting.

3.7.3. Transplanting

Eighteen days old seedlings were transplanted in the field. The transplanting was done on 15th July, 30th July and 14th August 2016. Flexible wire rope marked at specific interval (20 cm x 10 cm) with the help of colored cloth strips for maintaining the distance between plant and rows.

3.7.4. Fertilizer Application

The fertilizers were applied as per the requirement of crop. 100:60:40 kg ha⁻¹ N: P₂O₅: K₂O was applied in the form of Urea, SSP and MOP, respectively. The half dose of N was applied as basal dressing and the rest half N was applied in two split doses at 30 and 50 days after transplanting. The whole amount of phosphorus and potash was applied as basal during transplanting

3.7.5. Weed Management

The weeds were removed from the plot manually as per requirements; two hand weeding was done at 15 days interval.

3.7.6. Harvesting and Threshing

The crop was harvested on different dates as per maturity of the respective varieties. Before harvesting one row on each side of the treatments was removed and half meter on either side as a border. After harvesting the produce was sun dried for couple of days and threshing was done by beating the produce with bamboo sticks followed by winnowing manually for cleaning of grains.

Table No. 3.1 Date of harvesting of scented rice

Harvesting Dates	D ₁ (15 July)	D ₂ (30 July)	D ₃ (15 August)
Varities			
Badshahbhog selection -1	22/11/2016	26/11/2016	02/12/2016
Dubraj selection -1	22/11/2016	26/11/2016	02/12/2016
Tarun selection -1	22/11/2016	26/11/2016	02/12/2016

3.8 Observations

3.8.1 Pre-harvest observations

3.8.1.1 Phenological observations

The dates of occurrence of different phenological stages viz. tillering, panicle initiation, booting, panicle emergence, 50% flowering, milking, dough and maturity were observed visually and noted.

3.8.1.2 Plant height

Height of 5 randomly selected plants from each plot was taken at 15 days interval starting from 15 days after transplanting (DAT) till maturity. The plant height was measured from base of the plant to tip of the longest leaf and the mean height was worked out.

3.8.1.3 Number of tillers

Number of tillers counted at randomly selected 5 hills from experiment plot at 15 days interval starting from days after transplanting till reproductive growth phase.

3.8.1.4 Dry matter production

The dry matter production was recorded at 15 days interval from 15 days after transplanting to maturity. Five hills were randomly selected and uprooted each time to record dry matter production. The samples were oven dried at 60°C till the constant weight was achieved. After that the average dry matter production/hill was worked out. This was multiplied by the number of hills/m² to obtain the dry matter production/m².

3.8.2 Post harvest observations

3.8.2.1 Number of panicles per m²

Numbers of panicles were counted before harvesting from randomly 3 selected plots of 1 m² size and average was worked out by dividing the summation by five.

3.8.2.2 Length of panicle

Ten panicles were randomly selected from each plot and the length of each panicle was measured from base to tip of the panicle. The mean length was worked out by dividing the summation by ten.

3.8.2.3 Number of filled grains per panicle

The randomly selected 10 panicles from each plot taken for length of panicle were threshed separately and number of filled grains were counted and averaged.

3.8.2.4 Sterility percentage

The unfilled grains were also counted to work out the sterility percentage. The sterility percentage was worked out with the help of the following formula:

$$\text{Sterility percentage} = \frac{\text{Number of sterile grains/panicle}}{\text{Number of total grains/panicle}} \times 100$$

3.8.2.5 Test weight (g)

One thousand sound grains were counted from the bulk produce from each plot then the weight was recorded by using electronic balance.

3.8.2.6 Grain and Straw yield

The total produce harvested from net plot was weighted, threshed and cleaned. The cleaned grains were weighted plot wise in kilogram (kg). The weight of straw was worked out by subtracting the weight of grain from the total produce. Thus, the plot wise yield of grain and straw was finally converted in quintal per hectare.

3.8.2.7 Harvest index

The harvest index was worked out with the help of following formula:

$$\text{Harvest index} = \frac{\text{Grain yield}}{\text{Total yield (grain + straw)}} \times 100$$

3.8.2.8 Crop growth rate (g day⁻¹)

Crop growth rate represents the dry matter accumulation by a unit area of crop per unit time (Leopold and Kriedemann 1975) and is computed with the following formula:

$$\text{CGR} = \frac{W_2 - W_1}{t_2 - t_1} \text{ g day}^{-1}$$

Where,

$W_2 - W_1$ - Difference over dry biomass at the time interval ($t_2 - t_1$)

$t_2 - t_1$ - time interval in days

3.8.2.9 Relative growth rate (g/g/day)

Relative growth rate is an index of the amount of growing material per unit dry weight of plant per unit time (Leopold and Kriedemann 1975). The relative growth rate was computed by using following formula:

$$\text{RGR} = \frac{\ln W_2 - \ln W_1}{t_2 - t_1} \text{ g/g/ day}$$

Where,

$\ln$ is the logarithm at base e (natural log)

$W_2 - W_1$ - Difference in oven dry biomass at the time interval ($t_2 - t_1$)

$t_2 - t_1$ - time interval in days

3.9 Heat Units

3.9.1 Growing Degree Days

Growing degree days (GDD) concept assumes that there is a direct and linear relationship between growth and developments of plants and temperature and the growth is dependent on the total amount of heat units to which it is subjected during its life time. The growing degree days was computed by using following formula:

$$\text{GDD} = \sum [(T_x + T_n)/2 - \text{Base temperature}]$$

Where,

T_x = Daily maximum temperature

T_n = Daily minimum temperature

The base temperature is defined as, “The temperature below which no plant physiological activity takes place” which is considered 10°C for *Kharif* crops.

3.9.2 Photo Thermal Unit (PTU)

PTU is calculated by multiplying GDD with maximum possible sunshine hours (N).

$$\text{PTU} = \text{GDD} \times N$$

Where,

N = maximum possible sunshine hours.

3.9.3 Helio Thermal Unit (HTU)

HTU is calculated by multiplying GDD with actual sunshine hours (n).

$$\text{HTU} = \text{GDD} \times n$$

Where,

n = actual sunshine hour.

3.9.4 Heat Use Efficiency (HUE)

Heat use efficiency (HUE) for total dry matter was obtained as under

$$\text{HUE (g/m}^2 \text{ / } ^\circ \text{ day)} = \frac{\text{Biomass (g / m}^2\text{)}}{\text{GDD (}^\circ \text{days)}}$$

3.9.5 Radiation Use Efficiency (RUE)

$$\text{RUE (gMJ}^{-1}\text{)} = \text{Biomass (g /m}^2\text{)} / \text{IPAR (M J/m}^2\text{/day)}$$

Where,

IPAR is cumulative intercepted photo synthetically active radiation.

The photo synthetic active radiation can be calculated by using the following formula

$$\text{PAR} = \text{Rs} \times 0.5$$

Where,

Rs = incoming solar radiation (MJm⁻²)

The incoming solar radiation can be calculated by the formula

$$\text{Rs} = \text{Rs}^0 (a + b * n/N)$$

Where,

Rs⁰ = Extra terrestrial radiation (MJm⁻²)

n = Bright sunshine hours

N = Possible sunshine hours

a = 0.18, b = 0.5

3.10 Statistical analysis

Data were analyzed statistically adopting the technique of analysis of variance (ANOVA) using Factorial Randomized Block Design. The level of significance of the treatment mean square at 5 per cent probability was tested with “F” test value. The significant differences of the treatment means were further tested by using significance of critical difference at 5% level of respective degree of freedom of “t” values. The skeleton of ANOVA for Factorial Randomized Block Design is given below.

Table No. 3.2: Skeleton of ANOVA for factorial randomize block design

Source of variation	Df	Ss	mss	Fcal	Ftab (5%)
Replication	r-1	SSr	MSr	MSr/MSE	
Factor (a)	a-1	SSa	MSa	MSa/MSE	
Factor (b)	b-1	SSb	MSb	MSb/MSE	
Interaction (axb)	(a-1) (b-1)	SSab	MSab	MSab/MSE	
Error	(r-1) (ab-1)	SSE	MSE		
Total	rab-1	TSS			

CD for a

CD = t at error d.f. with significant level X SE (d) for a

$$\text{SEd for a} = \sqrt{\frac{2\text{MSE}}{rb}}$$

CD for b

CD = t at error d.f. with significant level X SE (d) for b

$$\text{SEd for b} = \sqrt{\frac{2\text{MSE}}{ra}}$$

CD for ab

CD = t at error d.f. with significant level X SE (d) for ab

$$\text{SE (d) for ab} = \sqrt{\frac{2\text{MSE}}{R}}$$

$$\text{CV\%} = \sqrt{\frac{\text{MSE}}{\text{GM}}}$$

Where,

r = Replication

SSr = Sum of square for replication

SSa = Sum of square for factor a

SSb = Sum of square for factor b

SSab = Sum of square for Interaction ab

SSE = Sum of square for Error

MSr = Mean sum of square for replication

MSa = Mean sum of square for factor a

MSb = Mean sum of square for factor b

MSab = Mean sum of square for Interaction ab

MSE = Mean sum of square for error GM = General Mean

All the data were tabulated and analysed statistically as per the procedure suggested by Panse and Sukhatme (1967) and Chandel (1984). The 'F' test was used for judging the significance of the treatment mean at 5% level. Whenever F test showed significant difference, the differences between treatment means were further tested by using critical difference (CD) value.

To compare different mean value of treatments, critical difference (CD) values were calculated as follows:

$$(i) \quad \text{SEm} \pm = \frac{\sqrt{\text{Ems}}}{N}$$

Where,

SEm $\pm$ Standard Error of Mean

EMS = Error Mean Square

n = Number of observations on which the mean values is based

(ii) CD (5%) = SEm $\times \sqrt{2} \times t$ at 5 % for Error d.f. (2.02)

3.11 Quality test

Standards for evaluation of grain length and shape of breeding materials vary among countries and marketing areas. Below is a useful classification for routine breeding evaluation.

Table No. 3.3 : Classification of grain length and shape for quality test

Size classification:			Shape classification:		
Scale	Size category	Length in mm	Scale	Shape	Length/width ratio
1	Very long	>7.56	1	Long and Slender	>3.0
2	Long	6.61 to 7.50	2	Medium	2.1 to 3.0
3	Medium or intermediate	5.51 to 6.60	3	Bold	1.1 to 2.0
4	Short	≤ 5.50	4	Round	1.1 or less

Table N0. 3.4: Characteristics features of traditional scented rice (Non-Basmati) scented rice

Kernel Length (L)	5.4-5.7
Length / Breadth ratio	3.3-3.35
Lc-Lu/Bc-Bu	2.8-4.6
Length / Breadth of kernel after cooking (Bc)	2.95-3.8
Length of kernel after cooking (Lc) / Length of kernel before cooking (Lu)	1.40-1.57
Breadth / Breadth of kernel before cooking (Bu)	1.31-1.61

Source: Bulletin IGKV December 2001

3.11.1 Hulling percentage

100 g of rice seeds were de-hulled using a standard de-husker and the average whole-grain yield was calculated.

3.11.2 Grain Classification

Ten de-husked entire brown rice grains were measured using dial micrometer and based on the L/B ratio, grains were classified into long slender (LS), short slender (SS), and medium slender (MS), long bold (LB) and short bold (SB).

3.11.3 Alkali spreading value (ASV) and Clearing test

Six milled rice grains were taken in Petri plates and 10 ml of 1.7% of KOH was added and kept in incubator at 27-30 °C for 23 hours. Then the alkali spreading value was calculated as low, low-intermediate, intermediate or high.

3.11.4 Volume expansion ratio (VER) and elongation ratio (ER)

15 ml of water was taken in 50 ml graduated centrifuge tubes and 5 g of rice sample was added. Initial volume increase was measured (Y) and soaked for 10 min. Then increase in volume before cooking was noted (Y-15). Rice samples were cooked for 20 min in a water bath and cooked rice was placed on bloating paper. Ten cooked rice kernels were selected (intact at both ends) and length of the kernels measured using graph paper for computing the kernel length after cooking (KLAC). Then the cooked rice was placed in 50 ml water taken in 100 ml measuring cylinder and increase in volume of cooked rice in 50 ml of water was measured (X). Then the volume raise was recorded (X-50). VER and ER were calculated (Anonymous, 2004).



Plate 3.1: Seed sowing, nursery management and transplanting in different growing environments

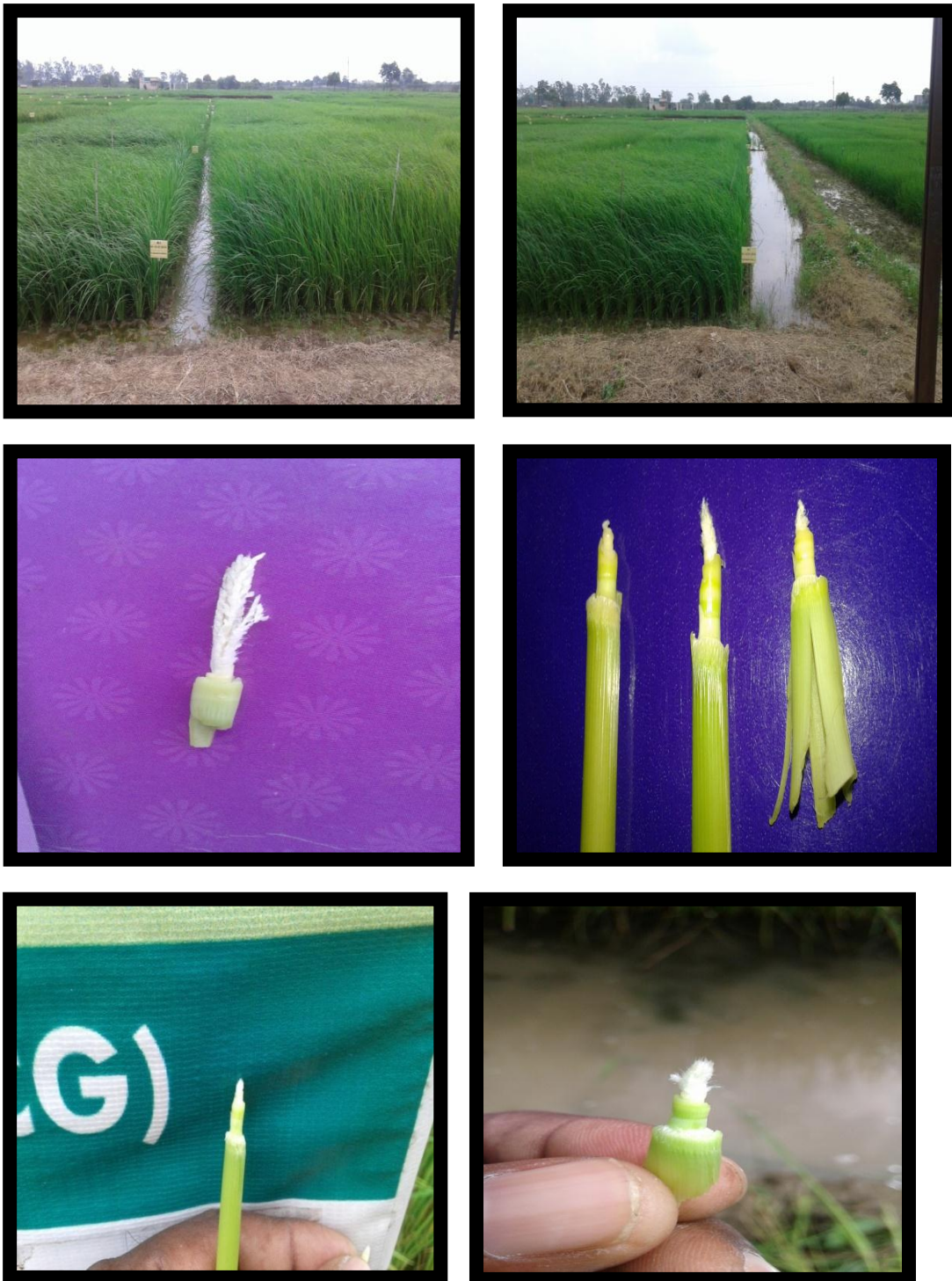


Plate 3.3 : Panicle initiation in rice



Plate 3.4 : Booting stage, Panicle emergence, flowering stag in rice

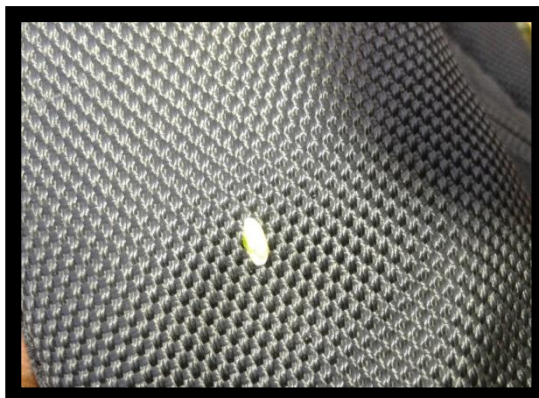


Milking stage



Dough stage

Plate 3.5: Milking and dough stage



Dough stage



Maturity stage



Plate 3.6: Maturity and Harvesting stage

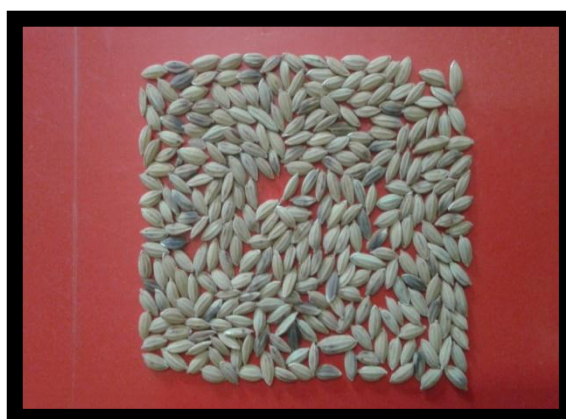


Threshing & Cleaning



Variety : Badshahbhog sel.-1

Variety : Dubraj selection-1



Variety : Tarun selection-1

Plate 3.7: Threshing & Cleaning of separated scented rice varieties



Plate 3.8: field visit by hon'ble VC sir and Scientists of university

CHAPTER – IV

RESULTS AND DISCUSSION

The present chapter deals with experimental findings and discussion obtained during the field investigation entitled **“Effect of weather parameters on growth and yield of scented rice under different growing environment”** experiment was conducted during the *Kharif* season of 2016, at Instructional Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.). The experimental finding was statistically analyzed and presented in appropriate tables, graphs and few were also depicted through figures. The results obtained from the experiment were briefly presented and discussed in this chapter under the following headings.

