Evaluation of different cultivars and methods of planting for rainfed rice (*Oryza sativa* L.) in the context of climate change

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JAYKRIT SINGH

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CERTIFICATE OF ORIGINAL WORK

This is to certify that the study conducted by **Mr. Jaykrit Singh** during **2012-13** as reported in the present thesis was under my guidance and supervision. The results reported by him are genuine and the candidate himself has written the script of the thesis. His thesis entitled, **"Evaluation of different cultivars and methods of planting for rainfed rice (*Oryza sativa* L.) in the context of climate change"**, is therefore, being forwarded for the acceptance in partial fulfillment of the requirements for the award of the degree of **Master of Science (Agriculture) in Agronomy** of the Allahabad School of Agriculture, Faculty of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences (Deemed-to-be-University), Allahabad - 211007 (U.P.).

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CERTIFICATE OF ACCEPTANCE OF EVALUATION COMMITTEE

This thesis entitled, **"Evaluation of different cultivars and methods of planting for rainfed rice (*Oryza sativa* L.) in the context of climate change"**, has been prepared and submitted by **Mr. Jaykrit Singh** in partial fulfillment of the requirements for the award of degree of **Master of Science (Agriculture) in Agronomy (Id. No. 11MSAGRO008)** of the Allahabad School of Agriculture, Faculty of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, (Deemed-to-be-University), Allahabad - 211007 (U.P.).

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SELF ATTESTATION

Certified that I have personally worked on the thesis titled, **"Evaluation of different cultivars and methods of planting for rainfed rice (*Oryza sativa* L.) in the context of climate change",**. The data presented in the thesis have been generated during the work and are genuine. None of the findings/information pertaining to the work has been concealed. The results embodied in this thesis have not been submitted to any other university or institute for the award of any degree or diploma.

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Allahabad

Date: ***Jaykrit Singh***

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LIST OF ABBREVIATIONS

₹	: Rupee(s)
&	: and
@	: at the rate of
^{0}C	: Degree Centigrade or Celsius
/	: per
%	: Percentage
$\overline{X}$	: Mean
σ	: Standard deviation
Agr.	: Agriculture
Agric.	: Agriculture
Agril.	: Agricultural
AEZ	: Agro Ecological Zone
AICRIP	: All India Coordinated Rice Improvement Project
ANOVA	: Analysis of Variance
Avg.	: Average
BPR	: Beushening Puddled rice
CD	: Critical Difference
CGR	: Crop Growth Rate
cm	: Centimeter(s)
CT	: Conventional transplanting
CTR	: Conventional transplanted rice
CV	: Co-efficient of variation
DAS	: Days after sowing
DAT	: Days after transplanting
Dev.	: Development
df	: Degrees of freedom
DM	: Dry matter
DMA	: Dry matter accumulation
DPO	: District Project Officer
DSR	: Direct seeded rice
EC	: Electrical Conductivity
Edu.	: Education
e.g.	: For example
EMS	: Error mean sum of squares

ESS	: Error sum of squares
et al.	: And others
etc.	: Etcetera ()
Ext.	: Extension
F Cal	: F calculated
F Tab	: F table
Fig.	: Figure
FPDCS	: Food production, distribution and consumption system
FYM	: Farmyard Manure
g	: gram
GOI	: Government of India
ha	: Hectare
HCL	: Hydrochloric acid
HYV	: High yielding variety/varieties
i.e.	: That is
ICM	: Integrated Crop Management
IFOAM	: International Federation of Organic Agriculture Movements
IMD	: India Meteorological Department
Intl.	: International
ITK	: Indigenous Traditional Knowledge
IWMI	: *International Water Management Institute*
J.	: Journal
K	: Potassium
K_2SO_4	: Pottasium sulphate
kg	: Kilogram
l	: Litre
$\log_e$	: Natural logarithm
m	: Meter(s)
m ha	: Million hectares
m^2	: Square meter(s)
Max./max.	: Maximum
Mg	: Milligram
Min./min.	: Minimum
ml	: Millilitre
mm	: Millimeter

MSS	: Mean Sum of Squares
MSSE	: Error Mean Sum of Squares
mt	: Million tonnes
n	: Number of observation
NaOH	: Sodium hydroxide
NH_4	: Ammonium
No.	: Number
NS	: Non-significant
NTP	: Normal transplanted
OC	: Organic carbon
OFAR	: On farm agriculture research
OM	: Organic matter
P	: Phosphorus
pH	: potential hydrogen ion
pp	: Pages
PRA	: Participatory Rural Appraisal
Proc.	: Proceedings
r	: Number of replications
RDF	: Recommended dose of fertilizers
Ref	: Reference(s)
Res.	: Research
RGR	: Relative Growth Rate
RH	: Relative Humidity
RMP	: Recommended management practices
RO	: Research Officer
RSS	: Sum of squares due to replication
S	: Significant
S. No.	: Serial number
SAF-BIN	: Strengthening Adaptive Farming in Bangladesh, India and Nepal
Sci.	: Science
SE	: Standard error
SEd±	: Standard error deviation
SHFC	: Small Holder Farming Community
SOM	: Soil organic matter
SP	: System of planting
SRI	: System of Rice Intensification

SS	: Sum of Squares
SV	: Source of Variation
t	: Tonne(s)
T	: Treatment
Temp.	: Temperature
TrSS	: Sum of squares due to treatment
TSS	: Total Sum of Squares
USDA	: United State Department of Agriculture
viz.	: Namely
VRA	: Village Research Assistant
Zn	: Zinc
Zn-EDTA	: Zincethylene diamine tetra acetic acid
$ZnSO_4$	: Zinc sulphate

CHAPTER I

INTRODUCTION

Rice is a cereal crop that belongs to family Poaceae (Dahanayake and Ranawake, 2012). It is the staple food for more than 60% of world population. Asia is the home of rice as more than two billion people are getting 60 to 70% of their energy requirement from rice and its derived products. Almost 90% of the total rice is produced and consumed in Asia (Adhya, 2010). Worldwide, 661.81 mt of rice at an average yield of 3.5 t ha^{-1} is being harvested from 155.17 m ha annually and producing 21% of world's food calorie supply.

Nutritionally, it contains 80% carbohydrates, 7 to 8% proteins, 3% fat and 3% fiber (Juliano, 1985). The by-products of rice milling are used for a variety of purposes. Rice bran is used as cattle and poultry feed. Rice hull can be used in manufacture of insulation materials, cement, cardboard, and as litter in poultry keeping. Rice straw is widely used as cattle feed as well as litter during winter (Singh *et al*., 2010). The global rice requirements in 2025 will be in the order of 800 mt. The present production is little less than 600 mt and an additional 200 mt will have to be produced by increasing productivity ha^{-1} to meet the future requirements (Swaminathan, 2006).

India has 43.97 m ha area under rice and production figure of 100 mt (GOI, 2012). India shares the world's 22.81% rice production. India holds 2nd and China 1st position in rice production in the world (USDA, 2013). Madhya Pradesh has an area of 1.66 m ha and production figure of 3.78 mt with a productivity of 1.106 t ha^{-1} of rice. The total area of rice under irrigated situation is only 2.23 lacs ha. The total rice production of M.P. is 1.710 lacs t, out of which 1.313 lacs t is from rainfed and 0.397 lacs t is from irrigated area. The mean productivity of rice in M.P. is 1103 kg ha^{-1}, while rice under irrigated area has a productivity figure of 1273 kg ha^{-1} (RKMP, 2012).

There is hardly any possibility of increasing the area under rice, as there is competitive demand of land for commercial crops. The only option left out to face the challenge of meeting the enormous demand for rice is to try for vertical increase in the production. Most of the research work so far has been concentrated on irrigated ecosystem, as a result of which, the gap between average yield level of farmers and the potential yield level has been narrowed down substantially. However, the yield gap is still very wide in the rainfed ecosystem (Mahapatra *et al*., 1996). In order to meet the future demand of India's burgeoning population, there is a need to enhance the yield levels of rice in rainfed ecosystem also, as the total area of rice under rainfed is more than the area under irrigated condition.

In the changing scenario of research, particularly where the driving force is critical, as in the existent crisis of rainfed farming, adaptive farming, which is what the farming community knowingly or unknowingly implements, will thrive superior if ample support is provided. Thus, in the current experiment, 'on farm adaptive research' approach has been attempted. In contrast to the conventional 'top-down' approach, the independence and involvement of the farming populace was given due consideration, which included the amalgamation of traditional practices, techniques (ITKs) *etc*. During the process of formulating the various treatments of the trial, refinement in the ITKs was done, which were suitably incorporated along with the advanced and appropriate recommendations. This was done so that the existing constraints would be addressed through a Farmer-Scientist and Stake-holders' interaction, to develop a sustainable package for the Food production, distribution and consumption system (FPDCS) in the context of climate change. In the present experiment Participatory Rural Appraisal (PRA) tools and other resources were extensively used to solicit the probable cause and promising agronomic solution for rainfed rice of Mandla district.

The availability of inter-disciplinary expertise within the Strengthening Adaptive Farming in Bangladesh, India and Nepal (SAF-BIN) team and research partner, *i.e.*, SHIATS enabled the identification and prioritization of constraints related to rainfed rice production systems. The attempt to classify different production constraints lead to four broad categories:

i. Climatic constraints: Narrowing of rainy season, delay of monsoon, breaks in the monsoon activity, prolonged dry periods during the crop season and even continuous flooding affect the production due to heavy rain and high moisture (Subash and Mohan, 2010).
ii. Biophysical constraints : Non-availability of suitable high yielding varieties, high cost of HYV seeds, complexity of new practices, heavy weed growth and pest and disease incidence
iii. Socioeconomic constraints : High cost of inputs, high cost of labour, non-availability of trained labour, non-availability of credit facilities and escalating prices of nitrogenous fertilizers (Khan *et al*., 2006).

iv. Technological constraints: Lack of awareness of technologies, lack of conviction, non-availability of desired technology, low input use, inappropriate plant spacing and late sowing and selection. The traditional method of rice cultivation does not have the ability to explore natural potential of the rice plant because it is generally transplanted with old seedlings, closely spaced and continual flooding, which hold back the plants' natural potential (Tripathi *et al*., 2004 and Singh and Varshney, 2010).

Further, in the climate change scenario some of the key vulnerable problems which were pointed out in Mandla region included higher invasion of pest [Semilooper (*Naranga aenescens*)] and disease due to change in environment. Highly erratic pattern of rainfall invariably led to late sowing, early withdrawal of monsoon affected the critical stages of crop growth (tillering stage, panicle initiation, internode elongation and milk stage). Scarcity of water during these phases also hampered the performance of rice.

While working out the solution to these constraints through a participatory and multi-pronged approach, the plausible options were observed to be as follows:

The options of suitable genotypes are among the most important factors in rainfed rice production. Indigenous genotypes are observed by the farming community as possessing moderate resistance or tolerance towards stress, particularly at anthesis (flowering) stage, though their tillering ability is moderate. There is a need to specify and select the genotypes, which have enhanced yielding ability in rainfed lowland and upland conditions. Indigenous genotypes are a good option because it is uncomplicated to assess, principally due the availability and acceptability. However, the alternative option of HYV also possess higher adaptability and productivity, thereby, the food security problem may be addressed in an amicable way.

Direct seeded rice offers the advantage of PMDS, *i.e.*, pre monsoon dry sowing before the start of the wet season, permitting the use of early rains for crop establishment or up to 30 days after the onset of rains, quicker seeding, helps in timely sowing, ensure proper plant population, reduced labour and hence less drudgery, earlier crop maturity (10 to 12 days), higher tolerance to water-deficit, low production cost (saving on labour cost) and often higher profit in areas with fairly assured rainfall (Gill, 2008, Saleh *et al*., 1993 and My *et al*., 1995). Hence the probability of success of this method in the upland condition is another acceptable option for obtaining better yield.

Beushening, a traditional rice cultivation system, is common throughout the rainfed lowland region of eastern India. Locally, this practice is known as *beushen* in Orissa and Bihar, *biasi* in eastern Madhya Pradesh (Ghosh *et al*., 1960). The effectiveness of this traditional agronomic operation, such as diminished weed infestation, increased water-use efficiency, improved tillering and nutrient uptake and reduced insect-pests, makes it acceptable to the farmers with poor and limited resources in these areas. The possibility of achieving reasonably good production with limited inputs and less intensive labour use, under conditions of uncertain rainwater and infertile soils is another promising aspect (Singh *et al*., 1994 and Tomar, 2000).

SRI is actually an amalgamation of refined and intensive management practices for rice production at farmers' fields. The conservation of land, water and biodiversity and utilization of the hitherto ignored biological power of plant and solar energy, are the novelties of SRI. On account of its growing global acceptance, SRI has emerged as a movement among farmers (Barah, 2009). SRI practices were reported to yield higher and save water compared to farmers' practices in Madagascar, Bangladesh, Nepal and Sri Lanka, among other countries (Barrett *et al*., 2004; Husain *et al*., 2004; Latif *et al*., 2005 and Namara *et al*., 2003) as well as the southern peninsula of this sub-continent (Satyanarayana *et al*., 2007). Thus SRI certainly holds potential for rainfed rice ecosystems of M.P. in general and Mandla in particular.

World energy crisis have diverted attention of agronomists and soil scientists to find out the other possible alternate sources of nitrogen. Farmyard manure is bulky organic manure which is a storehouse of major nutrients and improve physical properties of soil especially the structure, water holding capacity, bulk density, porosity, cation exchange capacity, *etc*. A part from these, it has been reported that the enzymatic activities were enhanced which encourage root development and yield of rice crops (Khan *et al*., 2006 and Shekara *et al*., 2010). Hence, the need of the hour is to re-introduce, wherever feasible, at least partially, the concepts of organic farming.

In the light of the aforestated constraints and probable solutions, the present investigation entitled, "Evaluation of different cultivars and methods of planting for rainfed rice (*Oryza sativa* L.) in the context of climate change", was carried under SAF-BIN (on farm adaptive research) on farmers' field in the 10 villages of district Mandla of Madhya Pradesh by the active participation of the Associate Partner (Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad), during the *Kharif* season of 2012, with the following objectives.

OBJECTIVES

1. To find out the suitable genotypes for rainfed rice of the AEZ-5 (as per FAO).
2. To evaluate the methods of planting of rainfed rice for its suitability.
3. To find out appropriate nutrient management practice.
4. To determine economics of different treatment combinations.

CHAPTER II

REVIEW OF LITERATURE

In this chapter, attempt has been made to review the important and relevant research work related to the present thesis entitled, "Evaluation of different cultivars and methods of planting for rainfed rice (*Oryza sativa* L.) in the context of climate change", and the work is classified in to appropriate headings.

As stated in the chapter 'Introduction', while planning and formulating the present experimental trial through a Farmers-Scientists-Stake-holders' interactive approach, PRA tools and other means were widely used to sort out the plausible cause and agronomic solution for rainfed rice of Mandla district, particularly in the context of climate change. Operational Manual (2010) prepared by Er. Sunil Simon (Program Manager of SACU and India), Dr. Pranab Choudhury (Program Consultant).

2.1 Vulnerability of rice to the climate change

According to Khan *et al*. (2009), vulnerability is the degree to which a system is susceptible to, or unable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed as well as the system's sensitivity and adaptive capacity. Vulnerability to climate change varies across regions, sectors, and social groups.

Saseendran *et al*. (1999) reported that the vulnerability of rice crop was evident and the temperature sensitivity experiments had shown that for a positive change in temperature up to 5 ˚C, there was a continuous decline in the yield. For every one degree increment, the decline in the yield is about 6%. Also, in another experiment, it was noticed that the physiological effect of ambient CO_2 at 2 ˚C in temperature increase was compensated for the yield losses. Further, increase of 1 ˚C temperature without any increase in CO_2 resulted in 5, 8, 5 and 7% decrease in grain yield respectively of north, west, east and southern regions of India. Increase of 2 ˚C temperature resulted in 10-16% reduction in yield in different regions, while a 4 ˚C rise led to 21-30% reduction (Khan *et al*., 2009).

Hundal and Kaur (1996) examined the climate change impact on productivity of rice crop in Punjab region. They concluded that if all other climate variables were to remain constant, temperature increase of 1, 2 and 3 °C from the present day condition would reduce the grain yield of rice by 5.4, 7.4 and 25.1% respectively.

Nguyen (2006) reported that variability in the amount and distribution of rainfall is the most important factor limiting yield of rainfed rice. Variability in the onset of the rainy season leads to variation in the start of the planting season in rainfed rice. Moreover, in freely drained upland, moisture stress severely damages or even kills rice plant in an area that receives as much as 200 mm of precipitation in 1 day and then receives no rainfall for the next 20 days. Complete crop failure usually occurs when severe drought stress takes place during the reproductive stages. However, extreme temperatures – whether low or high – cause injury to the rice plant. In tropical regions, high temperature is a constraint to rice production. The most damaging effect is on grain sterility; just 1 or 2 hours of high temperature (more than 37 °C) at anthesis result in a large percentage of grain sterility.

Khan *et al*. (2009) opined that the global warming may affect growth and development of all organisms including insect pests themselves. Among all the abiotic factors, temperature is the most important one affecting insect distribution and abundance in time and space, since these are cold-blooded animals. The insects cannot regulate their body temperature and thereby, ambient temperature influences their survival, growth, development and reproduction. Any small change in temperature can result in changed virulence as well as appearance of new pests in a region.

Peng *et al*. (2004) articulated that as temperature varies from month to month, it is possible to select the right date for crop establishment in such a way that the reproductive and grain filling phases of rice fall into those months with a relatively low temperature. This would minimize the negative effect of temperature increase on rice yield.

Contrasting facts have been also reported and some literature state that the direct effect of climate change on rice crops in different agro-climatic regions in India would always be positive, irrespective of the various uncertainties. Depending upon the scenario, rice yields increased between 1.0 and 16.8% in pessimistic scenarios of climate change depending upon the level of management and model used. These increases were between 3.5 and

33.8% in optimistic scenarios. These conclusions are highly dependent on the specific thresholds of phenology and photosynthesis to change in temperature used in the models (Khan *et al*., 2009).

Nakagawa *et al*., 2003 stated that in some locations temperature increase would improve the crop establishment of rice, for example in Mediterranean areas, where cool weather usually causes poor crop establishment. However, they concluded that the negative effects associated with temperature increment heavily outweigh the positive.

2.1.1 Response of rice genotypes to rainfed condition

CRRI (1996) apprised that the tolerance of rice genotypes to drought in general is associated with (i) higher germination in polyethylene glycol, (ii) less starch disintegration in root and low destruction of chlorophyll, (iii) tillering in quick succession before the onset of drought, (iv) longer root length (>25 cm), (v) higher leaf moisture content and greater accumulation of sugars in non-reducing form. However, it was also stated that tolerance to water-logging is associated with (i) fast, early tiller development, (ii) liberation of more oxygen from the root, (iii) moderate pectin-methyl esterase activity in the culm, and (iv) greater chlorophyll b and higher photosynthetic rate of the top leaves above water level. The occurrence of flowering early in the morning was described many years ago as a useful phenomenon imparting heat tolerance to rice genotypes (IRRI, 1977).

Under the AICRIP (Rice) project the traditional germplasm were collected in collaboration with Biodiversity Board, Bhopal M.P., by the RAWE students, KVKs and the State Department of Agriculture from various locations of Madhya Pradesh. In the rainfed upland: *Dehula, Bagri, Karahani, Lonagi, Sonkharchi, Ajan Raimunwa*, *Biranj, Rambhog, Kausari, Nokhi, Karga, Lonhadi, Karanphool*, *Newari, Jiledar, Jalkeshar, Kanak*, *Luchai, Badalphool Kerakhambh, Gurmatia, Laldhan, Hausakanak, Mansoori, Ranikajal Dadbanko* and tolerant to drought: *Dehula, Bharri, Johar, Bagri, Karaga, Nokhi* and *Karanphool*, which was reported by RKMP (2012). However, some released varieties, which were most suitable for M.P. climatic condition, (rainfed upland) are Annapurna, Jagruthi, Bala, Praghathi, Garima, Poorva, JR 75, Shyamala (rainfed shallow lowland), Abha (drought tolerant) as reported by Singh *et al.* (2010).