4.1 Weather conditions during crop period.

4.2 Phenological studies.

4.3 Growth parameters.

4.4 Yield attributes and yield.

4.5 Heat units.

4.1 Weather conditions during crop period

During the crop growth period the maximum temperature ranged from 26.5°C to 35.0°C whereas minimum temperature ranged from 11.3°C to 28.6°C. The total rainfall recorded 1029.4 mm, the morning relative humidity varied from 85 to 97 per cent whereas; in after noon it varied from 25 to 89 per cent, the wind velocity ranged from 0.9 km/h to 11.2 km/h and sunshine duration varied from 0.9 – 10 hours.

Table 4.1: - Weekly Meteorological Data during *Kharif* season - 2016
Station: Labhandi, Raipur (C.G.)

Wk No.	Date	Max. Temp. (°C)	Min. Temp. (°C)	Rain- fall (mm)	Relative Humidity (%)		Wind Velocity (Kmph)	Sun Shine (hours)
					I	II		
26	25-01	35.0	26.2	32.4	88	59	6.2	8.0
27	Jul 02-08	31.0	24.5	107.6	95	83	11.2	1.9
28	09-15	29.3	25.1	59.0	91	80	8.0	1.5
29	16-22	30.6	24.5	207.0	94	79	6.1	0.9
30	23-29	31.9	25.4	56.2	91	69	3.9	5.8
31	30-05	30.7	25.3	28.0	92	81	7.0	2.9
32	Aug 06-12	32.3	28.6	22.0	91	77	8.7	1.6
33	13-19	28.7	21.6	11.6	89	77	9.4	1.3
34	20-26	31.9	25.6	4.2	90	70	5.0	5.2
35	27-02	32.2	26.0	22.2	90	67	3.6	4.8
36	Sep 03-09	30.7	25.3	62.8	87	68	5.9	1.4
37	10-16	31.1	24.3	132.8	95	80	2.9	3.3
38	17-23	32.2	24.9	91.6	94	69	2.5	6.2
39	24-30	30.0	24.5	134.6	97	89	2.8	3.4
40	Oct 01-07	26.5	24.8	48.2	95	72	2.7	4.5
41	08-14	31.5	22.9	9.2	94	50	1.4	5.6
42	15-21	31.6	19.0	0.0	90	35	1.1	10.0
43	22-28	31.5	18.1	0.0	89	36	1.5	9.5
44	29-04	30.6	19.8	0.0	85	51	2.1	8.0
45	Nov 05-11	30.2	15.7	0.0	88	29	1.9	8.5
46	12-18	29.0	14.4	0.0	89	35	1.5	7.8
47	19-25	30.0	11.3	0.0	89	25	0.9	8.5
48	26-02	30.7	13.0	0.0	88	27	1.2	8.5
	Total			1029.4				
	Mean	30.8	22.2		90.9	61.2	4.2	5.2

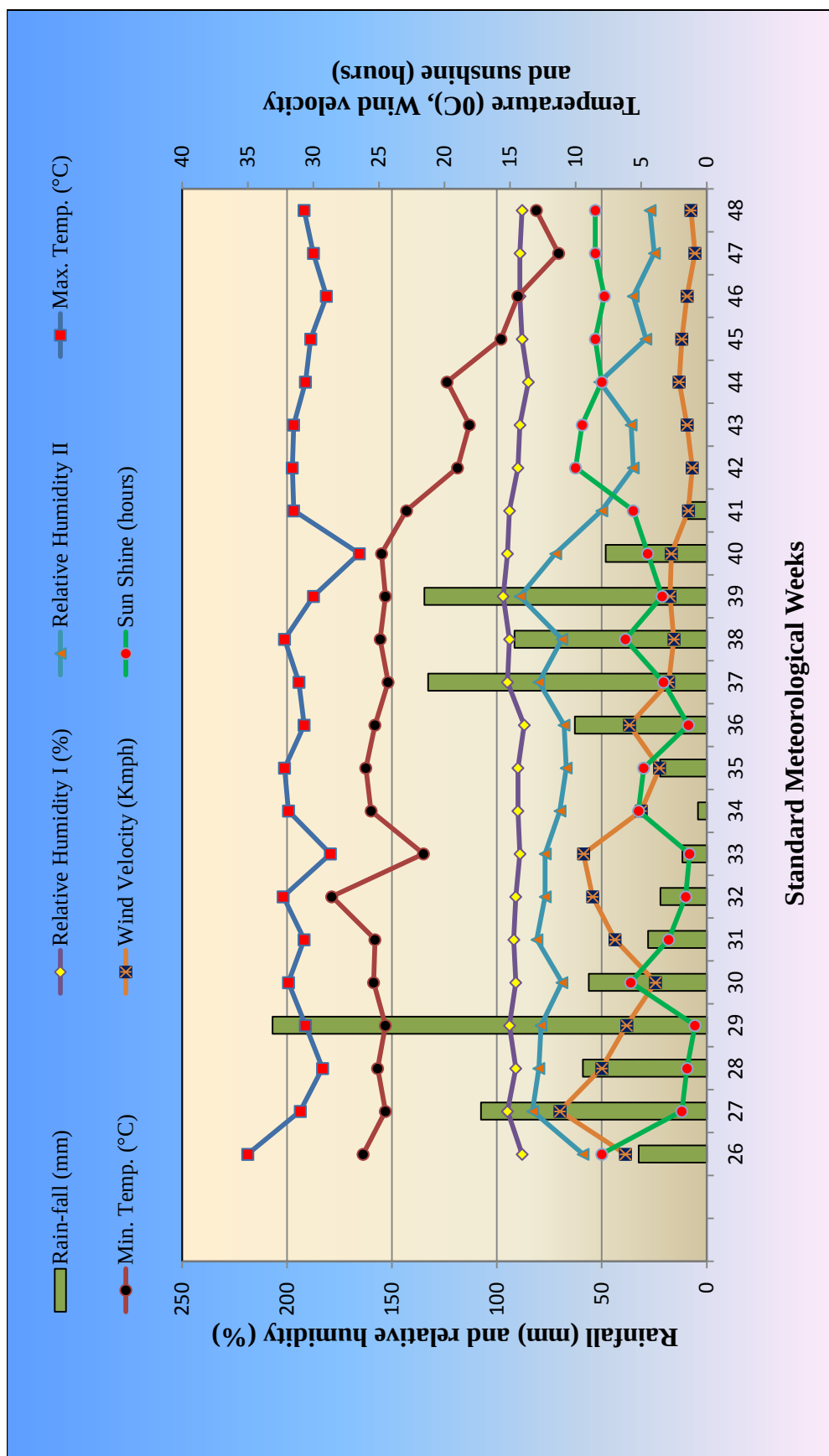


Fig. 4.1: Meteorological data during Kharif season-2016

4.2 Phenological studies

The data regarding days taken by different scented rice varieties to reach different phenological stages i.e. seedling, tillering, panicle initiation, booting, panicle emergence, 50 per cent flowering, milking, dough and maturity sown under three growing environments shown in Table 4.2. Thus, crop sown on 27st June (D₁) took some more days to reach maturity stage as compared to delayed growing environments on 27th July (D₃). The early sown crop takes more number of days to each phenological stage as compared to late sown crop especially in vegetative phase between tillering to panicle initiation stage. Analysis of variance shows sufficient variation among varieties in all growing environments and yield contributing characters. This might be due to the early sowing of crop that was sown in optimum temperature which took more number of days for 50 percent flowering and maturity as compared to late sown crop. Apart from these phenophases other phenological events also decreased by some days under delayed sown condition. These statements are agreeing with the finding of Khedikar *et al.* (2003).

Results mentioned in the Table 4.2 shows all the varieties are taking approx same number of days after transplanting to the start of tillering in all growing environments. After that there is a lot of variation to reach different phenophases of scented rice. The crop shows the variation because of variation in weather conditions /factors viz. temperature and relative humidity in the atmosphere during the crop growth and phenophasic change based on change with growing environments.

It has been observed that weather conditions during *Kharif* season viz. temperature, humidity and rainfall fluctuated every meteorological week. Average temperature found 25-30°C during last June to Oct. After that the range of temperature decreased to 20-25°C in Oct.-Dec. Relative humidity also fluctuated in different meteorological weeks. During July RH found in the range of 80-89% and during 1st August to 15th September it decreased at level 77-80% than increase was observed after 15th Sep. to 1st week of Oct. (80-93%). Further it decreased 57-72% at 15th Oct. to December.

Table– 4.2: Effect of different growing environments on phenology of different scented rice varieties

Growing environments	Seedling	Tillering	PI stage	Booting Stage	PE stage	50% Flowering	Milking	Dough	Maturity Stage
<u>V I Badshahbhog selection- 1</u>									
(D ₁) 27 th June	18	33	87	99	107	110	118	128	143
(D ₂) 12 th July	18	32	79	90	98	101	108	119	132
(D ₃) 27 th July	18	33	71	80	85	94	100	109	121
<u>V II Dubraj selection -1</u>									
(D ₁) 27 th June	18	33	91	103	111	115	123	132	145
(D ₂) 12 th July	18	34	81	92	101	104	111	122	133
(D ₃) 27 th July	18	33	74	83	87	97	103	112	124
<u>V III Tarun selection- 1</u>									
(D ₁) 27 th June	18	34	92	104	111	116	124	132	145
(D ₂) 12 th July	18	34	82	93	102	105	111	122	133
(D ₃) 27 th July	18	33	75	83	88	98	103	112	123

4.2.1 Effect of weather parameters on growth, phenophase and yield

Effects of weather parameters on growth, phenophase and yield are as given in Table No.4.3. Table showed that the correlation between weather parameter and dry matter was non-significant at P₁ stage (sowing to panicle initiation) of scented rice were. However, P₂ stage (Panicle initiation stage to 50% flowering) showed significantly positive correlation between minimum temperature, RH-1, RH-2 and dry matter. At P₃ stage (50% flowering-maturity) dry matter production was significantly positive correlated with minimum temperature, sunshine hours and RH-1. Most of the weather parameters were highly significantly correlated with dry matter at P₃. Therefore, weather parameter and dry matter relationship at P₃ stage play an important role in Total dry matter production.

However, grain yield negatively significantly correlated with sunshine hours at P₁ stage (sowing to panicle initiation) of scented rice. At P₂ stage (Panicle initiation stage (PI) - 50% flowering) grain yield showed positive correlation with minimum temperature and RH-1 while it showed significantly negative correlation with sunshine hour. Grain yield was showed significantly positive correlation with minimum temperature at P₃ stage (50% flowering - maturity). Most of the weather parameters were significantly affected the grain yield at P₂ stage. In general panicle stage – 50% flowering are most critical stage to proper grain filling and responsible for optimum grain yield. These results are in general agreement with the finding of Chahal *et al.* (2007). Correlation between different scented rice varieties and weather parameters was found non-significant.

The most important result found by Cheng *et al.* (2016) reported that higher daily minimum temperature during the vegetative stage increase paddy rice yield and found that higher daily maximum temperature during the vegetative and ripening stage reduced paddy rice yield.

Similarly experiment of rice as a our field found by Kumar *et al.* (2016) result were found the growth and agrometeorological indices during vegetative phase and

post vegetative phase showed significantly positive correlation with yield and yield attributes.

Table- 4.3 : Correlation of weather parameters between growth, phenophase and yield

Weather variables	Correlation coefficient				
Dry matter	Tmax	Tmin	SSH	RH- 1	RH- 2
P ₁ (Sowing - PI stage)	0.996	0.906	-0.995	-0.906	0.086
P ₂ (PI stage - 50% Flowering)	-0.975	1.000*	-0.997	0.998*	1.000*
P ₃ (50% Flowering - Maturity)	0.989	1.000**	0.999*	0.998*	0.930
Yield					
P ₁ (Sowing - PI stage)	0.99	0.928	-0.999*	-0.928	0.142
P ₂ (PI stage - 50% Flowering)	-0.986	0.999*	-1.000*	1.000**	0.997
P ₃ (50% Flowering - Maturity)	0.979	0.998*	0.996	0.993	0.949

Tmax = Maximum temperature, Tmin = minimum temperature, SSH = Sun shine hour
RH1 = relative humidity of morning, RH2= relative humidity of afternoon

Table- 4.4 : Correlation of different scented rice varieties between weather parameters

Weather variables	Correlation coefficient			
Dry matter	Tmax	Tmin	SSH	RH (mean)
Badshah bhog selection-1	-0.371	-0.177	0.131	-0.124
Dubraj selection-1	-0.685	-0.227	0.140	-0.127
Tarun bhog selection-1	-0.445	0.067	-0.169	0.177
Yield				
Badshah bhog selection-1	0.062	0.129	-0.153	0.172
Dubraj selection-1	-0.011	0.193	-0.202	0.191
Tarun bhog selection-1	0.787	0.700	-0.650	0.652

Tmax = Maximum temperature, Tmin = minimum temperature, SSH = Sun shine hour
RH = relative humidity (mean)

4.3 Growth parameters

4.3.1 Plant height

The data on plant height of rice genotypes recorded at different growth stages as influenced by various treatments are presented in Table 4.6. Plant height differed significantly due to different growing environments at all growth stages. At 15 DAT, significantly highest plant height was recorded with 27th July (D₃) 25.5 cm followed by 12th July (D₂) 24.4 cm, which were at par. Significantly lowest plant height was recorded with 27th June (D₁) 21.7 cm. Significantly highest plant height was recorded with 12th July (D₂) 36.1 cm followed by 27th June (D₁) 35.9 cm which were at par. Lowest plant height was recorded with 27th July (D₃) 32.6 cm. At 45 DAT non-significantly highest plant height 44.6 cm was noticed in 27th June (D₁) followed by 27th July (D₃) 44.5 cm, and lowest plant height recorded under 12th July (D₂) growing environments 43.9 cm. Highest plant height observed with 27th June (D₁) 81.9 cm followed by 12th July (D₂) 80.0 cm and lowest plant height was reported with 27th June (D₃) 77.8 cm at 60 DAT where D₁, D₂ and D₃ being significantly differed. At 75 DAT highest plant height observed with 12th July (D₂) 149.7 cm followed by 27th June D₁ 148.7 cm which were at par and lowest plant height was reported with 27th July D₃ (132.9 cm). At 90 DAT highest plant height observed with 27th June (D₁) 161.2 cm followed by 12th July (D₂) 154.2 cm which were at par and lowest plant height was reported with 27th July (D₃) 135.3 cm, At maturity significantly highest plant height observed with 27th June (D₁) 163.5 cm followed by 12th July (D₂) 154.7 cm which were at par and lowest plant height was reported with 27th July (D₃) 136.0 cm.

Plant height based on varieties showed the significant difference at 5% level of significance at all the stages before 75 DAT. Plant heights differed significantly due to varieties at all the stages. Highest plant height (26.4 cm, 37.2 cm, 48.4 cm and 85.9 cm, at 15 DAT, 30 DAT, 45 DAT and at 60 DAT respectively) was recorded with Badshah bhog selection-1 (V₁). Significantly lower plant height was noticed with Dubraj selection-1 (21.3 cm, 32.4 cm, 38.7 cm, and 73.3. cm at 15 DAT, 30 DAT, 45 DAT and at 60 DAT respectively). But after 75 DAT found non-significant difference in plant height.

Plant height differed due to different growing environments. Significantly highest plant height 25.5 cm, at 15 DAT under D₃ and 36.1 cm found at 30 DAT under D₂ growing environment after that 81.9 cm was recorded significantly at 60 DAT respectively in under 27th June (D₁). Further highest plant height was observed under D₂ growing environment at 75 DAT. Significantly highest plant height was noticed in under 27th June (D₁) 161.2 cm at 90 DAT and 163.5 cm at maturity. In general plant height was highest in D₁ as compared to D₂ and D₃ in all the observations. Finally at maturity D₁ was found to have significantly highest plant height. The plant height increased at faster rate up to 15 days after transplanting. The plant height again increased rapidly further from 30 to 90 days after transplanting except 45 DAT. Thereafter increase in plant height was only marginal. Finally at maturity the highest plant height of 163.5 cm was obtained in 27th June (D₁) followed by 154.7 cm was obtained in 12th July (D₂).