Some of the characteristic features of these varieties/cultivars are described by researchers. Zhou *et al.* (2007) and Manickavelu *et al.* (2010) opined that drought resistant genotypes can be determined by measuring some characteristics such as leaf rolling, leaf drying, yield potential, delayed flowering, reduced plant height or drought response index (DRI) under both normal and drought stress conditions. Different rice cultivars have different responses to drought stress and there is wide genetic diversity among rice genotypes regarding sensitivity and tolerance to drought. In cereals especially rice, reproduction stages, including pollination and fertilization, are water critical and water deficit stress decreases yield and yield components significantly as reported by Lafitte *et al.* (2004).

2.2 Effect of methods of planting on growth, yield attributes and yield of rice

Aslam *et al*. (2008) reported that the higher paddy yield recorded in transplanting technique was attributed to good crop conditions, efficient utilization of natural resources (soil, light, water, air *etc*.), which resulted in higher number of tillers and panicles unit^{-1} area and spikelets panicle^{-1} than in direct sown dense populated crop.

Aboualizadeh (2013) reported that most number of days to start of tillering (15.13 days), number of days to initial heading (54.69 days), number of days to 50% flowering (64.75 days), number of days to full heading (89.89 days) and number of days to physiological maturity (105.7 days) were observed in conventional system, but the least number of days to start of tillering (11.44 and 11.74 days), number of days to initial heading (51.47 and 51.78 days), days number to 50% flowering (61.5 and 61.75 days), number of days to full heading (86.5 and 86.5 days) and number of days to physiological maturity (101.6 and 101.5 days) were obtained in SRI and improved system.

Sowmya *et al*. (2011) reported that the comparison between the methods of cultivation (SRI and NTP), the growth parameters, *viz*., plant height, number of tillers m^{-2} and dry matter production at tillering, flowering and harvest were higher with conventional method compared to SRI. The accelerated growth and development of the crop under SRI at advanced stages resulted in comparable dry matter accumulation with that of normal transplanting at flowering and crop harvest.

Manjunatha *et al*. (2010) reported that planting of 9 days (6.07 t ha^{-1}) or 12 days (6.02 t ha^{-1}) old seedlings gave significantly higher grain yield than 15 (5.79 t ha^{-1}), 18 (5.77 t ha^{-1}) and 21 days (5.72 t ha^{-1}) old seedlings. This was because of the higher number of panicles hill^{-1} (48.93 and 48.17 under planting of 9 days and 12 days old seedlings, respectively), panicle length (21.07 and 21.24 cm under planting of 9 and 12 days old seedlings, respectively), number of grains panicle^{-1} (159.33 and 158.13 under planting of 9 and 12 days, respectively) and test weight (20.74 and 20.58 g under planting of 9 days and 12 days old seedlings, respectively). Further, they stated that transplanting younger seedlings, *i.e.*, less than 15 days old seedlings had higher tillering capacity and more vigour, which in turn helped in extracting nutrients from soil. Similarly, Senthilkumar *et al*. (2007) reported that planting younger seedlings (modified planting) behaved alike the conventional planting. Younger seedlings attributed to more number of tiller production, higher number of spikelets unit^{-1} area but it did not reflect on final grain yield because of the high sterility percentage and reduced grain weight. In between panicle initiation and flowering, there were four extended days for direct seeded crop which ultimately reflected on the grain yield difference, wherein direct seeding was better than transplanting.

Bozorgi *et al*. (2011) stated that number of seedling per hill is another important factor that can play important role in boosting yield of rice, because it influences the tiller formation, solar radiation interception, total sunshine reception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately affects the growth and development of rice plant. They further reported that comparison of mean between number of seedlings hill^{-1} showed that the highest grain yield, harvest index and number of grains panicle^{-1} with 3.53 t ha^{-1}, 43.28% and 87.67 respectively was recorded from 3 seedlings hill^{-1}. The lowest grain yield with 3.12 t ha^{-1} and number of grains panicle^{-1} with 80.89 grains panicle^{-1} was found from 1 seedling hill^{-1}. The maximum amount of straw yield, biological yield and number of tillers m^{-2} was recorded from 5 seedlings hill^{-1} respectively with 4.8 t ha^{-1}, 8.2 t ha^{-1} and 276.70. Minimum values of these traits respectively with 4.41 t ha^{-1}, 7.53 t ha^{-1} and 217.40 was recorder from 1 seedling hill^{-1}. However, it was also observed that in densely populated rice field the inter-specific competition between the plants is high in which sometimes results in gradual shading and lodging and thus increase production of straw instead of grain.

Thakur *et al*. (2010) reported that the dry weights of aboveground parts of individual hills and in per unit area were significantly greater in SRI than in recommended management practices (RMP) plants. Performance of individual hill was significantly improved with wider spacing compared with closer-spaced hills, in terms of root growth and xylem exudation rates, leaf number and leaf size, canopy angle, tiller and panicle number, panicle length and grain number panicle^{-1}, grain filling percentage and test weight and straw yield, irrespective of where SRI was employed. SRI yielded 40% more than the recommended practice.

Shekhar *et al.* (2009) reported that on an average integrated crop management (ICM) (6.67 t ha^{-1}) and SRI (6.43 t ha^{-1}) produced respectively 14.5% and 10.6% more grain yield compared to CT (5.81 t ha^{-1}). However, the significantly superior panicle weight (3.75 g) was observed in the SRI.

Wijebandara *et al.* (2009) observed in the northern dry zone of Karnataka, plant height at 30, 60 and 90 DAT and at harvest were significantly higher in SRI method of cultivation (55.1 cm) as compared to conventional method (40.1 cm) at 30 DAT. Similar trend was observed at 60, 90 DAT and at harvest. The significantly higher number of tillers hill^{-1} (at 30 DAT), grain yield and straw yield (23.1, 6.69 and 8.18 t ha^{-1} respectively) was observed in SRI method as compared to conventional method (13.7, 3.68 and 4.46 t ha^{-1} respectively). Rice seedlings when planted earlier (8 to 12 days old seedlings) need to be provided enough space to express their full potential in terms of growth of leaves, tillers and roots. Enough space, along with other favourable conditions, allows the plant roots to grow profusely both vertically in deeper parts of the soil and horizontally to cover a larger area, and when roots are spread to a large volume of soil, they tap more nutrients, which results in the development of taller and larger plants with larger numbers of tillers and grains. However, Anitha and Chellappan (2011) observed that under humid tropics (Kerala) condition, planting of two 20 day-old seedlings significantly increased the grain (14%) and straw yield (17%) compared to planting 10 day-old single seedlings.

Geethalakshmi *et al.* (2008) reported that rice under SRI produced significantly more number of tillers m^{-2} (414 and 448) than other systems of rice production. This was closely followed by transplanted rice and direct sown rice. System of rice intensification (SRI) registered significantly more number of productive tillers m^{-2} (383 and 416) than other rice cultivation methods in both the seasons (summer *and kharif*). Among the different rice production methods, system of rice cultivation (SRI) produced significantly higher grain yield (6.02 and 6.68 t ha^{-1}), followed by transplanted rice (5.73 and 6.26 t ha^{-1}).

Krishna *et al*. (2008) reported that SRI method had recorded significantly higher grain yield (2.94 t ha^{-1}) as compared to traditional method (2.37 t ha^{-1}). The per cent increase in grain yield ha^{-1} under SRI method was 20.25 over traditional method.

Sharma and Masand (2008) reported that the panicle size was larger under the new method (ICM) and number of grains panicle^{-1} were significantly more in SRI (130) and ICM (113) than CT (94).

Nissanka and Bandara (2004) reported 9 and 12% more grain yield in SRI compared to conventional transplanting and direct sowing methods.

Rupela *et al*. (2006) reported that grain yield in all the four seasons (post rainy 2004-05 to rainy 2006) was significantly more in plots of SRI than those of flooded rice. Mean grain yield (based on seasons) in SRI plots ranged from 6.91 t ha^{-1} to 8.2 t ha^{-1}, which was 22 to 28% more than that in relevant control plots (range of 5.38 t ha^{-1} to 6.74 t ha^{-1}).

Chandrapala *et al*. (2010) reported that in the 2007-08 and 2008-09 significantly higher plant dry weight (53.6 and 59.0 g respectively), grains panicle^{-1} (122 and 121 respectively), test weight (21.9 and 22.0 g respectively) and biological yield (11.48 and 11.67 t ha^{-1} respectively) of rice crop was observed under SRI method when compared with DS and CT methods.

Bommayasamy *et al*. (2010) reported that among the tested, 20 cm × 20 cm lead to significantly higher CGR during both the years (2003 and 2004) and 30 cm × 30 cm recorded the least CGR values. However, significantly higher grain and straw yield (8.00 and 9.15 t ha^{-1} respectively) was recorded with 20 cm × 20 cm spacing followed by 30 cm × 30 cm spacing led to 11% yield reduction over 20 cm × 20 cm spacing. Similar trend in CGR was also reported by Baskar *et al*. (2012).

Tomar (2000) reported that *Beushening* facilitated stable rice yields under low-input levels and uncertain climatic conditions. Rice cultivars mostly used by farmers are of local origin and have a long duration (150 to 170 days) and medium tillering capacity. These varieties can withstand drought and submergence to some extent. Yields of *beushened* rice, however, are lower than those of transplanted rice; transplanting is usually not suitable in most of these areas.

Raj *et al*. (2012) reported that the higher panicle length (21.85 cm) and panicle weight (4.05 g) were recorded in farmer's practice of manual transplanting, which was on par with mechanized transplanting. A positive correlation was found between panicle length and number of grains panicle^{-1}, greater the panicle length more was the number of grains panicle^{-1}. On the other hand direct seeded rice recorded significantly higher test weight (26.9 g) of grains compared to other methods.