The interaction between varieties and growing environments plant height has not shown the significant difference at 5% level of significance at all the stages except at 15 DAT.

Similar results was also be reported by Diwan 2014 when maximum plant height was obtained under normal condition and growing environment.

Mukesh *et al.* (2013) at Hisar, found that early transplanting dates (25th June and 10th July) increased the grain yield of scented rice as compared to late planting (25th July). The late planting improve the quality traits viz. hulling, milling and head rice recovery than early planting.

Table 4.5: Plant height (cm) at different stages in rice as affected by interaction between different growing environments and different varieties

Varieties		D ₁ (27th June)	D ₂ (12th July)	D ₃ (27th July)	Mean
15 DAT	V ₁ (Badshahbhog selection -1)	23.9	25.6	29.7	26.4
	V ₂ (Dubraj Selection -1)	19.2	22.7	22.0	21.3
	V ₃ (Tarun Selection-1)	22.1	24.9	24.8	24.0
	Mean	21.7	24.4	25.5	23.9
30 DAT	V ₁ (Badshahbhog selection -1)	39.1	37.9	34.5	37.2
	V ₂ (Dubraj Selection -1)	32.8	33.6	30.7	32.4
	V ₃ (Tarun Selection-1)	35.7	36.6	32.4	34.9
	Mean	35.9	36.1	32.6	34.8
45 DAT	V ₁ (Badshahbhog selection -1)	49.4	47.6	48.0	48.4
	V ₂ (Dubraj Selection -1)	38.1	38.3	39.5	38.7
	V ₃ (Tarun Selection-1)	46.3	45.7	46.1	46.0
	Mean	44.6	43.9	44.5	44.4
60 DAT	V ₁ (Badshahbhog selection -1)	88.0	85.9	83.8	85.9
	V ₂ (Dubraj Selection -1)	74.3	73.0	72.6	73.3
	V ₃ (Tarun Selection-1)	83.3	81.2	77.0	80.5
	Mean	81.9	80.0	77.8	79.9
75 DAT	V ₁ (Badshahbhog selection -1)	141.7	146.9	128.5	139.0
	V ₂ (Dubraj Selection -1)	154.6	152.2	138.7	148.5
	V ₃ (Tarun Selection-1)	149.9	150.0	131.6	143.8
	Mean	148.7	149.7	132.9	143.8
90 DAT	V ₁ (Badshahbhog selection -1)	158.2	153.0	130.7	147.3
	V ₂ (Dubraj Selection -1)	162.8	156.1	141.8	153.6
	V ₃ (Tarun Selection-1)	162.6	153.5	133.4	149.8
	Mean	161.2	154.2	135.3	150.2
At maturity	V ₁ (Badshahbhog selection -1)	161.1	153.6	131.3	148.6
	V ₂ (Dubraj Selection -1)	165.9	156.6	142.6	155.1
	V ₃ (Tarun Selection-1)	163.4	153.8	134.0	150.4
	Mean	163.5	154.7	136.0	151.4

		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT
SEm ±	Date of sowing (D)	0.35	0.43	0.47	0.51	2.80	2.77	2.67
	Varieties (V)	0.35	0.43	0.47	0.51	2.80	2.77	2.67
CD	Date of sowing (D)	1.1**	1.3**	NS	1.5**	8.4**	8.3**	8.0**
(P=0.05)	Varieties (V)	1.1**	1.3**	1.4**	1.5**	NS	NS	NS

* = significant at 5% level, ** = significant at 1% level

Table 4.6: Plant height (cm) at different stages in rice as affected by different growing environments and different varieties

Treatments	Plant height (cm)						
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	At maturity
Growing environments							
D₁ – 27th June	21.7	35.9	44.6	81.9	148.7	161.2	163.5
D₂ – 12th July	24.4	36.1	43.9	80.0	149.7	154.2	154.7
D₃ – 27th July	25.5	32.6	44.5	77.8	132.9	135.3	136.0
SEm ±	0.35	0.43	0.47	0.51	2.80	2.77	2.67
CD (p=0.05)	1.1**	1.3**	NS	1.5**	8.4**	8.3**	8.0**
Varieties							
V I Badshahbhog selection-1	26.4	37.2	48.4	85.9	139.0	147.3	148.6
V II Dubraj selection -1	21.3	32.4	38.7	73.3	148.5	153.6	155.1
V III Tarun selection -1	24.0	34.9	46.0	80.5	143.8	149.8	150.4
SEm ±	0.35	0.43	0.47	0.51	2.8	2.77	2.67
CD (p=0.05)	1.1**	1.3**	1.4**	1.5**	NS	NS	NS
Interaction D X V							
SEm ±	0.61	0.76	0.82	0.89	4.85	4.81	4.64
CD (p=0.05)	1.8*	NS	NS	NS	NS	NS	NS

* = significant at 5% level, ** = significant at 1% level

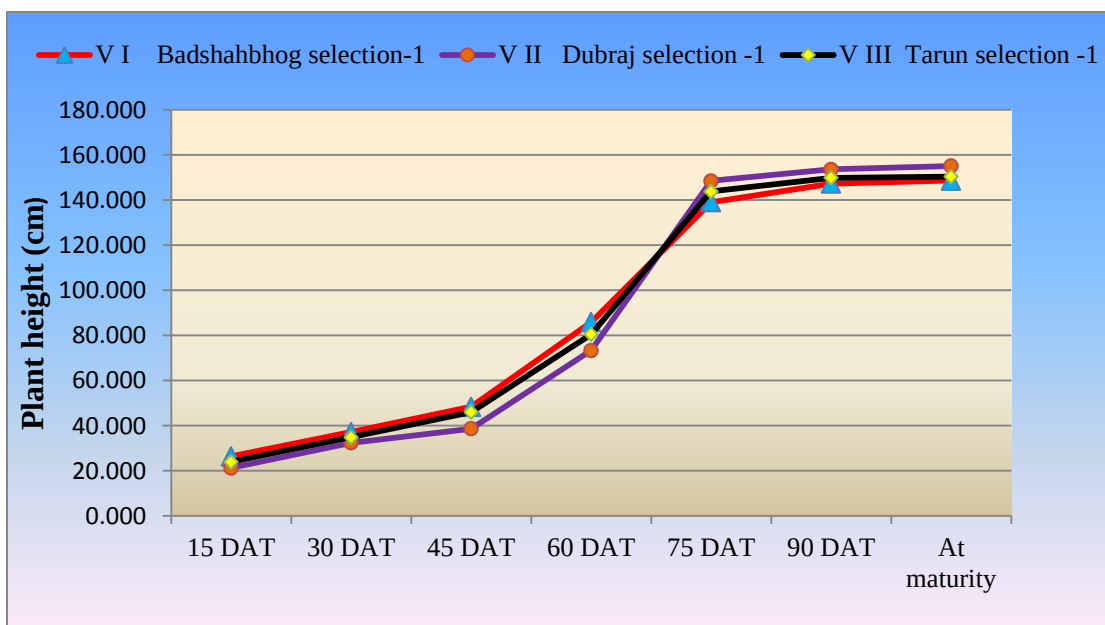
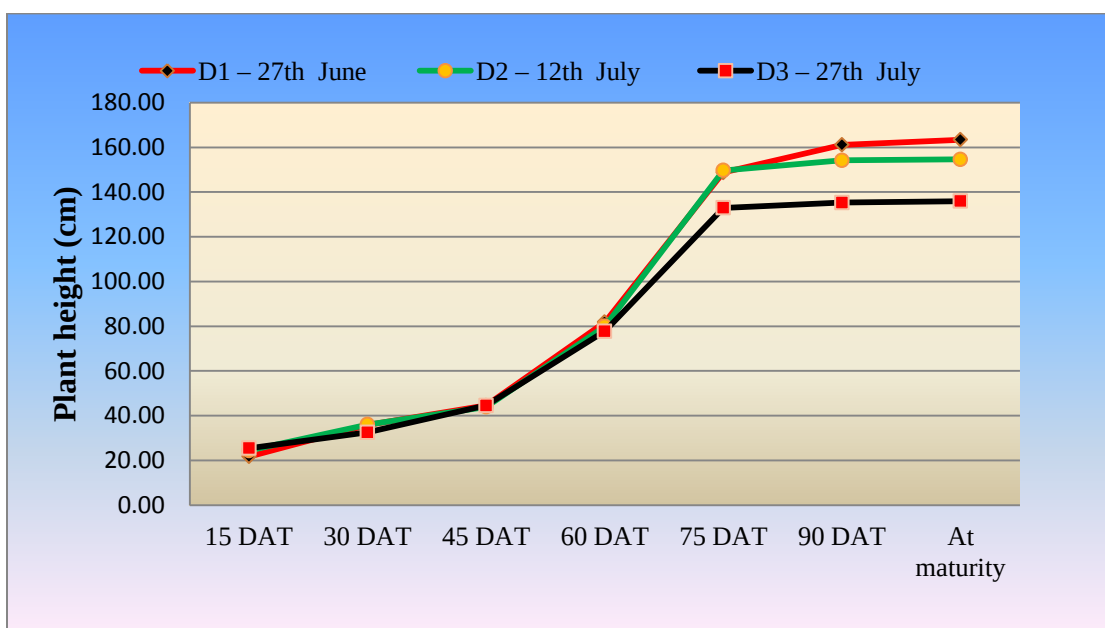


Fig- 4.2: Plant height of different varieties of scented rice at 15 days interval under different growing environments

4.3.2 Total dry matter production (g/hill)

The performance of total dry matter production of different varieties to different growing environments was recorded at different growth stages as influenced by various treatments are given in the Table 4.7. Total dry matter production (TDMP) differed significantly with respect to different growing environments at all growth stages except 60 DAT. At all the growth stages highest TDMP was found different in different growing environments. The highest TDMP at 15 DAT, 30 DAT, were 2.00 gm/plant (hill) and 16.00 g/plant (hill) found under 27th July (D₃) growing environments after that at 45 DAT, 60 DAT, were 45.46 g/hill, 79.22 g/hill, under 12th July (D₂) than 75 DAT, 90 DAT and at maturity, 140.94 g/hill, 149.72 g/hill and 150.83 g/hill were recorded at 27th June (D₁). The highest TDMP at all the growth stages was recorded in V₂ (Dubraj selection-1) and data were significantly different only at 15 DAT.

Total dry matter production (TDMP) differed non-significantly due to varieties at all the growth stages except 15 DAT, 30 DAT and 45 DAT. It can be seen that the lowest TDMP was recorded with Tarun selection-1 but at 60 DAT, 75 DAT, 90 DAT and at maturity V₁ (Badshah bhog selection-1) showed lowest TDM because there was less interception of solar radiation due to lodging in Badshah bhog selection-1. This variety was seen to be sensitive to lodging effect as compared to other aromatic rice varieties. The total dry matter production increased with mid season sowing. The 27th June (D₁) and 12th July (D₂) crop had longer vegetative growth period that produced higher amount of biomass resulting in higher total dry matter production (TDMP) than the D₃ (27th July) growing environments. Higher amount of dry matter was observed in D₂ (12th July) due to less number of cloudy hours, higher sunshine hours and adequate rainfall during crop period which helped to enhance TDMP. As the weather became cloud free in most of the days of September–October, the crop growth became faster while under D₃ lesser accumulation of dry matter has been observed due to short plant and cold spell at night. The results are in conformity with the findings of Salam *et al.* (2004).

Table 4.7: Dry matter accumulation (g hill⁻¹) at different stages in rice as affected by different growing environments and varieties

Treatments		Total dry matter accumulation (g hill ⁻¹) at different stages						
<u>Growing environments</u>		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	At maturity
D₁ – 27th June		1.14	8.78	36.50	75.67	140.94	149.72	150.83
D₂ – 12th July		1.17	10.39	45.56	79.22	137.17	139.06	140.06
D₃ – 27th July		2.00	16.00	36.50	74.72	118.78	125.50	125.50
SEm ±		0.213	0.757	1.480	1.339	1.803	1.916	1.950
CD (p=0.05)		0.639*	2.269**	4.437**	(NS)	5.406**	5.744**	5.846**
<u>Varieties</u>		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	At maturity
V I Badshah bhog selection-1		1.400	11.056	39.278	74.944	130.333	135.500	136.167
V II Dubraj selection-1		1.526	13.222	41.056	78.389	134.222	140.333	140.944
V III Tarun selection -1		1.378	10.889	38.222	76.278	132.333	138.444	139.278
SEm ±		0.213	0.757	1.480	1.339	1.803	1.916	1.950
CD (p=0.05)		0.639	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)

* = significant at 5% level, ** = significant at 1% level

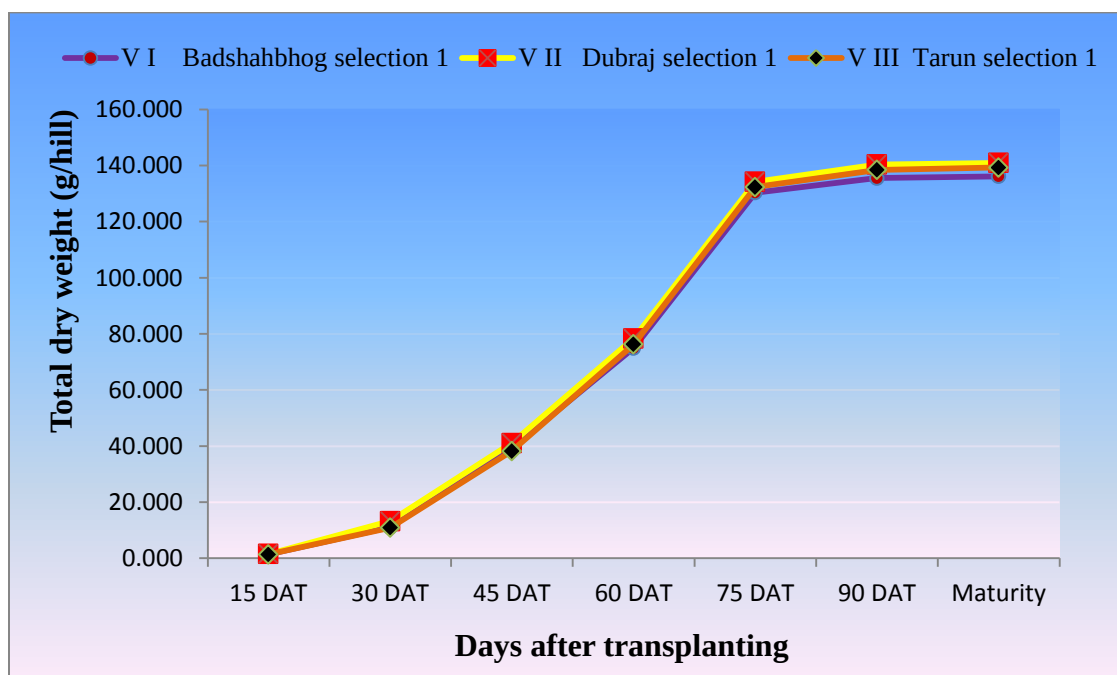
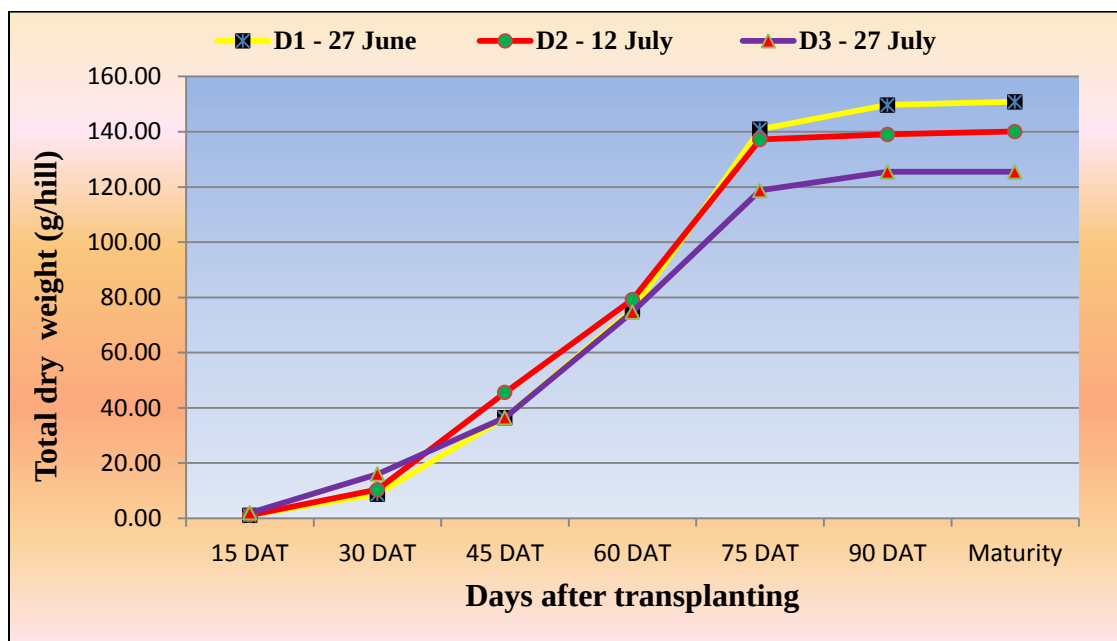


Fig-4.3: Total dry matter production (g/hill) of scented rice varieties at 15 days interval under different growing environments

4.3.3 Crop growth rate (g/hill/day)

The data presented in Table 4.8 and Fig. 4.4, showed crop growth rate of different varieties and the values of crop growth rate were fluctuating during different stages. The highest crop growth rate was observed during 46-60 days after transplanting in V₂ (Dubraj selection-1) 2.79 g/hill/day followed by V₃ (Tarun selection-1) 2.77 g/hill/day and V₁ (Badshah bhog selection-1) 2.57 g/hill/day. Among different growing environment and crop growth rate was found highest in 27th July D₃ growing environments 4.09 g/hill/day between 46-60 days after transplanting followed by 12th July D₂ in all the observations between 46-60 days after transplanting. The crop growth increased with advancement of crop growth and reached at maximum between 46-60 days after transplanting. Highest crop growth rate associated with timely sowing was mainly due to highest leaf area index. This accumulated dry matter at a faster rate per unit time and thereby reducing tiller mortality and senescence of older leaf (Mc Donald, 1984).