Another aspect which some literature reported was that early planting in June second fortnight with 20 × 20 cm spacing recorded 9.10% higher panicles m^{2}, lengthier panicle with higher number of filled grains panicle^{-1} (108) compared to the same time of planting in 25 × 25 cm. The number of panicles m^{-2} was higher at increased plant density and decreased with wider spacing (Damodaran *et al*., 2012). According to Gill *et al*. (2006), the delayed transplanting in July compared to June resulted in sharp reduction in grain yield due to reduction in favourable growing period. Further, wider spacing may increase yield plant^{-1} but may often lead to a decrease in grain yield unit^{-1} area due to less plant population.

2.3 Effect of nutrient options on growth, yield attributes and yield of rice

2.3.1 Effect of organic manures including (FYM) on growth and yield

Widawsky and O' Toole (1990) pointed that scarcity of the water, uneven distribution of rains and significant gaps between rains are constraints to productivity and efficient nutrient use in rainfed lowland. Soils with very low organic matter content and low fertilizer application rate further accentuate the effect of drought. As a result, high yield losses have been reported in lowland agro-ecosystem.

Satheesh and Balasubramanian (2003) reported that organic manures exhibited 22.7% and 21.5% higher total P and K uptake respectively in both the seasons of study when compared to chemical N fertilizer applied treatments. The significant increase in grain yield was supported by higher number of panicle bearing tillers, straight ear heads and test weight, which was observed more in organic manure applied plot as compared to inorganic fertilizer. Application of farmyard manure resulted in higher yields than that of other treatments; this could be owing to higher quantity of nutrients supplied through farmyard manure at 10 t ha^{-1} than in other treatments.

Shekara *et al.* (2010) reported that application of 20 t FYM ha^{-1} was recorded significantly more productive tillers hill^{-1}, filled spikelets, test weight, which cumulatively lead to higher grain yield (6.01 and 6.44 t ha^{-1} in 2005 and 2006, respectively) than 5 t and no FYM application. Kumar *et al*. (2003) also reported that significantly higher grain and straw yield (4.88 and 6.08 t ha^{-1} respectively) were registered with the application of FYM 20 @ t ha^{-1}.

Yadav *et al*. (2008) reported that the significantly higher grain yield (22.63 kg ha^{-1} day^{-1}) was observed in the treatment with green manuring (*Glyricidia* @ 10 t ha^{-1}). However, treatment neem cake @ 2.5 t ha^{-1} and FYM @ 10 t ha^{-1} (21.93 and 21.36 kg ha^{-1} day^{-1} respectively) were found to be statistically at par with treatment green manuring (*Glyricidia* @ 10 t ha^{-1}). Treatment green manuring (*Glyricidia* 10 t ha^{-1}) was recorded good productivity due to supply of optimum of quantity of nutrient throughout of the life period of crop.

Kharub and Chander (2008) reported that the significantly higher grain yield (5.47 t ha^{-1}) was observed in the chemical fertilizer application. However, treatment 15-30, 15-40, 22.5-20, 22.5-30, 22.5-40, 30-0, 30-20, 30-30 and 30-40 t FYM (5.09, 5.13, 5.15, 5.23,5.31, 5.04, 5.19, 5.37 and 5.35 t ha^{-1} respectively) were recorded to be at par with the treatment chemical fertilizer application. Similar trend was observed in the straw yield of rice, which were 7.6 to 10.8 t ha^{-1} under inorganic fertilizer and 7.9 to 9.9 t ha^{-1} under FYM.

However, Husain *et al*. (2009) reported that the significantly higher grain yield (4.11 t ha^{-1}) of rice recorded when Zn @ 25 kg ha^{-1} and FYM @ 5 t ha^{-1} both were applied in rice, but Zn @ 25 kg ha^{-1} in both of the crops (rice and wheat) and FYM @ 5 t ha^{-1} in rice excelled all the treatments.

2.3.2 Effect of inorganic sources of nitrogen and zinc on growth and yield of rice

The rice in rainfed areas responds well to P and K applications, which provide drought and disease-pest resistance to the crop. In fact, even in rainfed areas, extensive overexploitation of soil nutrient reserves has already occurred. To increase productivity under rainfed conditions, balanced fertilization would be essential and inevitable (Tiwari, 2002).

Paraye *et al*. (1996) recorded that split application of 100 kg N ha^{-1} significantly influenced all the yield attributes along with grain yield except effective tillers m^{-2} in pooled analysis. Split application of nitrogen in the treatment 30% basal + 40% at tillering and 30% at panicle initiation gave significantly higher grain yield (4.47 t ha^{-1}), which was 13.45 and 23.31% higher than the treatment with 50% basal + 25% at tillering and 25% at panicle initiation and treatment 50% basal + 30% at tillering and 20% respectively.

Yosef (2012) reported that maximum tiller number and number of grain panicle^{-1} under nitrogenous fertilizer treatment was (27.6 and 96.51with respectively) observed for 150 kg ha^{-1} nitrogen and the minimum value were (22.8 and 94.94 with respectively) obtained for 50 kg ha^{-1} nitrogenous fertilizer.

Singh *et al*. (2007) reported that the N response of wet-direct seeded rice ranged from 80 to 120 kg ha^{-1}, beyond which the yields levelled off. Response to applied N was not influenced by farmyard manure application. Application of 120 kg N ha^{-1} in 3 equal split doses at 20, 40 and 60 days after seeding significantly increase the grain yield (7.45 t ha^{-1}).

Rao *et al.* (2004) reported that N had variable influence on growth parameters *viz*., plant height, leaf area, number of tillers and dry matter production of rice which were significantly higher. Timely availability of N under this situation (50% N through fertilizer and 50% N through different organics) would have facilitated better photosynthesis activity and promote the dry matter production. Similarly, Chowdhury *et al*. (2011) observed that under rainfed condition (prevalent waterlogged scenario), with marginal increase in panicle number, at higher N level in older seedlings panicle growth played key role, improving yield of the crop. In both the years, harvest index showed closer association with grain yield (*r2* = 0.52, 0.76, n 27) than total dry matter (*r2* = 0.21, 0.56 at n 27) in 2007 and 2008 respectively with grain yield.

Mustafa *et al*. (2011) reported that basal application of zinc at the rate of 25 kg ha^{-1}, foliar application at 15 and 30 DAT at the rate of 0.5% Zn solution produced statistically similar panicle lengths 26.22, 26.64 and 26.27 cm, respectively. With regard to method, basal application of zinc at the rate of 25 kg ha^{-1} and all foliar treatments produced statistically similar number of branches per panicle. The minimum number of abortive kernels 4.44% was observed in treatment with basal application at the rate of 25 kg ha^{-1} and maximum number of abortive kernels 8.05% was observed in treatment with no zinc application. Kernel quality increased with the application of zinc. Opaque kernels were those which had attained full size but not translucent due to the lack of carbohydrates. Opaqueness of the kernels was reduced with the application of zinc, which might be due to the increased contribution in the grain formation, or decrease in utilization of carbohydrates in plant tissue.

2.4 Effect of nutrient options on physico-chemical properties of rice

Manjunath *et al*. (2012) reported that the significantly increase in OC content and P_2O_5 (1.44% and 35.5 kg ha^{-1} respectively) were recorded in the treatment FYM @ 10 t ha^{-1}. However, OC in the paddy straw @ 10 t ha^{-1} + hyacinth @ 10 t ha^{-1} and P_2O_5 in the treatments vermicompost @ 10 t ha^{-1}, paddy straw @ 10 t ha^{-1} + hyacinth @ 10 t ha^{-1}, 100% NPK and control was recorded statistically at par with the treatment FYM @ 10 t ha^{-1}.

Upadhyay *et al*. (2011) reported that soil organic carbon (0.78%), available N (287.30 kg ha^{-1}), available P (12.9 kg ha^{-1}) and available K (289.50 kg ha^{-1}) was higher compared to initial soil status in the treatment organic manure.

Kharub and Chander (2008) reported that the continuous application of FYM for three years (2004-05 to 2006-07) significantly improved the soil organic carbon compared with that of inorganic fertilizer and no fertilizer application. The soil organic carbon increased from 0.32% on no fertiliser application to 0.42% under the highest FYM application. The increase was 14.3% compared with the initial value, however at the end of experiment it was 0.36% with inorganic fertilizer, being equivalent to initial value. Similarly, the availability of major nutrients also improved significantly in the FYM-treated plots in those receiving inorganic fertilizer and zero fertilizer. The available N increased from 139 (initial value) to 154 kg ha^{-1}, available P from 16.5 (initial value) to 17.4 kg ha^{-1} and available K from 154 (initial value) to 158 kg ha^{-1}under the highest dose of FYM, showing 10.7, 5.4 and 2.6% increase respectively. However, the available N, P and K values were 141, 17.2 and 148 kg ha^{-1} respectively at the end of the experiment. The available K content decreased with the inorganic fertilization because of its lesser application and greater removal from the soil through rice crops.

2.5 Economic analyses of planting system and nutrient management practices of rice

Chandrapala *et al*. (2010) observed that net returns and benefit: cost ratio (58,045 ₹ ha^{-1} and 2.12) were found to be highest with SRI method and least in DSR. The highest returns from SRI method was due to higher grain yield and lower cost of cultivation as seed requirement was less (5 kg ha^{-1}) and less labour cost for weed control because of the use of cono weeder.

Barah (2009) reported that the combined effect of reduction in cost and higher yield has resulted in increase in net return to the extent of over 31 per cent. The average cost of production (paid out cost) had been worked out to be ₹ 269 quintal^{-1} of rice under SRI practice and ₹ 365 quintal^{-1} under normal practices, an advantage of 26% in cost of production.

On the hand Shekhar *et al.* (2009) reported that the higher grain and straw yield under the new methods under common date of nursery, recorded higher mean net returns (₹ 40,943 ha^{-1}) and benefit: cost ratio (2.04) in ICM followed by SRI (₹ 39,120 ha^{-1}) and 1.98). Whereas, the net returns and benefit: cost ratio under same date of transplanting in CT, ICM and SRI were ₹ 34,316, ₹ 27,892 and ₹ 28,376 ha^{-1} and 1.77, 1.42 and 1.42 respectively.

Khanda *et al*. (1996) reported that nitrogen and Zn fertilization generated an additional income of ₹ 619 ha^{-1} and ₹ 0.07 ₹ $^{-1}$ invested compared with N fertilization alone, which are owing to synergistic action of nitrogen and zinc. Among the N levels, 90 kg ha^{-1} recorded the maximum return of (₹ 5,321 ha^{-1}) and net return of ₹ 0.69 ₹ $^{-1}$ invested.

CHAPTER III

MATERIALS AND METHODS

The materials, methodology and techniques adopted during the course of investigation entitled, "Evaluation of different cultivars and methods of planting for rainfed rice (*Oryza sativa* L.) in the context of climate change", are described in this chapter under the apposite headings.

The experiment was conducted as part of an International Project entitled, "Building Resilience to Climate Change through Strengthening Adaptive Small Scale Farming System in Rainfed Areas in Bangladesh, India and Nepal" (SAFBIN) program, an on farm adaptive research (OFAR) with Associate research Partner (SHIATS) and participate farmers of rainfed Mandla district, with the help of PRA tools and other realistic resources Group Discussion (GD), ITKs knowledge's comes and the prevalence of traditional practices applied during the course of experimental trial on rice crop. Further enhanced and built the food security of SHF for the balance FPDCS.

3.1 Experimental site

The on farm adaptive research of rainfed rice was conducted in 62 farmers' field in Mandla district of Madhya Pradesh during the *kharif* season. The 10 villages are located at $22^0 26' 50.52''$ N to $22^0 27' 30.28''$ N latitude, $80^0 45' 12.89''$ E to $80^0 45' 53.99''$ E longitude and 611 m to 641 m altitude above the mean sea level. The 10 villages are situated about 80 km away towards south east direction from the district head quarters, Mandla city.

3.2 Soil of the experimental field

Prior to laying out of the experiment, soil samples were collected randomly from the 3 clusters covering 10 villages. Soil samples were taken from 5 spots of the experimental field at a depth of 15 cm. A representative homogenous composite sample was drawn by mixing all these soil samples together, which was analyzed to determine the physico-chemical properties of the soil. The 3 clusters consisted of villages within proximity, *viz*., 1st cluster **(**Ghota, Khamariya and Katighan), 2nd cluster (Bijatola, Tikariya, Kheri and Kurela) and 3rd cluster (Jaitpuri, Bhadvar and Begakeda). The result of analysis along with the methods used for determination is presented under the following heads:

3.2.1 Mechanical analysis of the soil

The mechanical analysis of soil (0 to 15 cm depth) is presented in Tables 3.1.1 to 3.1.3.

Table 3.1.1 Mechanical analysis of the soil of experimental field of 1st cluster (Ghota, Khamariya and Katighan)

Mineral fraction	Value (unit)	Method (references)
Sand	33.44%	Bouyoucos hydrometer method (Bouyoucos, 1927)
Silt	32.48%	
Clay	34.08%	
Textural class	Clay loam	

Table 3.1.2 Mechanical analysis of the soil of experimental field of 2nd cluster (Bijatola, Tikariya, Kheri and Kurela)

Mineral fraction	Value (unit)	Method (references)
Sand	30.70%	Bouyoucos hydrometer method (Bouyoucos, 1927)
Silt	40.22%	
Clay	29.08%	
Textural class	Silty clay loam	

Table 3.1.3 Mechanical analysis of the soil of experimental field of 3rd cluster (Jaitpuri, Bhadvar and Begakeda)

Mineral fraction	Value (unit)	Method (references)
Sand	32.09%	Bouyoucos hydrometer method (Bouyoucos, 1927)
Silt	28.83%	
Clay	39.08%	
Textural class	Clay loam	

3.2.2 Chemical analysis of soil

Chemical analysis of the soil (0 to 15 cm depth) is presented in Tables 3.2.1 to 3.2.3.

Table 3.2.1 Chemical analysis of soil at pre experimental stage of planting of 1st cluster (Ghota, Khamariya and Katighan)

Parameter	Value (unit)	Method (references)
Available nitrogen	245 kg ha^{-1}	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus	12.60 kg ha^{-1}	Olsen method (Olsen *et al*., 1954)
Available potassium	293.00 kg ha^{-1}	Flame Photometer method (Toth and Prince, 1949)
Organic carbon	0.29%	Walkley and Black method (Jackson, 1973)
pH	7.66	Glass electrode pH meter (Jackson, 1973)
Electrical Conductivity	0.18 (dS m^{-1})	Method No.4 USDA Hand Book No.16 (Richards, 1954)

Table 3.2.2 Chemical analysis of soil at pre experimental stage of planting of 2nd cluster (Bijatola, Tikariya, Kheri and Kurela)

Parameter	Value (unit)	Method (references)
Available nitrogen	195 kg ha^{-1}	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus	12.51 kg ha^{-1}	Olsen method (Olsen *et al*., 1954)
Available potassium	274.78 kg ha^{-1}	Flame Photometer method (Toth and Prince, 1949)
Organic carbon	0.23%	Walkley and Black method (Jackson, 1973)
pH	7.53	Glass electrode pH meter (Jackson, 1973)
Electrical Conductivity	0.16 (dS m^{-1})	Method No.4 USDA Hand Book No.16 (Richards, 1954)

Table 3.2.3 Chemical analysis of soil at pre experimental stage of planting of 3rd cluster (Jaitpuri, Bhadvar and Begakeda)

Parameter	Value (unit)	Method (references)
Available nitrogen	275 kg ha^{-1}	Alkaline permanganate method (Subbiah and Asija, 1956)
Available phosphorus	13.50 kg ha^{-1}	Olsen method (Olsen *et al*., 1954)
Available potassium	313.25 kg ha^{-1}	Flame Photometer method (Toth and Prince, 1949)
Organic carbon	0.32%	Walkley and Black method (Jackson, 1973)
pH	7.72	Glass electrode pH meter (Jackson, 1973)
Electrical Conductivity	0.16 (dS m^{-1})	Method No.4 USDA Hand Book No.16 (Richards, 1954)

3.3 Cropping history

The experimental field had plots in all 3 clusters, which had been under rice-fallow rotation since 2007. Due to the unavailability of irrigation resources the farmers have not been growing any crop, except in *kharif* season, when sufficient rainfall enables them to grow a fairly successful crop of rice.

Table 3.3 Cropping history of the experimental field of all the three clusters

Years	Cropping season		
	Kharif	***Rabi***	***Zaid***
2007-08	Rice	Fallow	Fallow
2008-09	Rice	Fallow	Fallow
2009-10	Rice	Fallow	Fallow
2010-11	Rice	Fallow	Fallow
2011-12	Rice	Fallow	Fallow
2012-13	Rice (Experimental Crop)	Fallow	Fallow

3.4 Climate and Weather condition

Based on the Agro Climatic Zones, Mandla (Madhya Pradesh) come Sub-humid Tropical Hilly/Plateau AES under AEZ 5 of FAO. It has sub-tropical and semi-arid climate with the southwest monsoon commencing from June and withdrawing by the end of September. The rainfall is unevenly distributed and most of it is received between June and September. The meteorological data including the weekly average of maximum and minimum temperature, relative humidity and total rainfall recorded at Mandla, during the period of experiment is presented in table 3.4 and figure 3.1.

Table 3.4 Mean weekly total rainfall during the cropping season (*Kharif*, 2012) of Mandla district, M.P.

Months	Week	Total rainfall (mm)	Number of rainy days/monthly
June	I	0	6
	II	0	
	III	194.6	
	IV	11	
July	I	250.7	17
	II	170.2	
	III	66.9	
	IV	131.4	
August	I	68.9	23
	II	91.5	
	III	89.4	
	IV	135.8	
September	I	58.8	12
	II	89.6	
	III	8	
	IV	0	
	I	8.6	1

October	II	0	
	III	0	
	IV	0	
November	I	23.8	
	II	0	1
	III	0	
	IV	0	
December	I	0	
	II	0	
	III	0	
	IV	0	
Grand total Rainfall (mm) = 1399.20			

Source: IMD, Pune (2013)