In D₃ (27th July) growing environments higher crop growth rate was in between 46-60 DAT due to good amount of rainfall during that period 132.8 mm and good initial conditions of rainfall and continuous sunny conditions. Similarly in D₂ (12th July) growing environments also viewed higher crop growth rate due to rainfall receipt of 62.8 mm and moderate conditions of sunshine hours. D₁ (27th June) growing environment also viewed higher crop growth rate at after 75 DAT to at maturity due to similar weather condition as both growing environment at particular that interval duration.

4.3.4 Relative growth rate (g/g/day)

The values given in Table 4.9, Fig.- 4.5, showing the relative growth rate were highest for the crop sown on 12th July (D₂) growing environments as compared to the crop sown on 27th July (D₃) growing environments and 27th June (D₁) growing environments. In 12th July growing environment the relative growth rate reached maximum of 0.98 g/g/day during 16-30 DAT. It decreased slightly in relative growth

rate during 31 to 45 days after transplanting in all growing environments. In 27th July (D₃) the relative growth rate was the minimum @ 0.02 g/g/day in between 76-90 DAT.

According to varieties the relative growth rate was maximum of V₂ (Dubraj selection-1) 0.93 g/g/day in between 16-30 days after transplanting but significantly difference was found between 91to maturity in Badshah bhog selection-1.

Table 4.8: Crop growth rate g /hill/day of different scented rice varieties as influenced by different growing environments

Treatments		Crop growth rate g /hill/day								
<u>Growing environments</u>		0-15 DAT	16 - 30 DAT	31 - 45 DAT	46 - 60 DAT	61 - 75 DAT	76 - 90 DAT	91 - Maturity		
D1 – 27 th June		0.08	0.37	1.36	1.79	2.28	3.33	0.29		
D2 – 12 th July		0.08	0.61	2.12	2.25	3.03	1.43	0.10		
D3 – 27 th July		0.13	0.93	1.41	4.09	1.19	0.37	0.14		
SEm ±		0.01	0.06	0.15	0.34	0.35	0.27	0.04		
CD (p=0.05)		0.04*	0.18**	0.46**	1.03**	1.06**	0.81**	0.10**		

<u>Varieties</u>		0-15 DAT	16 - 30 DAT	31 - 45 DAT	46 - 60 DAT	61 - 75 DAT	76 - 90 DAT	91 - Maturity		
V I	Badshahbhog selection-1	0.09	0.61	1.79	2.57	1.93	1.69	0.24		
V II	Dubraj selection -1	0.10	0.74	1.66	2.79	2.05	1.86	0.14		
V III	Tarun selection- 1	0.09	0.57	1.46	2.77	2.53	1.57	0.15		
SEm ±		0.01	0.06	0.15	0.59	0.35	0.27	0.04		
CD (p=0.05)		(NS)	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)		

* = significant at 5% level, ** = significant at 1% level

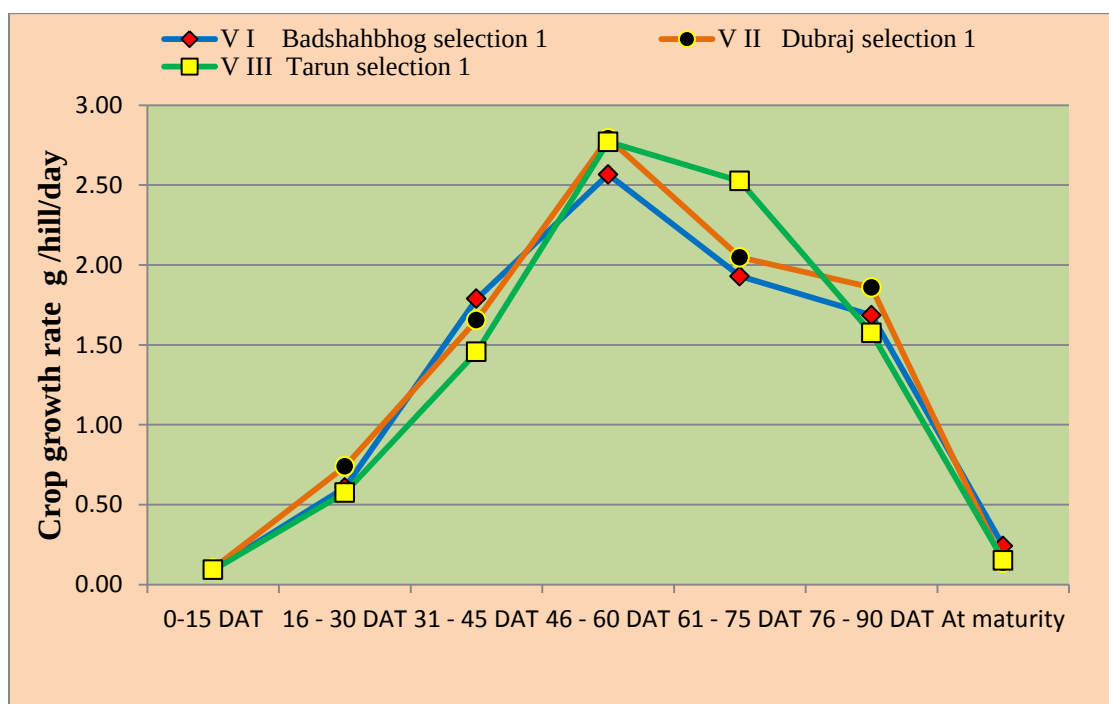
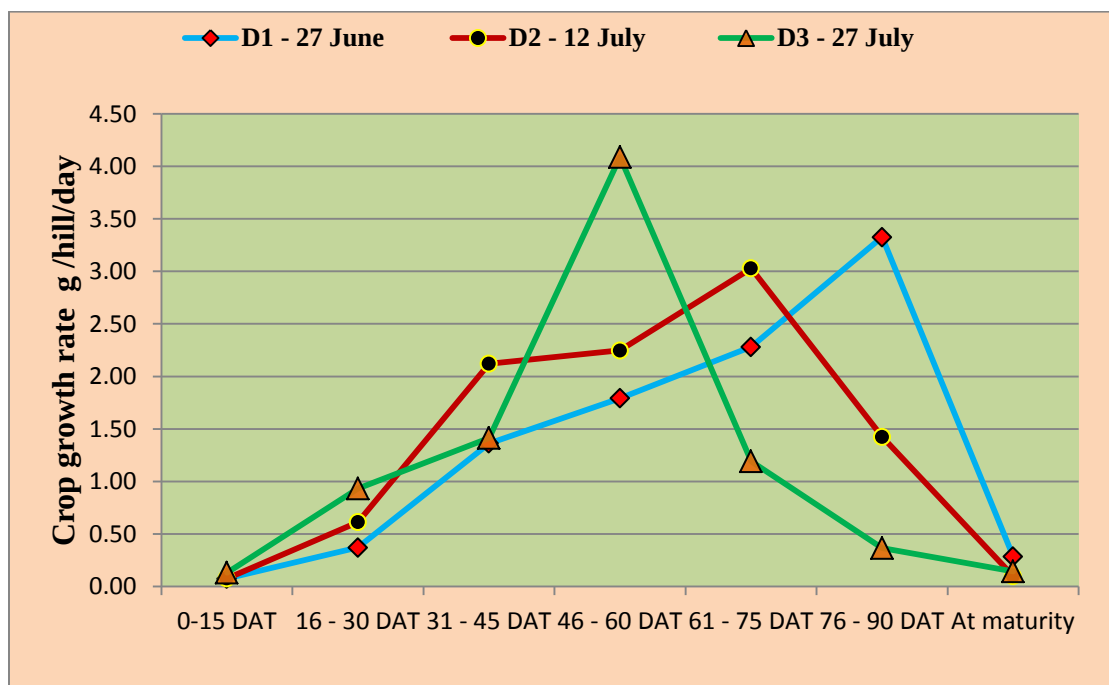


Fig- 4.4: Crop growth rate of different scented rice varieties at 15 days intervals under different growing environments

Table 4.9 : Relative growth rate g/g/day in different scented rice varieties as influenced by different growing environments

Treatments		Relative growth rate g /g/day									
Growing environments		0-15 DAT	16 - 30 DAT	31 - 45 DAT	46 - 60 DAT	61 - 75 DAT	76 - 90 DAT	91-Maturity			
D1 – 27 th June		0.04	0.76	0.62	0.30	0.22	0.07	0.07	0.07		
D2 – 12 th July		0.02	0.98	0.62	0.26	0.20	0.07	0.00	0.00		
D3 – 27 th July		0.28	0.92	0.37	0.42	0.07	0.02	0.01	0.01		
SEm ±		0.06	0.08	0.05	0.05	0.03	0.01	0.01	0.01		
CD (p=0.05)		0.19*	(NS)	0.14**	(NS)	0.09**	0.04**	0.02**	0.02**		

Varieties		0-15 DAT	16 - 30 DAT	31 - 45 DAT	46 - 60 DAT	61 - 75 DAT	76 - 90 DAT	91 –Maturity			
V I	Badshahbhog selection -1	0.083	0.899	0.573	0.303	0.152	0.048	0.038	0.038		
V II	Dubraj selection- 1	0.153	0.928	0.489	0.316	0.146	0.052	0.023	0.023		
V III	Tarun selection- 1	0.097	0.834	0.547	0.362	0.202	0.059	0.013	0.013		
SEm ±		0.06	0.08	0.05	0.05	0.03	0.01	0.01	0.01		
CD (p=0.05)		(NS)	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)	0.02*		

* = significant at 5% level, ** = significant at 1% level

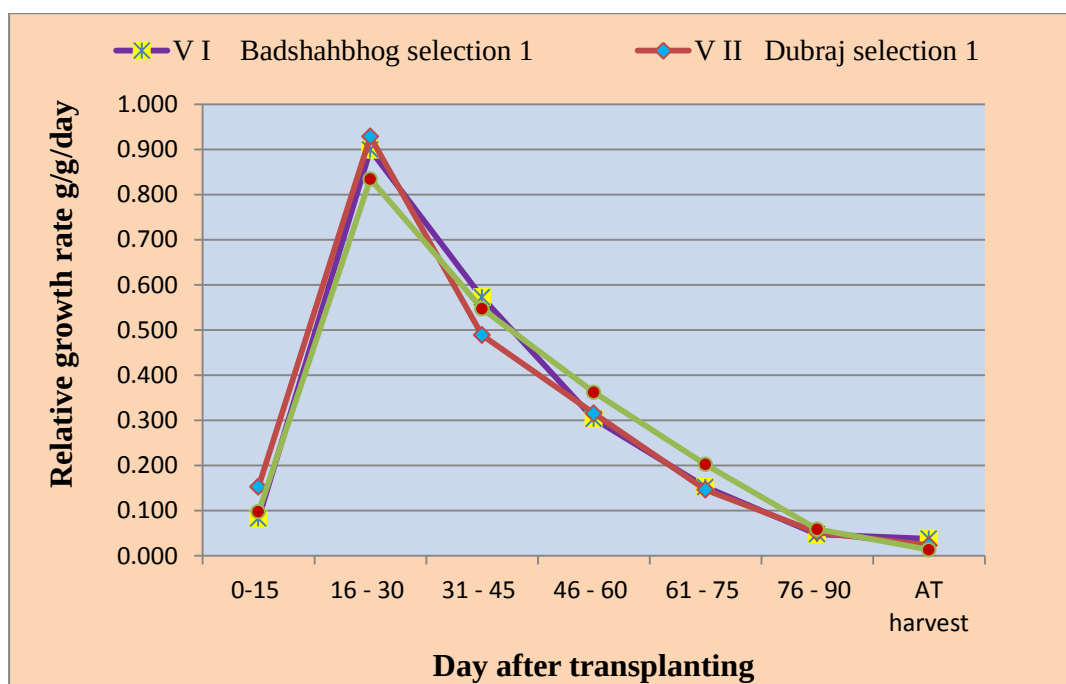
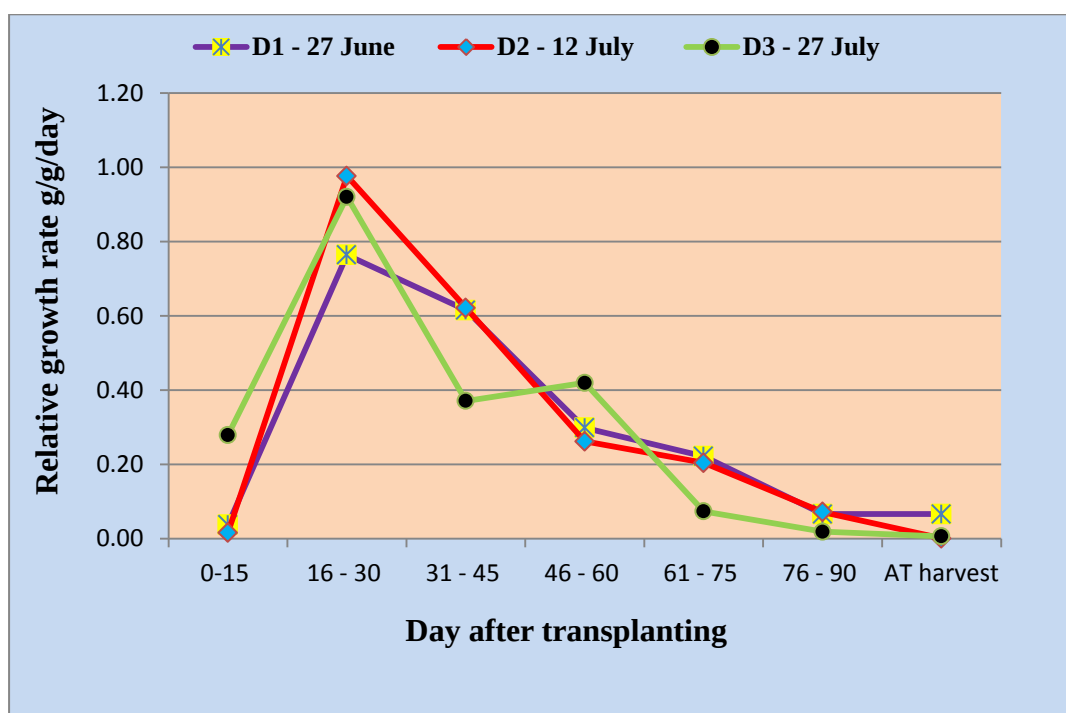


Fig – 4.5: Relative growth rate of different scented rice varieties at 15 days interval under different growing environments

4.4 Yield attributes and yield

4.4.1 No. of effective tillers per m²

The numbers of effective tillers per meter square of different growing environments and varieties are shown in Table 4.10. Number of effective tillers per meter square was affected due to growing environments. Highest numbers of effective tillers per meter square were observed under 27th June D₁ (246.41) followed by 12th July D₂ (232.26) and lowest was found under 27th July D₃ (224.37). Similarly number of tillers per meter square differed due to varieties. Highest number of effective tillers per meter square was recorded with Tarun selection-1 (V₃) 235.48 followed by Dubraj selection-1 (V₂) 234.93 and Badshahbhog selection-1 (V₁) 232.63. Badshah bhog selection-1 (V₁) produced less number of effective tillers as compared to Dubraj selection-1 (V₂) and Tarun selection-1 (V₃). The interaction effect due to growing environments and varieties on number of effective tillers per meter square was found non-significant at 5% level of significance.