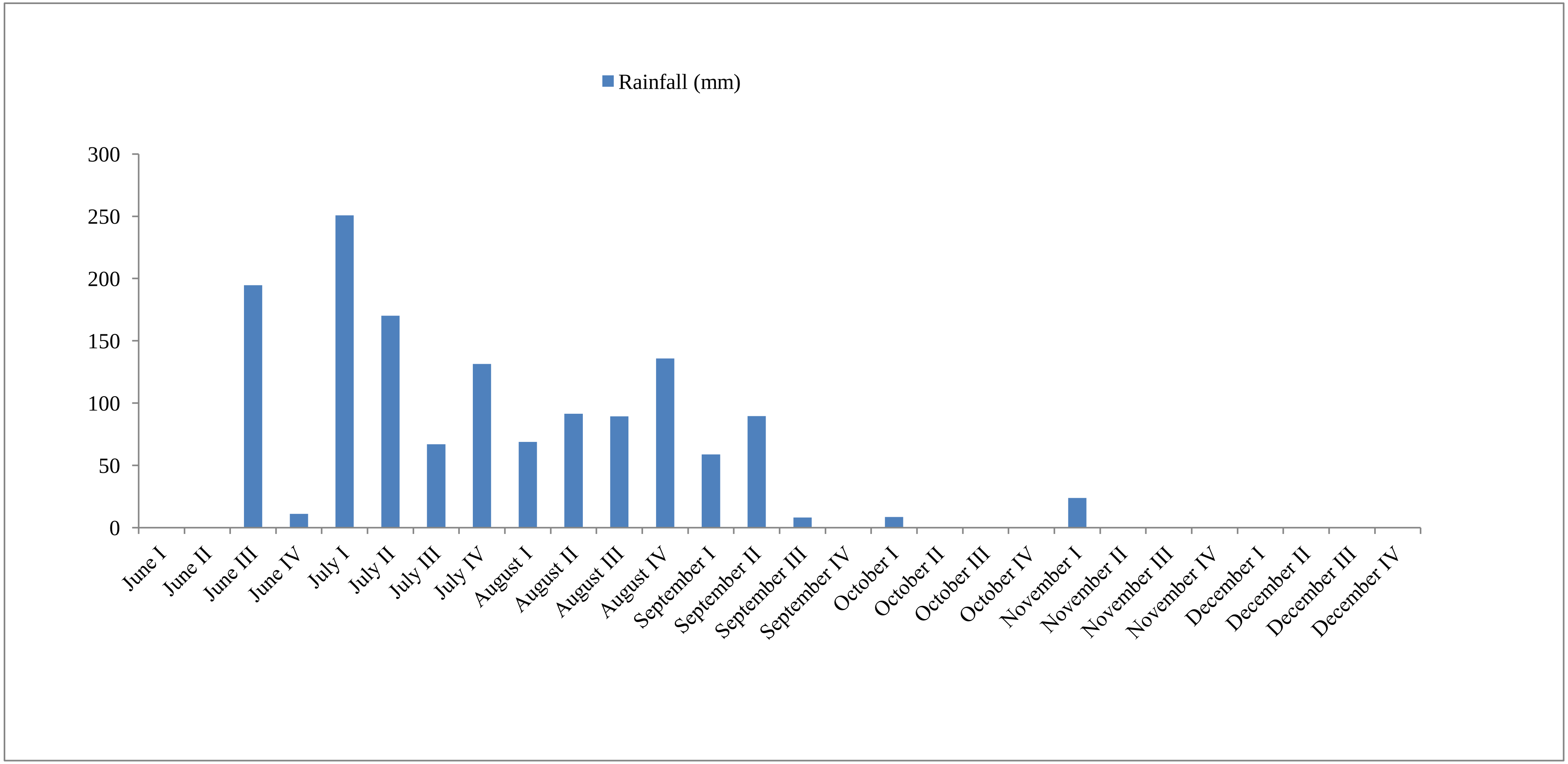


Fig. 3.1 Meteorological observation (weekly) total rainfall during the experimental period (*Kharif*, 2012) of Mandla district

3.5 Experimental details

The experimental details are given under the following different headings:

3.5.1 Experimental design

The experiment was conducted in Randomized Block Design (RBD) consisting of 3 factors, *viz*., six genotypes, four methods of planting and two options of nutrient management. The treatments with options of nutrient management had 10 replications, but the treatments consisting genotypes and methods of planting were replicated only twice.

3.5.2 Details of layout

Experimental design	: RBD
Total number of plots	: 62
Net plot size	: 5.0 m × 4.0 m (20.0 m^2)
Width of bunds	: 0.3 m
Net cultivated area	: 1240 m^2
Gross cultivated area	: 1612 m^2

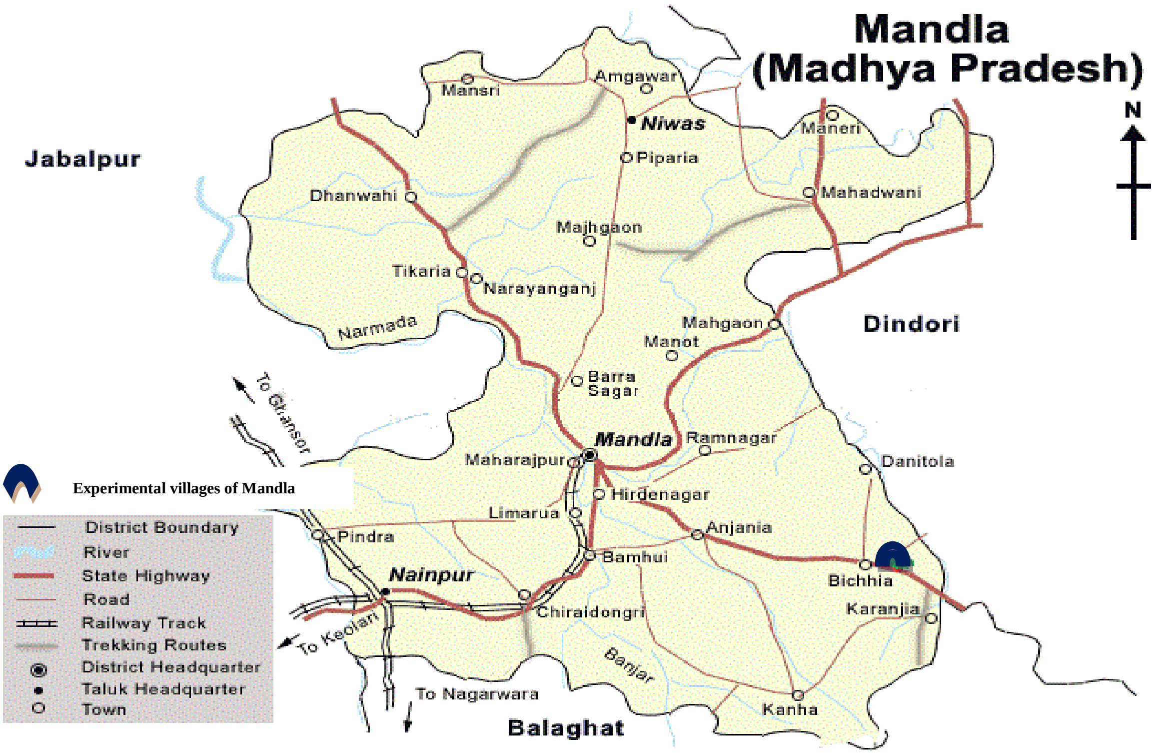


Fig 3.2 Map of Mandla district (M.P) depicting the 10 villages where the Rainfed Rice experimental trials were conducted

3.5.3 Details of crop cultivation

Crop	:	Rice
Spacing		
SRI	:	25 cm × 25 cm
CTR	:	20 cm × 15 cm
DSR	:	10 cm × 5 cm
BPR	:	15 cm × 5 cm

3.5.4 Treatment factors

On *farm adaptive research* (OFAR)

Factor I: Different genotypes

i. Indigenous varieties (*Luchai, Bhadochinga, Araigutta* and *Safari*)
ii. High yielding varieties (HYV_S) MTU 1010 and IR 64

Factor II: Methods of planting

i. Direct seeded rice (DSR)
ii. Beushening puddled rice (BPR)
iii. Conventional transplanting rice (CTR)
iv. System of rice intensification (SRI)

Factor III: Nutrient management

i. Inorganic source (50 kg N ha^{-1} through FYM + 3% *Matka khaad*)
ii. Organic source (100 kg N ha^{-1} through Urea + 5.25 kg Zn ha^{-1} through Zinc Sulphate)

3.6 Details of raising the test crop

The schedule of different pre and post sowing/planting operations carried out in the experimental field has been given in Table 3.5.

Table 3.5 Chronological record of agro-techniques (Calendar of operations) during experiment

S. No.	Operations	Range of date	Range of DAS/DAT
1	2	3	4
1.1	Field preparation (for DSR) (ploughing + harrowing + planking)	10.06.2012 to 18.06.2012	
a.	Soaking of seed	12.06.2012 to 19.06.2012	
b.	Seed sowing	13.06.2012 to 20.06.2012	
1.2	Field preparation for BPR (ploughing + harrowing + leveling + planking)	05.07.2012 to 13.07.2012	
1.2.1	Puddling with the help of bullocks	07.07.2012 to 12.07.2012	
a.	Soaking of seed	07.07.2012 to 11.07.2012	
b.	Incubation of soaked seed for pre-sprouting	08.07.2012 to 13.07.2012	
c.	Seed sowing (for DSR)	09.07.2012 to 14.07.2012	
1.3	Nursery preparation (for CTR)	05.07.2012 to 14.07.2012	
a.	Soaking of seed	06.07.2012 to 15.07.2012	
b.	Incubation of soaked seed for pre-sprouting	07.07.2012 to 16.07.2012	
1	2	3	4

c.	Seed bed preparation & seed sowing		08.07.2012 to 17.07.2012	
1.4 a.	Soaking of seed (for SRI)		16.07.2012 to 18.07.2012	
b.	Incubation of soaked seed for pre-sprouting		17.07.2012 to 19.07.2012	
c.	Seed bed preparation & seed sowing		21.07.2012 to 22.07.2012	
1.4.5	Initial field preparation (ploughing +	(i) CTR	23.07.2012 to 29.07.2012	
	harrowing + planking)	(ii) SRI	29.08.2012 to 01.09.2012	
1.4.6	Basal application of organic manure	(i) CTR	24.07.2012-29.08.2012	
	(FYM @ 10 t ha^{-1})	(ii) SRI	29.10.2012 to 30.08.2012	
2	Layout and leveling	(i) CTR	26.07.2012 to 02.08.2012	
		(ii) SRI	30.07.2012 to 31.07.2012	
3	Puddling with the help of bullocks drown indigenous puddler	(i) CTR	27.07.2012 to 04.08.2012	
		(ii) SRI	01.08.2012 to 02.08.2012	
4	Transplanting/Seeding	(i) CTR	28.07.2012 to 02.08.2012	24 to 29 DAS
		(ii) SRI	01.08.2012 to 02.08.2012	11 to 12 DAS
5	Weeding			
a.	Manual weeding in DSR	1st	13.08.2012 to 18.08.2012	25 to 35 DAS
		2nd	17.08.2012 to 28.08.2012	39 to 48 DAS

1	2		3	4
b.	Manual weeding in CTR	1st	27.08.2012 to	30 to 35

		01.09.2012	DAT
	2nd	16.09.2012 to 21.09.2012	50 to 55 DAT
c.	Manual weeding in SRI 1st	19.08.2012 to 24.08.2012	18 to 20 DAT
	2nd	10.08.2012 to 15.08.2012	40 to 42 DAT
d.	Beushening cultural operation	03.08.2012 to 08.08.2012	30 to 37 DAS
6.1	Urea (foliar spraying)		
	(a) 1st foliar spray	15.08.2012 to 20.08.2012	18 to 23 DAT
	(b) 2nd foliar spray	05.09.2012 to 11.09.2012	40 to 45 DAT
	(c) 3rd foliar spray	26.09.2012 to 30.09.2012	60 to 64 DAT
6.2	*Matka khaad* (foliar spraying) #		
	(a) 1st foliar spray		
	(i) Direct seeded rice (DSR)	10.08.2012 to 14.08.2012	19 to 24 DAT
	(ii) Beushening puddled rice (BPR)	29.07.2012 to 03.08.2012	20 to 23 DAT
	(iii) Conventional transplanted rice (CTR)	16.08.2012 to 20.08.2012	18 to 22 DAT
	(b) 2nd foliar spray		
	(i) Direct seeded rice (DSR)	02.09.2012 to 30.08.2012	40 to 44 DAT
	(ii) Beushening puddled rice (BPR)	19.08.2012 to 22.08.2012	40 to 42 DAS
	(iii) Conventional transplanted rice (CTR)	03.09.2012 to 06.09.2012	38 to 40 DAT
	(iv) System of rice intensification (SRI)	19.08.2012 to	30 to 31
1	**2**	**3**	**4**
		20.08.2012	DAT