Table No. 4.10: No. of effective tillers per m² in scented rice varieties as affected by different growing environments

Treatments	No. of effective tillers per m ²
Growing environments	
D ₁ – 27 th June	246.41
D ₂ – 12 th July	232.26
D ₃ – 27 th July	224.37
SEm ±	6.128
CD (p=0.05)	(NS)
Varities	
V I Badshahbhog selection- 1	232.63
V II Dubraj selection- 1	234.93
V III Tarun selection -1	235.48
SEm ±	6.12
CD (p=0.05)	(NS)
Interaction D X V	
SEm ±	10.61
CD (p=0.05)	(NS)

* = significant at 5% level, ** = significant at 1% level

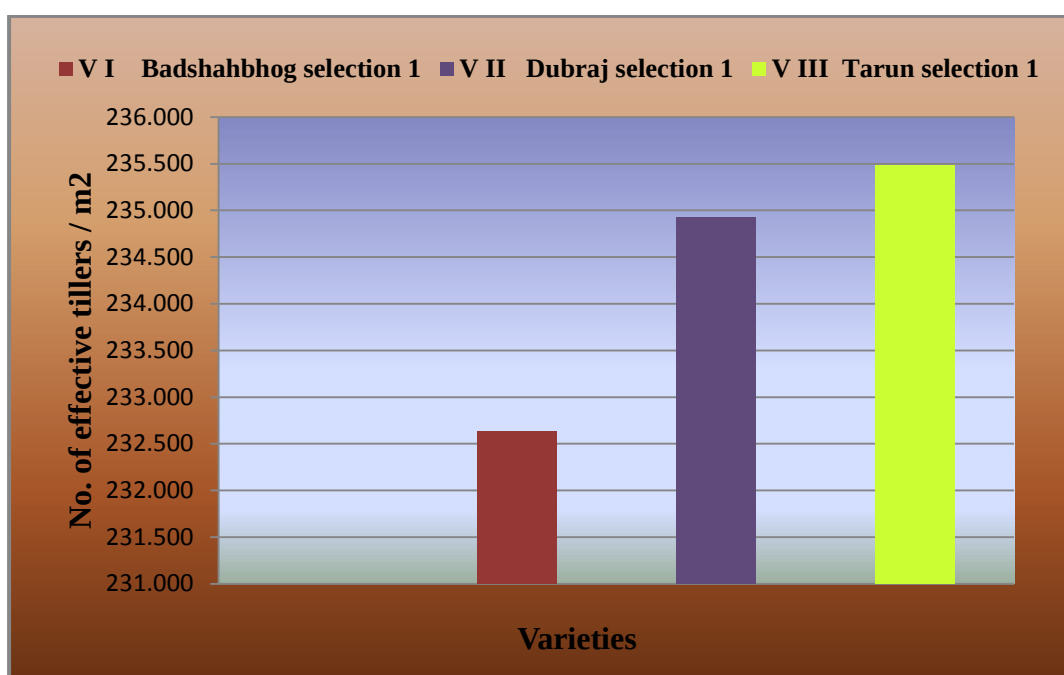
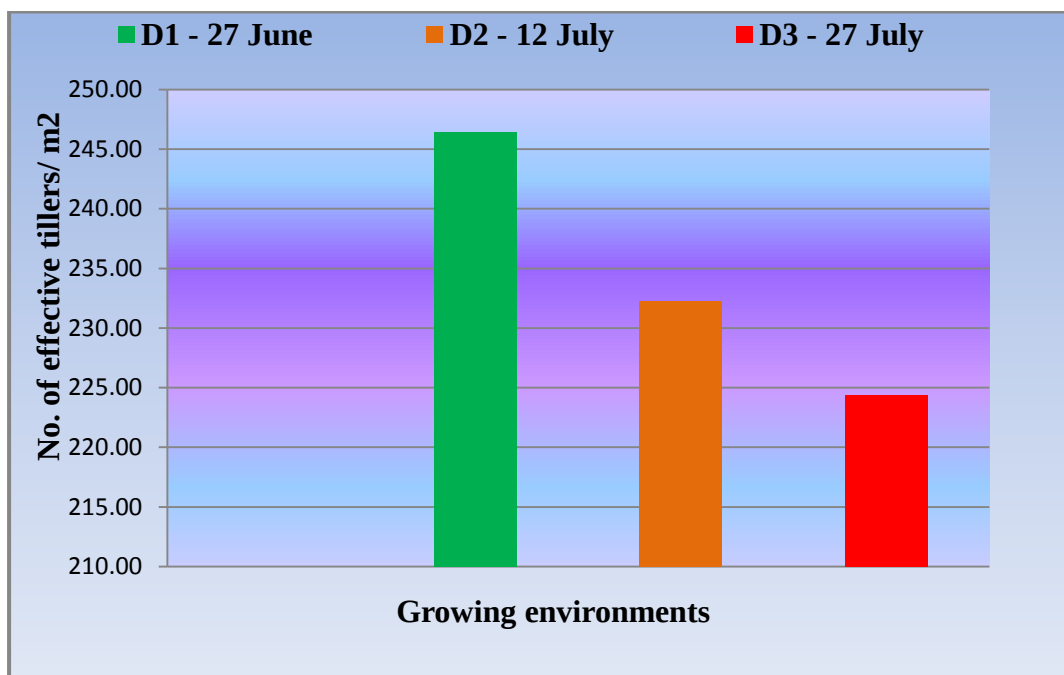


Fig-4.6: Effective tillers per m² in different scented rice varieties as affected by different growing environments

4.4.2 Length of panicles

The lengths of panicles are affected due to different growing environments and varieties as given in Table 4.11. The length of panicle has not been significantly affected due to different growing environments. D₂ (12th July) was found to record highest length of panicle 23.6 cm followed by D₁ (27th June) 23.42 cm and lowest length of panicle found in D₃ (27th July) 23.4 cm. However, this length of panicles happens to be more or less a genetic character and hence not influenced by growing environments.

However different varieties significantly influenced length of panicle. Badshah bhog selection-1 recorded highest length of panicle 27.2 cm followed by 21.7 cm in variety Tarun selection-1 both were significantly differed. The lowest length of panicle 21.6 cm was observed with Dubraj selection-1 but V₂ and V₃ were significantly at par. The interaction between growing environments and varieties was found non-significant at 5% level.

Table No. 4.11: Length of panicle (cm) in different scented rice varieties affected by different growing environments

Treatments	Panicle length (cm)
Growing environments	
D ₁ – 27 th June	23.4
D ₂ – 12 th July	23.6
D ₃ – 27 th July	23.4
SEm ±	0.37
CD (p=0.05)	(NS)
<u>Varieties</u>	
V I Badshahbhog selection- 1	27.2
V II Dubraj selection- 1	21.6
V III Tarun selection-1	21.7
SEm ±	0.37
CD (p=0.05)	1.11**
<u>Interaction D X V</u>	
SEm ±	0.643
CD (p=0.05)	(NS)

* = significant at 5% level, ** = significant at 1% level

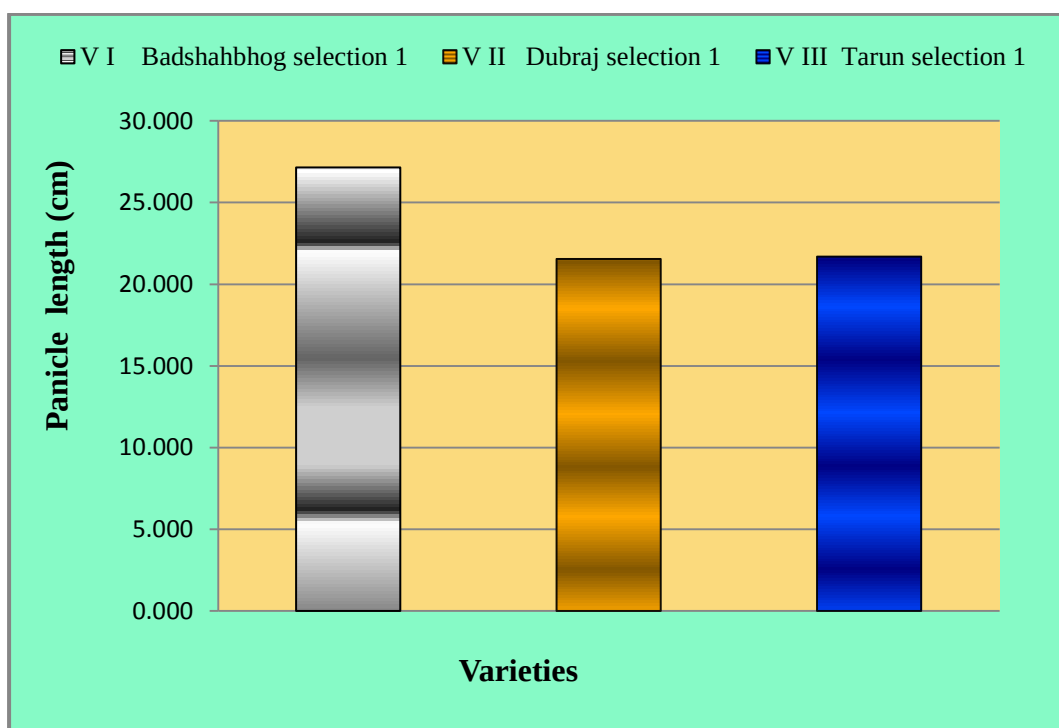
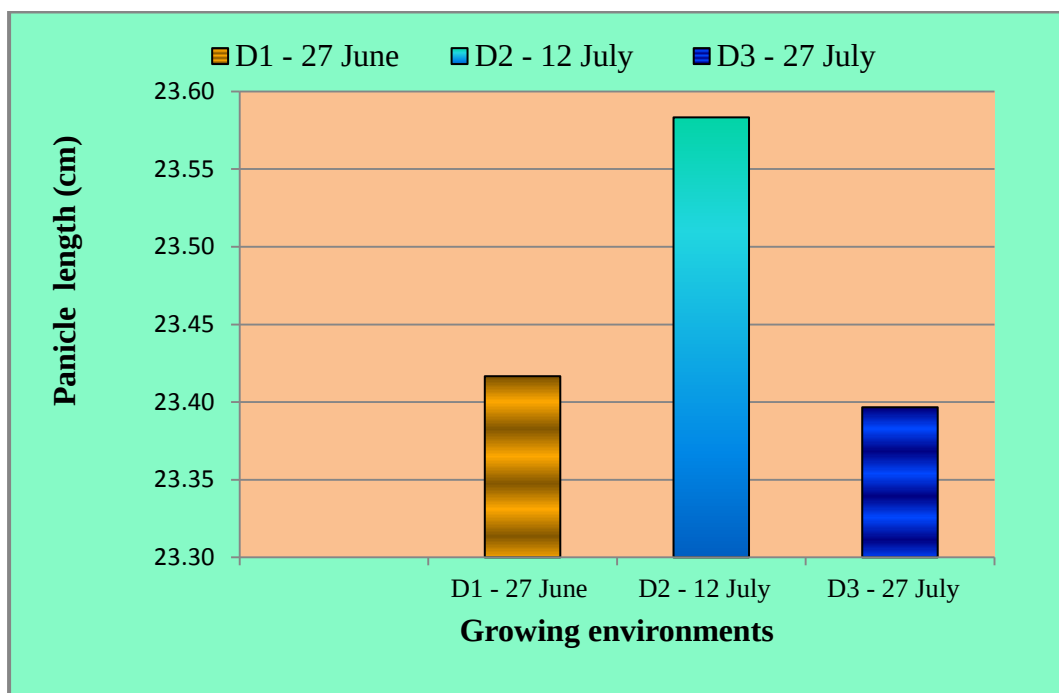


Fig- 4.7: Length of panicles of different scented rice varieties as influenced by different growing environments.

4.4.3 Number of filled grains per panicle

The data observed of number of filled grain per panicle shown in Table 4.12. The data revealed that growing environments was not significantly influencing the number of filled grains per panicle. However, the highest number of filled grains per panicle was recorded with 12th July (D₂) 207.4 followed by 27th June (D₃) 198.4 and lowest was found under 27th June (D₁) 192.1. Number of filled grains per panicle for varieties was not significant at 5% level of significance. However the highest number of filled grains per panicle was recorded with Tarun selection-1 (211.7) followed by Badshah bhog selection-1 (202.2) and lowest was observed in Dubraj selection-1 (184.1). The interaction between varieties and growing environments was found non- significant.

The result showed that 12th July normal growing environment crop had produced more filled grains/panicle due to favorable weather condition for crop growth and better photosynthesis process favorable to produce highest number of filled grains/panicle as compared to 27th June growing environments.

Table No. 4.12: No. of filled grains per panicle in different scented rice varieties as influenced by different growing environments

Treatments	No. of filled grains per panicle
<u>Growing environments</u>	
D ₁ – 27 th June	192.1
D ₂ – 12 th July	207.4
D ₃ – 27 th July	198.4
SEm ±	9.1
CD (p=0.05)	(NS)
<u>Varieties</u>	
V I Badshahbhog selection-1	202.2
V II Dubraj selection- 1	184.1
V III Tarun selection -1	211.7
SEm ±	9.1
CD (p=0.05)	(NS)
<u>Interaction D X V</u>	
SEm ±	15.6
CD (p=0.05)	NS

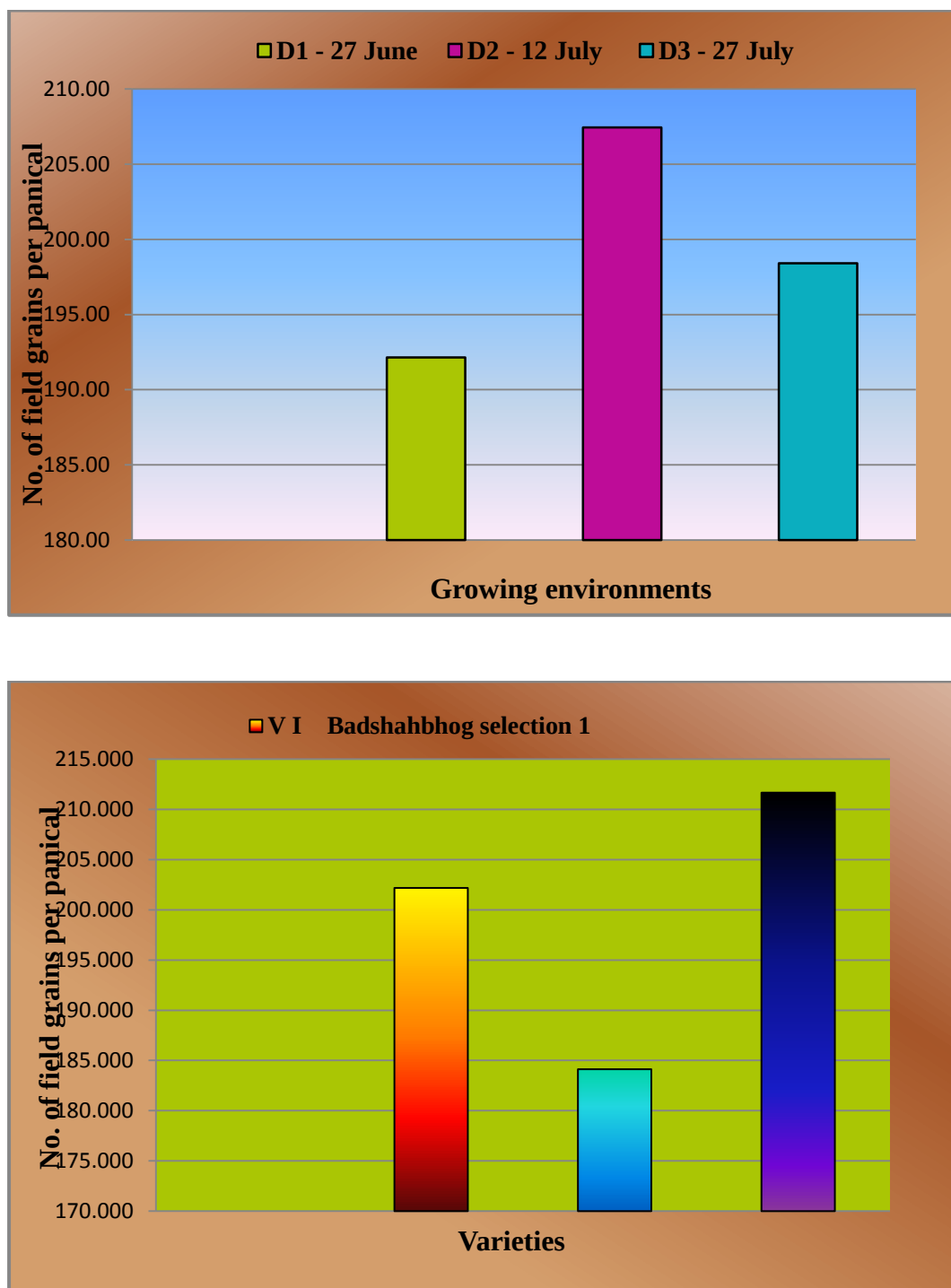


Fig- 4.8: No. of filled grains per panicles of different scented rice varieties as influenced by different growing environments

4.4.4 Sterility percentage

The data on sterility percentage in rice varieties as influenced by various growing environments are presented in the Table 4.13 and Fig 4.9. Highest sterility percentage was noticed under 27th July (D₃) 11.07% followed by 12th July (D₂) 9.55% and both were significantly different to each other. However lowest sterility percentage found in D₁ growing environments and it leads to interpretation than sterility is increasing with the delay in sowing and consequent transplanting. Production of lesser chaffy grains and sterility is a fortunate parameter as it has supplemented in to yield potential. The lowest sterility percentage was observed under 27th June (D₁) 7.73%. Highest sterility percentage was found with Badshah Bhog Selection-1 (10.53%) followed by Dubraj selection-1 (10.13%) and lowest sterility percentage was found with Tarun Selection-1 (7.69%). The interaction between varieties and growing environments was found non-significant.