	(c) 3rd foliar spray		
	(i) Direct seeded rice (DSR)	18.09.2012 to 20.09.2012	60 to 62 DAS
	(ii) Beushening puddled rice (BPR)	07.09.2012 to 10.09.2012	61 to 63 DAS
	(iii) Conventional transplanted rice (CTR)	23.09.2012 to 26.09.2012	58 to 62 DAT
	(iv) System of rice intensification (SRI)	02.09.2012	45 to 47 DAT
	(d) 4th foliar spray		
	(i) Direct seeded rice (DSR)	28.09.2012 to 01-10-2012	70 to 74 DAS
	(ii) Beushening puddled rice (BPR)	22.09.2012 to 24.09.2012	77 to 81 DAS
	(iii) Conventional transplanted rice (CTR)	16.10.2012 to 20.10.2012	80 to 82 DAT
	(iv) System of rice intensification (SRI)	18.09.2012	61 to 63 DAT
7	Plant protection measures		
a.	Neem leaf and tender bark of greenish branches extract		
	(i) 1st application	28.08.2012 to 29.08.2012	31 to 32
	(ii) 2nd application	12.09.2012 to 16.08.2012	44 to 48
b.	* Foliar spray of Zinc Sulphate (in all treatments)	08.09.2012 to 10.09.2012	40 to 42
8	Harvesting		
	(i) Harvesting of DSR crop	12.10.2012 to 18.10.2012	111 to 120 DAS
	(ii) Harvesting BPR crop	05.11.2012 to 12.11.2012	119 to 130 DAS
1	**2**	**3**	**4**
	(iii) Harvesting of CTR crop	09.12.2012 to 20.12.2012	135 to 150 DAT

	(iii) Harvesting of SRI crop	27.10.2012 to 29.10.2012	118 to 120 DAT
9	Threshing		
	(i) DSR crop	17.10.2012 to 20.10.2012	117 to 124 DAS
	(ii) BPR crop	10.11.2012 to 17.11.2012	125 to 132 DAS
	(iii) CTR crop	13.12.2012 to 26.12.2012	140 to 156 DAT
	(iii) SRI crop	03.11.2012 to 04.11.2012	125 to 127 DAT

* As per consultation obtained from the certifying agency (Local Quality Certification Pvt. Ltd.) 0.3% zinc sulphate

Matka khaad (3%) was applied only in organic treatments

3.7.1 Land preparation

The experimental field was initially ploughed with the help of bullock drown desi plough followed by two harrowing, planking and leveling. After that flooding and puddling operations were done manually in experimental blocks. The layout of the 62 farmers' plots was demarcated manually with the help of rope, bamboo pegs, *etc* in the 10 villages. However, in the case of DSR, where upland condition was maintained, the plowing was followed by two harrowing and planking.

3.7.2 Germination test

Rice variety MTU 1010, *Luchai* and *Bhadochinga* were taken as test varieties in this investigation. Seeds of rice were tested for their germinability, before sowing in nursery or direct seeding. Germination test was done using filter paper and Petri-dish under farmer room conditions. The overall germination percentage of MTU 1010, *Luchai* and *Bhadochinga* cultivars were 83.16, 72.54 and 75.67% respectively. The seed quantity was adjusted accordingly.

3.7.3 Transplanting and sowing

3.7.3.1 Sowing of DSR

For the treatment direct seeded rice (DSR), sowing was done by broadcasting the seeds in the experimental field.

3.7.3.2 Sowing of BPR

For the treatment with beushening of puddled rice (BPR), sowing was done by broadcasting the seeds in well puddled experimental field.

3.7.3.3 Transplanting of CTR

In the conventional transplanted rice, 24 to 29 days old, 3 to 5 seedlings hill^{-1} was transplanted in the experimental field.

3.7.3.4 Transplanting of SRI

For SRI treatment, the transplanting of 11 to 12 days old rice seedlings and single seedling hill^{-1} was done in square pattern, using a rope with markings (knots) at 25 cm interval to guide the line of planting in the experimental field.

3.7.4 Gap filling

Gaps caused by mortality were filled by re-transplanting after 6 days of done in the treatments CTR/SRI transplanting. This operation was done for maintaining a proper hill to hill distance and standard plant population. However, in the DSR re-sowing is done for maintaining the patches (no germination of seed) and optimum plant population.

3.7.5 Application of FYM

Five days before transplanting/sowing, FYM was applied at the rate of 10 t ha^{-1}.

3.7.6 Top dressing with organic liquid manures and inorganic fertilizers

3.7.6.1 *Matka khaad*

Matka khaad was prepared with a mixture of five components in the ratio of 2:5:1:1:1, *viz*., cow dung, cow urine, madar leaf, neem leaf and jaggery respectively, which were fermented for 15 to 20 days. *Matka khaad* 3% solution was prepared by adding 30 ml prepared and filtered solution in 1 liter of water, and applied as foliar spray at 15 to 24, 30 to 44, 45 to 63, and 61 to 82 DAS/DAT as per the treatments. Above indigenous method was refinement of ITKs to formulating use included as a treatment. It was comes from farmers with the help of PRA tools, which is observed formulation to be helpful in restoring health and soil fertility as well as works as a prophylactic measure against the attack of termite.

3.7.6.2 Nitrogen application

A uniform dose of 100 kg N was applied through urea (46% N). Half of the total quantity of nitrogen was applied as basal and broadcast at the time of last puddling. The remaining amount of nitrogen was top dressed in three equal splits at 18 to 23, 40 to 45 and 60 to 64 DAT respectively.

3.7.6.3 Zinc application

In treatments with inorganic inputs, 25 kg $ZnSO_4$ was applied at the time of basal application of urea. Further, the 60 g zinc sulphate with 30 g lime dissolved in 20 l water (20 m^2 area) was foliar sprayed at 40 to 42 DAT/DAS to control *khaira* (Zn deficiency) in all the treatments as there were sporadic symptoms.

3.7.7 Intercultural operations

3.7.7.1 Beushening practice

A traditional cultural practice, in which the standing crop of rice (puddled direct seeded) is subjected to light cross-ploughing between 30 to 37 DAS, when 10 to 15 cm of rain water gets impounded in rice fields, followed by laddering and seedling redistribution, is known as Beushening. This practice loosens the soil, controls weeds, improves water-use efficiency, improves tillering and nutrient uptake, reduces insect pests, and helps redistribute seedlings.

In the current experiment, based on the treatment which was come from farmers' knowledge ITKs through PRA tools was add.

3.7.7.2 Weeding operation

Based on treatments, hand weeding was done twice, *i.e.*, DSR, CTR and SRI at 30 to 38, 30 to 35 and 18 to 20 DAS/DAT respectively, while the second weeding was done at 45 to 58, 50 to 55 and 40 to 42 DAS/DAT manually by two labourers for up to two days.

3.7.8 Irrigation

There was unavailability of irrigation water, hence the crop was totally based on rainfall. The soil moisture was maintained by preventing water losses through seepage *etc* by bunding and proper puddling.

3.7.9 Indigenous methods for controlling the insect pest infestation

The following different ITKs technologies come through PRA tools and others resource form the local farmers' of Mandla (M.P.), and the Farmer-Scientist and Stake-holders' consideration on ITKs knowledge, where necessary refinement was needed was done with the consult references and that formulation applied in experimental treatments.

3.7.9.1 Application of neem extract

It was prepared by boiling the neem leaf + neem seed + tender bark of greenish branches and the filtrate the extract. Neem extract 3% solution was prepared by adding 30 ml prepared and filtered solution in 1 litre of water, and applied as foliar spray at 31 to 32 and 44 to 48 DAS/DAT as per the treatment. This formulation functioning as a prophylactic, which helpful against the attack of termites. It was applied in two villages (Bijatola and Ghota).

3.7.9.2 Application of burned lubricant oil

Burned lubricant oil (2 to 3 l ha^{-1}) was applied flooded condition in the rice field to control the eggs/larvas of Semilooper/*Birli* (*Naranga aenescens*) infestation. It was applied only in village Bijatola.

3.7.9.3 Physical method of pest controlled

Putting the stick of *Tendu* (*Diaspyros melanoxylon*)/*Besaram* (*Ipomoea carnea*) in to the rice field so that the birds/owl perch there and eat insect/larvas of harbor pest and rat also. This method was applied in all 10 villages.

3.7.10 Application of botanical pesticide

3.7.10.1 Application of Neem oil

Neem oil (1.0%) was applied with water and copper oxychloride (250 g) at 40 and 53 DAS/DAT was sprayed in all organic treatments, to control termites, Semilooper (*Naranga aenescens*), Gundhi bug (*Leptocrosia varicornis*) and Cut worm (*Agrotis ypsilom*) of paddy.

3.7.11 Harvesting

The crop (DSR, BPR, CTR and SRI) was harvested separately when more than 90% of grains in the panicle were fully ripe and free from greenish tint. Harvest area (net plot) of 2.0 m^2 from each plot was marked and the same was physically harvested using sickles between 17.10.2012 to 20.10.2012 (117 to 124 days), 10.11.2012 to 17.11.2012 (125 to 132 days), 13.12.2012 to 26.12.2012 (140 to 156 days) and 03.11.2012 to 04.11.2012 (125 to 127 days) respectively for DSR, BPR, CTR and SRI. Thereafter, the produce from the net plot was tied in bundles separately and then tagged. The tagged bundles were allowed for curing (sun drying) in the field itself and thereafter these were transported to threshing floor. The weight of bundles was recorded for obtaining biological yield.