Table No. 4.13: Sterility percentage in different scented rice varieties as influenced by different growing environments

Treatments	Sterility (%)
Growing environments	
D ₁ – 27 th June	7.73
D ₂ – 12 th July	9.55
D ₃ – 27 th July	11.07
SEm ±	1.27
CD (p=0.05)	(NS)
Varities	
V I Badshahbhog selection -1	10.53
V II Dubraj selection- 1	10.13
V III Tarun selection- 1	7.69
SEm ±	1.27
CD (p=0.05)	(NS)
Intrraction D X V	
SEm ±	2.20
CD (p=0.05)	(NS)

* = significant at 5% level, ** = significant at 1% level

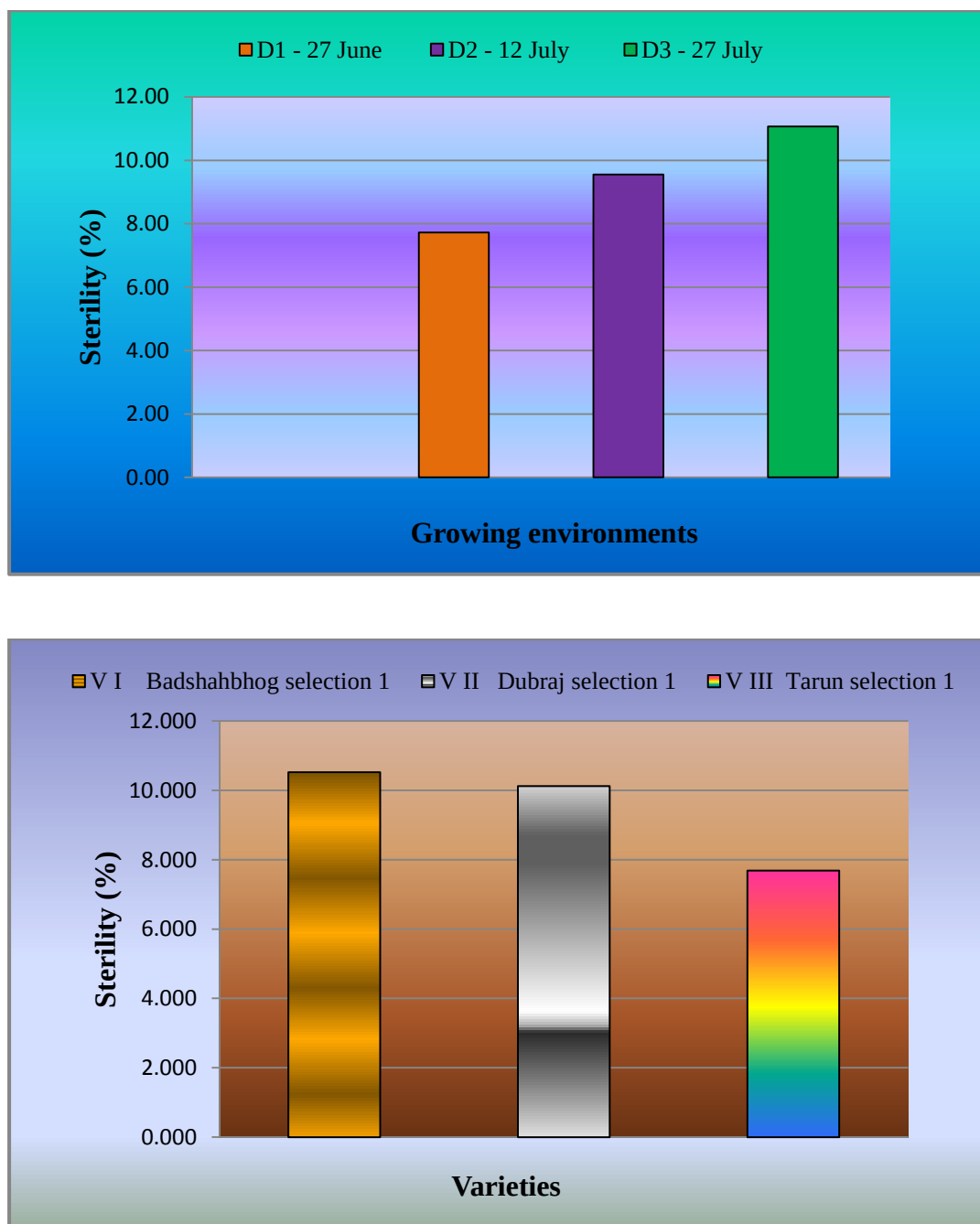


Fig – 4.9: Sterility percentage in different scented rice varieties as affected by different growing environments

4.4.5 Test weight (g)

The data on test weight of rice varieties as influenced by various growing environments are presented in the Table 4.14. Different growing environments did not influence test weight, however it was highest under 27th June (D₁) 15.23 g followed by 27th July (D₃) 15.18 g and lowest was found under 12th July (D₂) 14.80 g. The test weight which happens to be genetic parameter was significantly influenced by different varieties and highest test weight was obtained with Dubraj selection-1 (17.14 g) followed by Badshah bhog selection-1 (14.69 g) and both were significantly different. The lowest test weight was observed with Tarun selection-1 (13.38 g). Interaction between varieties and growing environments was found non-significant at 5% level of significance.

Table No. 4.14: Test weight (g) in different scented rice varieties as influenced by different growing environments

Treatments	Test weight (g)
Growing environments	
D ₁ – 27 th June	15.23
D ₂ – 12 th July	14.80
D ₃ – 27 th July	15.18
SEm ±	0.37
CD (p=0.05)	(NS)
Varieties	
V I Badshahbhog selection-1	14.69
V II Dubraj selection-1	17.14
V III Tarun selection-1	13.38
SEm ±	0.37
CD (p=0.05)	1.12**
Intrraction D X V	
SEm ±	0.65
CD (p=0.05)	(NS)

* = significant at 5% level, ** = significant at 1% level

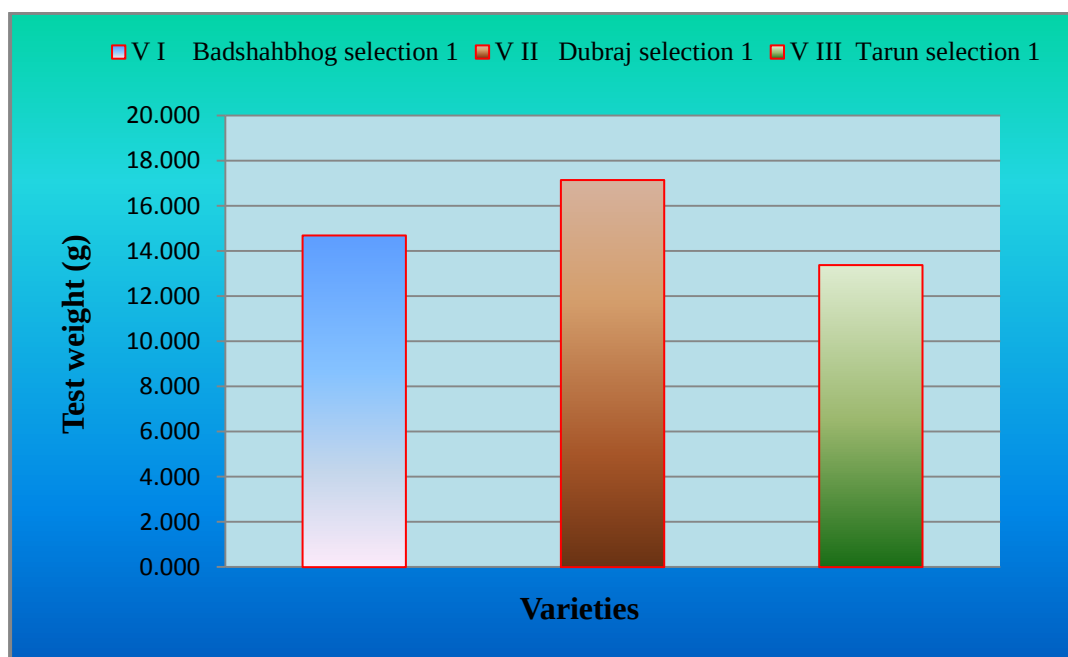
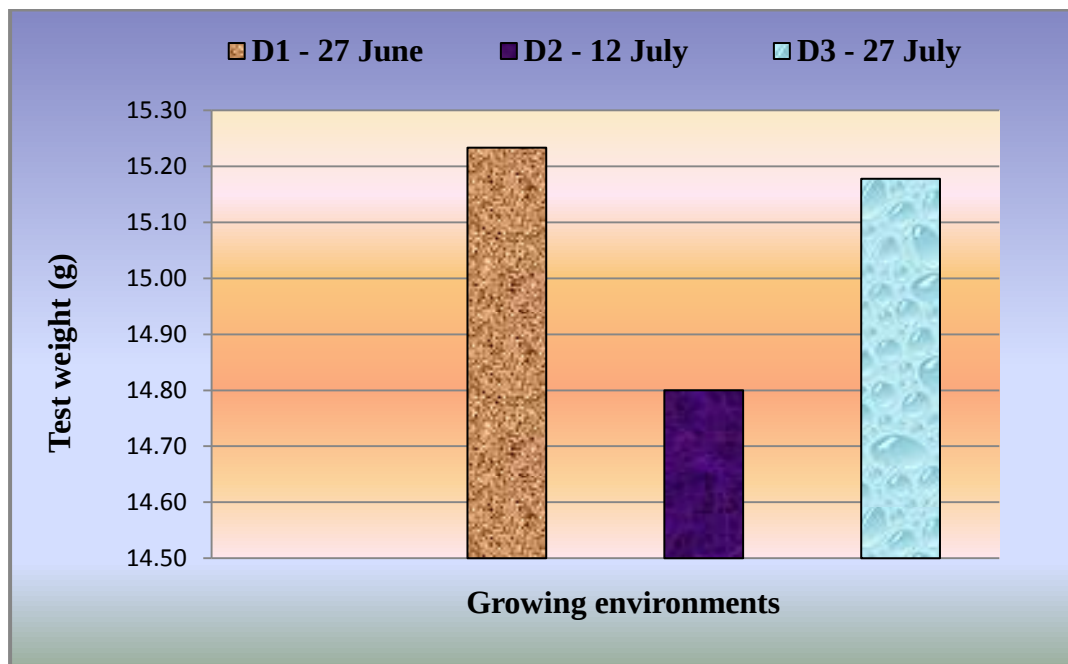


Fig - 4.10: Test weight (g) in different scented rice varieties as affected by different growing environments

4.4.6 Grain yield q/ha.

The data on grain yield in different scented rice varieties as affected by different growing environments are presented in the Table 4.16. The grain yield was influenced by different growing environments. The highest grain yield was recorded when crop sown on 27th June D₁ (19.18 q/ha) followed by 12th June D₂ (18.33 q/ha) and lowest grain yield found at 27th July D₃ growing environments (16.93 q/ha). Significantly highest grain yield was recorded with Dubraj selection-1 (19.97 q/ha) followed by Tarun selection-1 (18.27 q/ha) and lowest yield was recorded under Badshah bhog selection-1 (16.20 q/ha). It can be very well observed that Dubraj selection-1 (V₂) significant differed from Badshah bhog selection-1 (V₁) and significantly Tarun selection-1 and Badshah bhog selection-1 was found at par. The interaction between growing environments and varieties was found non-significant at 5% level of significance.

Grain yield in scented rice was observed highest at D₁ growing environments. Early growing environment was produced significantly higher plant height, higher dry matter, higher number tillers per square meter, higher test weigh and lower sterility were which recorded under D₁ (27th June) growing environment. Results showed grain yield increasing with early sowing and decreasing with delay in planting date. Also weather conditions viz. rainfall, temperature and high wind velocity influenced the grain yield. Similarly findings were also obtained by Dawadi and Chaudhary (2013), Morapour *et al.* (2013) and Mukesh *et al.* (2013).

Table No. 4.15: Two way table of Grain yield in scented rice varieties as affected by different growing environments

	D ₁ (27 th June)	D ₂ (12 th July)	D ₃ (27 th July)	MEAN
(V ₁) Badshahbhog selection- 1	16.37	16.81	15.42	16.2
(V ₂) Dubraj selection- 1	19.91	21.09	18.89	19.97
(V ₃) Tarun selection- 1	21.25	17.09	16.48	18.27
MEAN	19.18	18.33	16.93	18.15
	Growing environments	Varieties	Intracction	
SEm	0.77	0.77	1.34	
CD	NS	2.32*	NS	

Table No.4.16: Grain yield in scented rice varieties as affected by different growing environments

Treatments	Grain yield (qha⁻¹)
Growing environments	
D ₁ – 27 th June	19.18
D ₂ – 12 th July	18.33
D ₃ – 27 th July	16.93
SEm ±	0.77
CD (p=0.05)	NS
Varieties	
V I Badshahbhog selection-1	16.20
V II Dubraj selection-1	19.97
V III Tarun selection-1	18.27
SEm ±	0.77
CD (p=0.05)	2.32*
Intracction D X V	
SEm ±	1.34
CD (p=0.05)	NS

* = significant at 5% level, ** = significant at 1% level

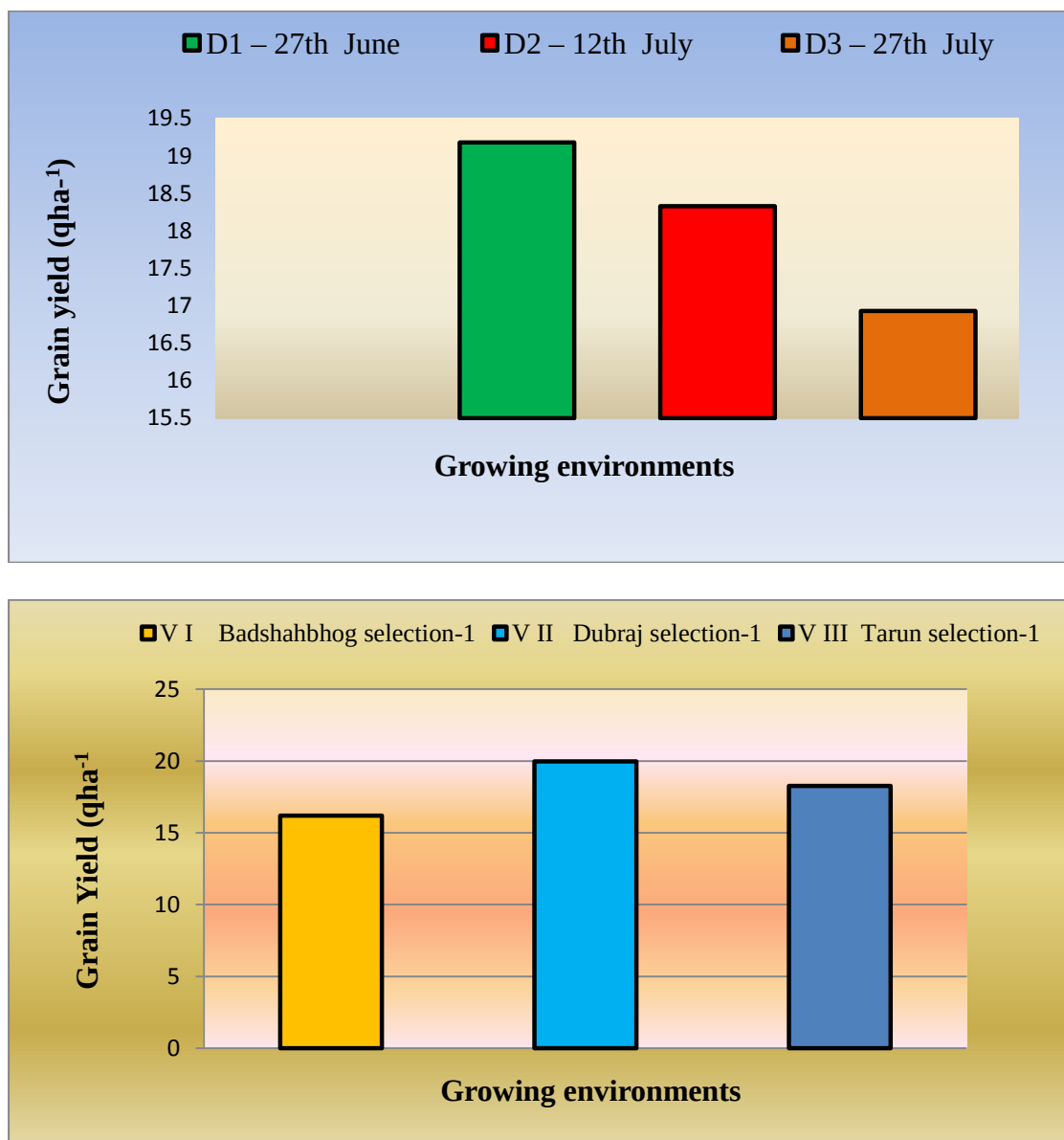


Fig-4.11: Grain yield in scented rice varieties as affected by different growing environments

4.4.7 Straw yield q/ha.

The data on straw yield is given in the Table 4.17. The straw yield (qha^{-1}) under different growing environments was found highest under 27th June (D_1) followed by 12th July (D_2) and lowest was found under 27th July (D_3) growing environments. The straw yield by different varieties and highest straw yield was observed by variety Badshahbhog selection-1 followed by Tarun selection-1 and least straw yield was found in Dubraj selection-1.

Table No. 4.17: Straw yield in different scented rice varieties as affected by different growing environments

Treatments	Straw yield qha^{-1}
Growing environments	
D_1 – 27 th June	29.21
D_2 – 12 th July	28.03
D_3 – 27 th July	27.89
SEm $\pm$	0.76
CD ($p=0.05$)	NS
Varieties	
V I Badshahbhog selection-1	29.96
V II Dubraj selection-1	27.24
V III Tarun selection-1	27.92
SEm $\pm$	0.76
CD ($p=0.05$)	NS
Intractions D X V	
SEm $\pm$	1.32
CD ($p=0.05$)	(NS)

* = significant at 5% level, ** = significant at 1% level



Fig-4.12: Straw yield in different scented rice varieties as affected by different growing environments

4.4.8 Harvest Index (%)

The data on Harvest index (%) of scented rice varieties as affected by growing environments are shown in the table 4.18. Harvest index was non-significantly influenced by different growing environments.

The harvest index was highest when crop sown on 27th June (D₁) 39.55% followed by 12th July (D₂) 39.51% and lowest under 27th July (D₃) growing environments (37.76). The harvest index showed significant difference due to different varieties and highest harvest index was noticed with Dubraj selection-1 (42.31%) followed by Tarun selection-1 (39.42%) both were significantly at par and lowest was found in Badshah bhog selection-1 (35.08%). The effect of interaction between growing environments and varieties was found non-significant at 5% level of significance.

Table No. 4.18: Harvest index (%) in different scented rice varieties as affected by different growing environments

Treatments	Harvest Index (%)
<u>Growing environments</u>	
D ₁ – 27 th June	39.55
D ₂ – 12 th July	39.51
D ₃ – 27 th July	37.76
SEm ±	1.549
CD (p=0.05)	NS
<u>Varieties</u>	
V I Badshah bhog selection-1	35.08
V II Dubraj selection-1	42.31
V III Tarun selection-1	39.42
SEm ±	1.549
CD (p=0.05)	4.64*
<u>Interaction (D X V)</u>	
SEm ±	2.682
CD (p=0.05)	(NS)

* = significant at 5% level, ** = significant at 1% level

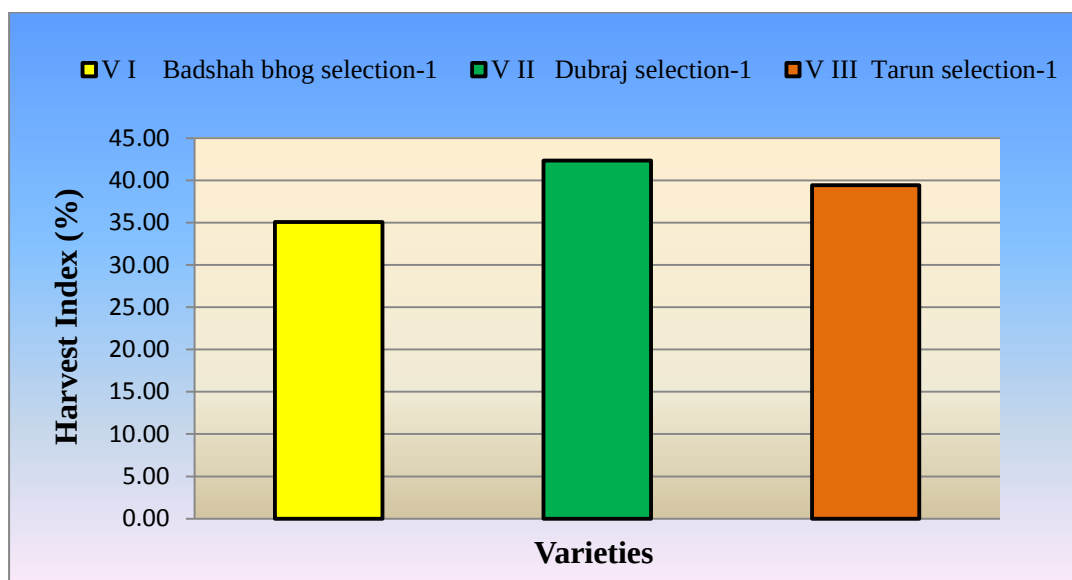
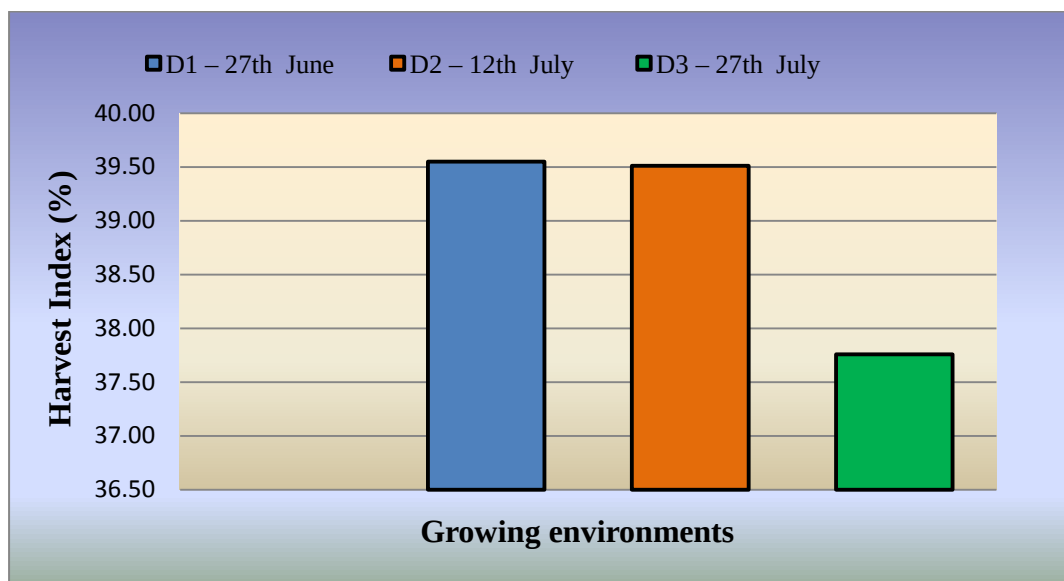


Fig - 4.13: Harvest index (%) in different scented rice varieties as affected by different growing environments

4.5 Heat units

4.5.1 Accumulated Growing Degree Day (GDD)

The accumulated Growing Degree Days (GDD) of different scented rice varieties under different growing environments from sowing to maturity are shown in Table 4.19. Highest accumulated Growing Degree Days (GDD) was recorded under D₁ growing environments in variety Dubraj selection-1 (2447) and Tarun selection-1 (2447) at maturity stage. In case of Dubraj selection-1 the highest accumulated Growing Degree Days (GDD) was observed under D₁ growing environments (24467) followed by D₂ growing environments (2203) and lowest was observed under D₃ growing environments (2003). In variety Badshah bhog selection-1 the highest accumulated Growing Degree Days (GDD) was found under D₁ (2427) followed by D₂ (2192) and D₃ growing environments (1968.1). Similarly in Tarun selection-1 the highest value of accumulated Growing Degree Days (GDD) was observed with D₁ (2447) followed by D₂ (2203) and D₃ growing environments (1991). The accumulated GDD are varying especially as per maturity period of different varieties. In general the accumulated growing degree day values decreased with delayed sowing due to early maturity of crops under delayed sown condition because of high value of temperature at maturity. These results are in general agreement with the findings of Sreenivas *et al.* (2010), Chopra and Chopra (2004).

4.5.2 Accumulated Photo Thermal Unit

Different varieties respond differently in terms of accumulated photo thermal units at the time of maturity as data shown in the Table 4.20. Highest accumulated photo thermal units were observed under D₁ growing environments in all the varieties. Accumulated photo thermal units of rice varieties under different growing environments varied considerably as shown in the table. In variety Dubraj selection-1 the highest accumulated photo thermal units were observed under D₁ (29891) followed by D₂ (26599) and D₃ growing environments (23870). In variety Tarun selection-1 the maximum accumulated photo thermal units were found under D₁ (29891) followed by D₂ (26599) and D₃ growing environments (23737). In case of variety Badshah bhog selection-1, the highest accumulated photo

thermal units were observed under D₁ (29668) followed by D₂ (26477) and D₃ growing environments (23476). Under research and instructional farm of IGKV Raipur condition Photo Thermal Units (PTU) seems to be more significantly correlated with grain yield. It is initially higher under D₁ (27th June) growing environments as grain yield is also seems to be under D₁ (27th June) growing environments as compared to D₂ (12th July) and D₃ (27th July) growing environments.

4.5.3 Accumulated Helio Thermal Units (HTU)

The observed value of accumulated Helio Thermal Units (HTU) at maturity stages of different varieties of rice under different growing environments given in the Table 4.21. Highest accumulated Helio Thermal Units (HTU) was observed under D₁ (27th June) growing environments in all the varieties viz. Dubraj selection-1, Tarun selection-1 and Badshah bhog selection-1. In Dubraj selection-1 the highest accumulated Helio Thermal Units (HTU) was observed under D₁ (27th June) 11658 followed by D₂ (12th July) 10867 and D₃ (27th July) growing environments 10747. Similarly in Tarun selection-1 the highest accumulated Helio Thermal Units was found under D₁ (27th June) 11658 followed by D₂ (12th July) 10868 and D₃ (27th July) growing environments 10639. In case of variety Badshah bhog selection-1 the highest accumulated Helio Thermal Units was recorded under D₁ (27th June) 11476 followed by D₂ (12th July) 10772 and D₃ (27th July) growing environments 10425.

Table - 4.19: Accumulated Growing Degree days (GDD) at different growth stages of different scented rice varieties under different growing environments

Growing environments	Seedling	Tillering	Panicle initiation	Booting	Panicle emergence	50% flowering	Milking	Dough	Maturity
<u>V I Badshah bhog selection-1</u>									
D₁ – 27th June	327	599	1555	1764	1906	1958	2079	2229	2427
D₂ – 12th July	324	557	1403	1596	1729	1774	1878	2043	2192
D₃ – 27th July	307	572	1256	1414	1491	1624	1715	1832	1967
<u>V II Dubraj selection-1</u>									
D₁ – 27th June	327	599	1629	1837	1974	2035	2154	2290	2447
D₂ – 12th July	324	593	1438	1631	1774	1818	1924	2078	2203
D₃ – 27th July	307	572	1310	1461	1521	1671	1762	1871	2003
<u>V III Tarun selection-1</u>									
D₁ – 27th June	327	618	1646	1854	1974	2050	2168	2290	2447
D₂ – 12th July	324	593	1454	1648	1789	1834	1924	2078	2203
D₃ – 27th July	307	572	1328	1461	1535	1685	1762	1871	1991

Table – 4.20: Accumulated Photo Thermal Units (PTU) at different growth stages of different scented rice varieties under different growing environments

Growing environments	Seedling	Tillering	Panicle initiation	Booting	Panicle emergence	50% flowering	Milking	Dough	Maturity
<u>VI Badshah bhog selection-1</u>									
D₁ – 27th June	4316	7821	19686	22133	23789	24394	25779	27456	29668
D₂ – 12th July	4185	7168	17495	19751	21309	21812	22975	24821	26477
D₃ – 27th July	3926	7220	15439	17281	18170	19660	20677	21986	23476
<u>VII Dubraj selection-1</u>									
D₁ – 27th June	4316	7821	20546	22986	24583	25283	26611	28141	29891
D₂ – 12th July	4185	7636	17898	20154	21812	22305	23491	25219	26599
D₃ – 27th July	3926	7220	16066	17832	18502	20186	21204	22421	23870
<u>VIII Tarun selection-1</u>									
D₁ – 27th June	4316	8060	20745	23179	24583	25448	26773	28141	29891
D₂ – 12th July	4185	7636	18091	20362	21979	22478	23491	25219	26599
D₃ – 27th July	3926	7220	16274	17832	18666	20344	21204	22421	23737

Table- 4.21: Accumulated Helio Thermal Units (HTU) at different growth stages of different scented rice varieties under different growing environments.

Growing environments	Seedling	Tillering	Panicle initiation	Booting	Panicle emergence	50% flowering	Milking	Dough	Maturity
<u>V I Badshah bhog selection-1</u>									
D₁ – 27th June	1097	2100	5435	6355	6901	7349	8560	9877	11476
D₂ – 12th July	1041	1548	4970	5659	6753	7212	8198	9547	10772
D₃ – 27th July	904	1837	4697	5574	6346	7628	8342	9331	10425
<u>V II Dubrai selection-1</u>									
D₁ – 27th June	1097	2100	5909	6675	7488	8120	9256	10388	11658
D₂ – 12th July	1041	1642	5056	5842	7212	7641	8578	9877	10868
D₃ – 27th July	904	1837	4901	6037	6642	7987	8719	9627	10747
<u>V III Tarun selection-1</u>									
D₁ – 27th June	1097	2218	5961	6675	7488	8270	9402	10388	11658
D₂ – 12th July	1041	1642	5114	5988	7358	7784	8578	9877	10868
D₃ – 27th July	904	1837	4943	6037	6786	8103	8719	9627	10639

4.5.4 Heat Use Efficiency ($\text{g/m}^2/\text{day}$)

Heat Use Efficiency (HUE) for different rice varieties under different growing environments at different stages are presented in the Table 4.22. It was found that the higher value of Heat Use Efficiency (HUE) in D_2 (12th July) growing environments (4.85) at 75 DAT. Among varieties, heat use efficiency was found significantly higher in cultivar Dubraj selection-1 and Tarun selection-1 which is significantly higher than Badshah bhog selection-1 variety. The Heat Use Efficiency found increasing along with advancing age and reached maximum at 75 DAT. However, after that started decreasing in 90 DAT and at harvest stage.

4.5.5 Radiation Use Efficiency (g/MJ^{-1})

Radiation Use Efficiency (RUE) of different rice genotypes under different growing environments at different growth stages varied considerably as shown in the Table 4.23. On study of Radiation Use Efficiency in D_1 (27th June) growing environments 14.16 g/mj^{-1} was significantly higher as compared to D_2 (12th July) 13.88 g/mj^{-1} and D_3 (27th July) growing environments 11.50 g/mj^{-1} , these two treatments being at par. In scented rice variety Tarun selection-1 (V_3) (13.48 g/mj^{-1}) Radiation Use Efficiency (RUE) was found to be highest and it was significantly higher than other varieties. In terms of Radiation Use Efficiency (RUE) second efficient variety Dubraj selection-1 (V_2) 13.47 g/mj^{-1} which was significantly higher than Badshah bhog selection-1 (V_1) 12.58 g/mj^{-1} at 75 DAT and decreased RUE in same varietal difference ratio. D_1 (27th June) growing environments is having higher radiation use efficiency (RUE) as well as higher grain yield and harvest index for Dubraj selection-1 and Tarun selection-1 varieties, which means radiation use efficiency can be directly co-related with grain yield.

Table 4.22: Accumulated Heat Use Efficiency (HUE) at affected by different scented rice varieties under different growing environments

Treatments	Heat Use Efficiency (g/m ² /°day) at different stages						
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	At maturity
Growing environments							
D₁ – 27th June	0.19	0.75	2.10	3.27	4.84	4.27	3.70
D₂ – 12th July	0.21	0.94	2.75	3.51	4.85	4.11	3.60
D₃ – 27th July	0.36	1.40	2.07	3.15	4.04	3.62	3.17
SEm ±	0.040	0.073	0.109	0.089	0.142	0.131	0.115
CD (p=0.05)	0.119*	0.218 **	0.326**	0.267 *	0.427**	0.393**	0.345*
Varieties							
VI Badshah bhog selection -1	0.24	0.95	2.24	3.15	4.37	3.81	3.32
V II Dubraj selection -1	0.27	1.17	2.41	3.42	4.68	4.10	3.58
V III Tarun selection -1	0.25	0.97	2.27	3.37	4.68	4.10	3.58
SEm ±	0.040	0.073	0.11	0.09	0.14	0.13	0.12
CD (p=0.05)	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)

* = significant at 5% level, ** = significant at 1% level

Table 4.23: Accumulated Radiation Use Efficiency (RUE) at affected by different scented rice varieties under different growing environments

Treatments		Radiation Use Efficiency (g/MJ ⁻¹) at different stages							
<u>Growing environments</u>		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	At harvest	
D ₁ – 27 th June		0.55	2.21	6.1	9.63	14.16	12.22	10.7	
D ₂ – 12 th July		0.65	2.77	8.17	10.37	13.88	11.91	9.54	
D ₃ – 27 th July		0.97	4.04	5.98	8.82	11.5	9.32	7.69	
SEm ±		0.12	0.21	0.32	0.26	0.41	0.36	0.31	
CD (p=0.05)		0.35*	0.63**	0.96**	0.78 **	1.23**	1.09 **	0.93 **	

<u>Varieties</u>		15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	At harvest	
V ₁ Badshah bhog selection-1		0.70	2.79	6.55	9.14	12.59	10.60	8.84	
V ₂ Dubraj selection -1		0.77	3.41	7.06	9.90	13.47	11.42	9.53	
V ₃ Tarun selection-1		0.70	2.81	6.64	9.77	13.48	11.44	9.56	
Sem ±		0.12	0.21	0.32	0.26	0.412	0.36	0.31	
CD (p=0.05)		(NS)	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)	

* = significant at 5% level, ** = significant at 1% level

4.6 Quality analysis of rice

Grain quality in rice is very difficult to define with precision as there are individual preferences. Rice is one cereal that is consumed mainly as whole milled and boiled grain. The desired properties may vary from one ethnic group or geographical region to another and may vary from country to country. The quality in rice may be considered from viewpoint of milling quality, grain size, shape, appearance and cooking characteristics. Scented rice quality is specially affected by environmental factors, soil factors and crop management factors. We tested the grain quality of cultivated scented rice varieties which was cultivated in experimental site at Raipur location by the laboratory of breeding department Indira Gandhi Krishi Vishwavidyalaya, Raipur. For quality test, samples used were approx 3 months old after harvest.

Table- 4.24: Basic characteristics of cultivated scented rice varieties

Variety	Duration (Days)	Head rice recovery	Productivity at state level (kg/ha.)	Productivity at national level (kg/ha.)
Badshah bhog selection-1	140-145	70.00%	2570	2994
Dubraj selection-1	140 - 145	61.30%	4200	3700
Tarun selection-1	135 - 140	68.00%	2800	4100

Source:- Krishi Darshika 2016 (IGKV)

4.6.1 Paddy Length and Paddy Breadth

The data regarding effect of different scented rice quality i.e. paddy length, paddy breadth, hulling%, milling%, 1000 seed weight, kernel length, Kernel length after cooking, elongation ratio and alkali spreading sown under three different growing environments shown in Table 4.25. Badshah Bhog Selection-1 showed highest paddy length 6.4 mm reported at 12th July (D₂) followed by 6.2 mm under 27th June (D₁) and lowest paddy length reported 6.0 mm under 27th July (D₃) growing environments. Highest paddy length 8.2 mm of Dubraj Selection-1 reported at 12th July (D₂) and 27th July (D₃) growing environments followed by 8.0 mm under 27th

June (D₁) growing environment but variety Tarun selection-1 showed constant length 6.0 mm in all three growing environments.

Now we conclude variety Badshah Bhog Selection-1 (V₁) having higher paddy length over other two varieties Dubraj selection-1 (V₂) and Tarun selection-1 (V₃). It can be interpreted that 12th July (D₂) growing environments suitable for better grain length for medium or intermediate size paddy varieties. Dubraj selection-1 variety which was very long variety showed the D₂ and D₃ growing environments are suitable for better grain length but all growing environments are suitable for Tarun selection-1 for maximum paddy length.

Paddy breadth found the medium shape (2.1-3.0 mm) in all three varieties in different growing environments except at 27th July (D₃) growing environments in varieties Badshah bhog selection-1 and Dubraj selection-1 that changed in bold size (≤ 2.0) and differed in both D₁, D₂ growing environments. Variety Tarun selection-1 found in medium shape at all growing environments and D₂ is suited for extreme medium quality of paddy width.

4.6.2 Milling Percentage and Hulling Percentage

The effect of different growing environments on all the three scented rice varieties in hulling and milling percentage of rice quality have been discussed.

Rice quality of paddy hulling percent in variety Badshah bhog selection-1 differed due to different growing environments. Highest hulling % has reported in 27th June (D₁) 70.93% followed by 12th July (D₂) 69.90% and lowest paddy hulling % reported at 27th July (D₃) growing environments (68.03%). Highest paddy hulling % of Dubraj Selection-1 reported at 27th July (D₃) 74.33% followed by 12th July (D₂) 72.70% and lowest hulling% 27th June (D₁) growing environments (69.91%). Variety Tarun Selection-1 were found to give highest hulling percent in 27th July (D₃) 70.44% followed by 12th July (D₂) 66.52% and lowest paddy hulling % has reported at 27th June (D₁) growing environments (62.73%). It can be interpreted that with delayed growing environments there is improvement in two varieties Dubraj selection-1 and

Tarun selection-1 increment to hulling percentage, however opposite situation in Badshahbhog selection-1.

Paddy milling percent in a variety of Badshah Bhog Selection-1 differed due to different growing environments. Highest milling % was reported at 12th July (D₂) 66.68% followed by at 27th June (D₁) 63.23% and lowest paddy milling % reported at 27th July (D₃) growing environments (61.94%). Highest paddy milling % of Dubraj selection-1 reported at 27th July (D₃) 67.11% followed by 12th July (D₂) 65.38% and lowest milling % 27th June (D₁) growing environments (62.90%). Similarly highest milling % was found in Tarun Selection -1 at 27th July (D₃) 67.40% followed by 12th July (D₂) 63.42% and lowest paddy milling % has reported at 27th June (D₁) growing environments (60.29%). Therefore it can be said that milling percentage goes on increasing with delayed sowing and transplanting.

4.6.3 Kernel length

Kernel length difference due to growing environments and different varieties has been presented in the Table 4.25. Different growing environments did not influence kernel length however the Badshah bhog selection-1 variety has reported highest kernel length on 12th July (D₂) growing environments (4.2 mm) followed by at 27th June (D₁) and 27th July (D₃). Highest kernel length of Dubraj selection-1 reported at 27th July (D₃) followed by 12th July (D₂) and 27th June (D₁) growing environments. Similarly in the variety of Tarun selection-1 highest kernel length 27th July (D₃) 4.1 mm followed by 12th July (D₂) 4.0 mm and lowest kernel length has reported at 27th June (D₁) growing environments 3.8 mm. Overall it can be observed that kernel length was highest in the variety Dubraj selection-1 followed by Badshah bhog selection-1 and Tarun selection-1.

4.6.4 Kernel Length after cooking

Kernel length after cooking (KLAC) has different value due to effect of growing environments on different scented rice varieties. Different growing environments did not influence Kernel length after cooking however it was highest in the variety of Badshah bhog Selection-1 reported at 12th July (D₂) 7.6 mm followed

by at 27th June (D₁) 7.3 mm and at 27th July (D₃) growing environments (7.3 mm). Highest KLAC of Dubraj selection-1 reported at 27th July (D₃) 9.2 mm followed by 12th July (D₂) 8.8 mm and 27th June (D₁) growing environments (8.8 mm). Similarly highest KLAC of Tarun selection-1 on 12th July (D₂) 6.9 mm followed by at 27th July (D₃) 6.6 mm and lowest KLAC has been under 27th June (D₁) growing environments (6.4 mm).

4.6.5 Elongation Ratio

Elongation ratio of rice quality has varied due to growing environments on different varieties. This component was not influenced by the growing environments. However, elongation ratio was found highest in the Badshah bhog selection-1 variety reported at 27th June (D₁) 1.83 mm and 27th July (D₃) 1.83 mm followed by at 12th July (D₂) growing environments (1.81 mm). Similarly highest Elongation ratio of Dubraj selection-1 reported at 27th July (D₃) 1.79 mm followed by 12th July (D₂) 1.76 mm and 27th June (D₁) growing environments (1.79 mm). For variety Tarun Selection-1 highest Elongation ratio was found under 12th July (D₂) of 1.73 mm followed by at 27th June (D₁) 1.68 mm and lowest Elongation ratio has been reported under 27th July (D₃) growing environments (1.61 mm).

4.6.6 Alkali spreading value

Alkali spreading value difference due to growing environments on different varieties has been presented in the Table 4.25. Different growing environments and varieties did not influence alkali spreading value; except Dubraj selection-1 variety in 27th June (D₁) growing environments. Alkali spreading value 5 is standard value for quality scented rice.

Table 4.25: Effect of different growing environments on quality of different scented rice varieties

Sowing date	Paddy length mm	Paddy breadth mm	Hulling %	Milling %	1000 seed weight(g)	Kernel length mm	KLAC (mm)	Elongation Ratio	Alkali spreading value
<u>V I Badshahbhog selection 1</u>									
D1 - 27 June	6.2	2.2	70.93	63.23	13.13	4.0	7.3	1.83	5
D2 - 12 July	6.4	2.2	69.9	66.68	12.75	4.2	7.6	1.81	5
D3 - 27 July	6.0	2.0	68.03	61.94	13.02	4.0	7.3	1.83	5
<u>V II Dubraj selection 1</u>									
D1 - 27 June	8.0	2.2	69.91	62.9	15.52	5.0	8.8	1.76	4
D2 - 12 July	8.2	2.2	72.7	65.38	16.64	5.0	8.8	1.76	5
D3 - 27 July	8.2	2.0	74.33	67.11	16.67	5.2	9.2	1.79	5
<u>V III Tarun selection 1</u>									
D1 - 27 June 2	6.0	2.4	62.73	60.29	12.26	3.8	6.4	1.68	5
D2 - 12 July	6.0	2.6	66.52	63.42	13.05	4.0	6.9	1.73	5
D3 - 27 July	6.0	2.4	70.44	67.4	13.05	4.1	6.6	1.61	5

KLAC= Kernel length after cooking

CHAPTER - V

SUMMARY AND CONCLUSIONS

The present investigation entitled “**Effect of weather parameters on growth and yield of scented rice under different growing environment**” was carried out during *Kharif* season 2016 at Research and Instructional Farm of Indira Gandhi Agricultural University, Raipur. The experiment was laid out in factorial randomized block design with three scented rice varieties under three growing environments with three replications. Based on the results obtained from the study some of the important points are summarized in the present chapter.

The phenological duration for tillering, panicle initiation, booting, panicle emergence, 50 per cent flowering, milking, dough and maturity were investigated under three scented varieties and different growing environments. It was found that crop sown on 27th June (D₁) took more number of days from sowing to maturity as compared to delayed sowing. Days to attain maturity in all the varieties viz. Badshahbhog selection-1, Dubraj selection-1, Tarun selection-1 were maximum under first growing environments (143 days, 145 days and 145 days respectively) followed by second growing environments (132 days, 133 days and 133 days respectively) and late growing environments (121 days, 124 days and 123 days respectively). The duration of the mid sown (D₂) rice was shortened by 11, 12 and 12 days due to delayed sowing in Badshah bhog selection-1, Tarun selection-1, Dubraj selection-1 whereas these varieties were shortened by 22, 21 and 22 days in duration of late growing environments condition (D₃).

The correlation between weather parameter and dry matter was significant at P₂ and P₃ stage of scented rice. P₂ stage (Panicle initiation stage -50% flowering) showed significantly positive correlation between minimum temperature, RH-1, RH-2 with dry matter. At P₃ stage (50% flowering-maturity) dry matter production was significantly positive correlated with minimum temperature, sunshine hour and RH-1. Similarly grain yield negatively significantly correlated with sunshine hour at P₁ stage (sowing to panicle initiation) of scented rice. At P₂ stage (Panicle initiation stage (PI)-50% flowering) grain yield showed positive correlation with minimum temperature and RH-1 while it showed significantly negative correlation

with sunshine hour. Grain yield was showed significantly positive correlation with minimum temperature at P₃ stage (50% flowering-maturity).

Plant height of three scented rice varieties under different growing environments was also studied. The highest plant height was observed in Dubraj selection-1 followed by Tarun selection-1 and Badshahbhog selection-1 at D₁ (27th June) growing environments. The dry matter accumulation was higher with Dubraj selection-1 as compared to Badshah bhog selection-1 and Tarun selection-1 under 27th June (D₁) growing environments at 90 DAT followed by 12th July (D₂) and 27th July (D₃) growing environments. The crop growth rate and relative growth rate was higher with Dubraj selection-1 as compared to Badshahbhog selection-1 and Tarun selection-1 while crop growth rate was recorded maximum under 27th July (D₃) growing environments during 46-60 days after transplanting over 12th July (D₂) and 27th July (D₁) and relative growth rate was recorded maximum under 12th July (D₂) during 16-30 days after transplanting over 27th July (D₃) and 27th June (D₁) growing environments.

Higher number of effective tillers/m² was recorded with Tarun selection-1 as compared to Dubraj selection-1 and Badshah bhog selection-1 under 27th June (D₁) growing environment. Higher number of filled grains per panicle, effective tillers were recorded with Tarun selection-1 as compared to Badshahbhog selection-1 and Dubraj selection-1 but sterility percentage and length of panicle was found highest in Badshah bhog selection-1 compared to Dubraj selection-1 and Tarun selection-1, Now we concluded variety Tarun selection-1 produced more numbers of effective tillers with lowest sterility percentage. Variety Badshahbhog selection-1 was found highest with sterility percentage while length of panicle was higher than other varieties. Test weight, grain yield and harvest index were comparatively higher in Dubraj selection-1, Tarun selection-1 and Badshah bhog selection-1 respectively but lowest test weight was recorded in Tarun selection-1. With respect to different growing environments, number of filled grains per panicle was recorded highest under 12th July (D₂) as compared to 27th June (D₁) and 27th July (D₃) growing environments. Grain yield and harvest index were recorded highest under 27th June (D₁) sowing as compared to 12th

July (D₂) and 27th July (D₃) growing environments, while test weight was also highest under 27th June (D₁) growing environments.

The accumulated growing degree days for different aromatic rice varieties varied considerably from sowing to maturity. The cumulative growing degree days at maturity stage were highest (2447) for Dubraj selection-1 and Tarun selection-1 followed by Badshah bhog selection-1 (2427) under 27th June growing environments (D₁). Maximum growing degree days were observed in early sown crop D₁ growing environments (27th June) as compared to late sown crop D₂ and D₃ growing environments (12th July and 27th July). The accumulated photo thermal units and helio thermal units under different growing environments varied considerably from sowing to maturity. At maturity stage Dubraj selection-1, Tarun selection-1 and Badshah bhog selection-1 sown on 27th June (D₁) recorded maximum photo thermal units (29891, 29891 and 29668 respectively). The maximum helio thermal units was recorded on 27th June growing environments in all the three rice varieties viz. Dubraj selection-1, Tarun selection-1 and Badshah bhog selection-1 (11658, 11658 and 11476 respectively). Finally, the total photo thermal units and total helio thermal units were recorded maximum under D₁ (27th June) growing environments) as compared to D₂ (12th July) and D₃ (27th June).

Heat use efficiency was higher in D₂ (12th July) growing environments (4.85g/m²/°day) at 75 DAT. Among varieties significantly higher HUE was found in variety Tarun selection-1 (4.68 g/m²/°day) followed by Dubraj selection-1 (4.68 g/m²/°day). The Heat Use Efficiency found increasing along with advancing age and reached maximum at 75 DAT and that decreased from 90 DAT. Radiation use efficiency was recorded highest in Tarun selection-1 (13.48 gMJ⁻¹) followed by Dubraj selection-1 (13.47 gMJ⁻¹) and Badshah bhog selection-1 (12.59 gMJ⁻¹) at 75 DAT. Similarly in terms of different environments it was found significantly highest in D₁ (27th June) growing environments (14.16 gMJ⁻¹). Number of effective tillers, test weight, grain yield, harvest index, plant height and total dry matter accumulation was found highest in D₁ growing environment, it means radiation use efficiency (RUE) can be directly co-related with crop growth development and grain weight.

CONCLUSION

1. With respect to effect of weather parameters on growth, phenophase and yield are Most of the weather parameters were highly significantly correlated with dry matter at P₃ stage (50% flowering-maturity) and most of the weather parameters were significantly affected the grain yield at P₂ stage ((Panicle initiation stage (PI)-50% flowering).
2. On the basis of experiment of aromatic rice on *Kharif*-2016, it was found that under 27th June nursery sowing produced better yield components (higher plant height, dry matter per hill, number of effective tillers, crop growth rate, relative growth rate, test weight, grain yield , harvest index) as compared to other growing environments.
3. With respect to the heat units viz., growing degree days, photo thermal unit, helio thermal unit, the first growing environment of scented rice on 27th June (D₁) is giving more values giving more values over after growing environments i.e. 12th July (D₂) and 27th July (D₃).
4. With respect of optimum growing environments radiation use efficiency and HUE are found better under D₁ (27th June) as compared to 12th July (D₂) and 27th July (D₃) growing environments.
Based on above findings (D₁) 27th June is best suited growing environments for new selection cultivars of scented rice based on yield attributes, yield and heat units.
5. Based on test weight, grain yield, and harvest index, plant height, total dry matter accumulation are significant in Dubraj selection-1 variety as higher production values followed by Tarun selection-1. It means that Dubraj selection-1 and Tarun selection-1 will be suitable cultivars with higher production for the Chhattisgarh plain regions.
6. Based on standard quality characters of scented rice (paddy length, paddy breadth, hulling and milling percentage, kernel length and kernel length after cooking) Dubraj selection-1 variety are best quality scented rice under all selection varieties.

SUGGESTION FOR FUTURE RESEARCH WORK

1. The effect of thermal regimes and radiation regimes in future experiment should be conducted for minimum of three years to generate detailed information.
2. It is suggested to practice with different dose of fertilizers and varied growing environments to draw practical oriented results for better quality, yield and farmer's economy.
3. It is also suggested to practice with different crop establishment techniques with respect to effect of light penetration on growth and yield.
4. There is a scope for increasing area and production of different selected scented rice varieties in different districts of Chhattisgarh plain. It will be helpful to increase farmer's income due to higher production and good quality rice.

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