3.7.12 Threshing

Threshing of rice was done manually by beating panicles on the sheaves with wooden baton and then seeds were separated by winnowing. This was done in temporary threshing floor (painted form fresh cow dung).

Observations recorded

Agronomic observations regarding the experimental parameters were recorded with the help of Village Research Assistants (VRAs) as per the schedule proposed in the synopsis. The interval of observations had a variation between 2 to 3 days, because of various technical reasons, including the distance to be covered. The field samples, both of plants and soil were taken to the Laboratory of the Department of Agronomy, SHIATS in Allahabad for necessary analyses.

3.8 Growth parameters

3.8.1 Plant height (cm)

Five hills from the inner rows, leaving the border rows, were selected randomly from each plot and tagged. The height of these plants were measured from the ground level up to the last node of rice till the pre-anthesis stage, however, post-anthesis stage it was measured till the tip of the panicle. It was recorded at 15, 30, 45, 60, 75 and 90 DAS/DAT.

3.8.2 Number of tillers hill^{-1}

Number of tillers hill^{-1} was recorded same tagged plant, which is stated in the earlier parameters (plant height).

3.8.3 Plant dry weight (g)

Three plants were randomly uprooted from each plot at 15, 30, 45, 60, 75 and 90 DAS/DAT and the roots were severed. The samples were air dried and then kept in oven for 72 hours at 70 ^{0}C, their dry weight was determined and the average dry weight hill^{-1} was calculated.

3.8.4 Crop growth rate (CGR)

It represent dry weight gained by a unit area of crop in a unit time expressed as g m^{-2} day^{-1} (Fisher, 1921). The values of plant dry weight at 0 to 15, 15 to 30, 30 to 45, 45 to 60, 60 to 75 and 75 to 90 DAS/DAT intervals were used for calculating the CGR. The value of CGR is expressed in g m^{-2} day^{-1}.

$$\text{Crop growth rate} = \frac{W_2 - W_1}{t_2 - t_1}$$

Where,

W_1 = Initial dry weight of plant (g)

W_2 = Final dry weight of plant (g)

t_1 = Initial time period

t_2 = Final time period

3.8.5 Relative growth rate (RGR)

It was described by Radford (1967) which indicates the increase in dry weight per unit dry matter over any specific time interval and it was calculated by the following equation:

$$\text{Relative growth rate (RGR)} = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$$

Where,

$\log_e$ = Natural logarithm

W_1 = Initial dry weight of plant (g)

W_2 = Final dry weight of plant (g)

t_1 = Initial time period

t_2 = Final time period

This parameter is also called efficiency index (y) and was calculated for the time intervals, *i.e.*, 15 to 30, 30 to 45, 45 to 60, 60 to 75 and 75 to 90 DAS/DAT using the data obtained from dry weight of plants.

3.8.6 Number of effective tillers hill^{-1}

The number of effective tillers hill^{-1} was recorded from five tagged hills in each plot at 90 DAS/DAT.

3.9 Yield and Yield attributes

3.9.1 Panicle length (cm)

Panicle length (cm) was observed at the time of harvest, randomly from five tagged hills and their averages were recorded.

3.9.2 Number of grains panicle^{-1}

Grains from the five panicles were counted separately which were obtained randomly from five tagged hills and their averages were recorded.

3.9.3 Test weight (g)

One thousand grains were randomly counted from panicles obtained from each plot and weighed and recorded as test weight (g) at approximately 14% moisture.

3.9.4 Grain yield (t ha^{-1})

Grains from harvest area (2.0 m^2) were dried in sun, cleaned and weighed separately from each plot for calculating the grain yield in t ha^{-1}.

3.9.5 Straw yield (t ha^{-1})

Straw from harvest area (2.0 m^2) was dried in sun, bundled, tagged and weighed separately from each plot for calculating the straw yield in t ha^{-1}.

3.9.6 Harvest index (%)

Harvest index was obtained by dividing the economic (grain) yield by the biological (grain + straw) yield. It was calculated for each of the plots and was represented in percentage. The following formula was used (Donald, 1962).

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

3.10 Post-harvest qualitative studies

Approximately 100 g seed samples were collected at the time of threshing from each plot, and thereafter, ground into powder with the help of manual grinder. The qualitative parameters, *viz*., Protein (%) and Carbohydrate (%) in grains were analyzed. The methodology which was adopted is described as follows.

3.10.1 Protein (%) in grain

It is calculated by the formula, Protein (%) = N (%) × 6.25. The nitrogen content of grains was analyzed by Micro-Kjeldahl's method (AOAC, 1965).

The Micro-Kjeldahl's method for total nitrogen content (%) essentially involves digestion of the sample to convert N compounds in the sample to NH_4 form. The grain sample was digested with sulphuric acid and catalyst mixture (K_2SO_4 + $CuSO_4$) was added to each digestion tube to raise the temperature of digestion and thereafter, cooled to room temperature. The digest was transferred to distillation flask with granulated zinc added to it (which acts as anti bumping agent). Thirty to 50 ml NaOH was poured into the distillation flask where NH_4 was captured in the flask containing boric acid and the ethylene blue indicator was mixed in receiving flask. Titration of the sample was done by using 0.05N HCl. Similar procedure for blank sample was followed. The N (%) content was calculated using the formula:

$$\text{Nitrogen (\%)} = \frac{(\text{Sample titre} - \text{Blank titre}) \times 0.05 \text{ N HCl} \times 14 \times 100}{\text{Weight of sample} \times 1000}$$

3.10.2 Carbohydrate (%) in the rice grain

The following formula was used for calculation (Ranganna, 2003).

Carbohydrate (%) = 100 - [Moisture (%) + Fat (%) + Ash (%) + Protein (%)]

3.10.3 Fat (%) in the rice grain

The extractor and extract flask were cleaned and dried. The extract flask was weighed on chemical balance up to 2 decimal. Two grams of prepared sample was placed on Whatman paper number 42, which was folded in to a shape of thimble and it was placed inside the extractor. Two hundred fifty ml of ether solvent was added in the extractor flask and to avoid overheating, the intensity of heat from electric coil was lowered with the help of regulator and 1000 ml of ether solvent were used in four cycles of siphoning, which was needed for complete removal of fat of grain sample.

The solvent was kept in flask and only the fat content was heated gently, till the smell of ether was not there. It was taken out and kept for cooling and the weight was recorded. It was represented in percentage. The following formula was used for calculation (Ranganna, 2003).

$$\text{Fat percentage} = \frac{(X - Y)}{\text{Weight of sample}} \times 100$$

Where,

X = Initial weight of flask

Y = Final weight of flask

3.10.4 Moisture (%) in the rice grain

3.10.4 Moisture (%) in the rice grain

This method consists in measuring the weight lost by prepared sample. The moisture content was determined by the air oven method and the methodology was used as follows. The temperature of the oven was set at 80 °C and samples were placed inside the oven and the final weight of samples were measured after 8 hours (Ranganna, 2003).

$$\text{Moisture percentage} = \frac{(X - Y)}{X} \times 100$$

Where,

X = Initial weight of grain sample

Y = Final weight of grain sample

3.10.5 Ash (%) in the rice grain

The ash content in rice was determined by the Bunsen burner and muffle furnace. The methodology was used as follows. Two g sample was prepared and put in the crucible and the initial weight was taken. The sample was kept over the Bunsen burner for 5 to 6 minutes. Samples were put inside the muffle furnace at 525 ˚C for 4 hours. And thereafter, it was cooled and the final weight recorded. The difference in weights gave the total ash content and was expressed as per cent (Ranganna, 2003).

$$\text{Ash percentage} = \frac{(X - Y)}{X} \times 100$$

Where,

X = Initial weight of grain sample

Y = Final weight of grain sample

3.11 Economic analysis

Common cost of production (ha^{-1}) was estimated by adding all the expenses, except cost of variable inputs of treatments, incurred in producing the crop.

Gross returns (ha^{-1}) for different treatments were calculated by multiplying the grain and straw yield to their respective prices. Net returns (ha^{-1}) was obtained by deducting the total cost of production from gross returns ha^{-1} for different treatments. Net return in terms of rupees $^{-1}$ invested was obtained by dividing the net returns (ha^{-1}) with the cost of production ha^{-1} for different treatments which reflects the efficiency of capital used.

3.12 Statistical analysis

The data recorded during the course of investigation was subjected to statistical analysis by "Analysis of variance technique" (Gomez and Gomez, 1976). The significant and non-significant treatment effects were judged with the help of 'F' (variance ratio) table. The significant differences between the means were tested against the critical difference at 5% probability level. For testing the hypothesis, the following skeleton of ANOVA table (3.6) was used.

Table 3.6 Skeleton of ANOVA table

Source of variation	**Df**	**SS**	**MSS**	**F Cal**	**F Tab at 5%**
Due to replications	(r-1)	RSS	$\frac{RSS}{(r-1)}$	$\frac{MSS(r)}{EMS}$	
Due to treatments	(t-1)	TrSS	$\frac{TrSS}{(t-1)}$	$\frac{MSS(t)}{EMS}$	
Due to error	(r-1)(t-1)	ESS	$\frac{ESS}{(r-1)(t-1)}$		
Total	(rt-1)	TSS			

Where,

Standard Error Deviation (SEd)

Standard error of mean was calculated by the following formula:

$$SEd = \sqrt{\frac{2 \times MSSE}{r}}$$

Co-efficient of variation (CV)

Co-efficient of variation was calculated by the following formula

$$CV (\%) = \frac{\sigma}{\bar{x}} \times 100$$

Where,

$$\sigma = SE \times \sqrt{n}$$

Critical difference (CD)

Critical difference was calculated by the following formula:

CD	=	SEd x ‘t’ error degree of freedom at 5%
$\bar{x}$	=	Mean
σ	=	Standard deviation
r	=	Number of replication
df	=	Degree of freedom
SS	=	Sum of squares
RSS	=	Sum of squares due to replication
TrSS	=	Sum of squares due to treatment
TSS	=	Total sum of squares

ESS	=	Error sum of squares
MSS(r)	=	Mean sum of squares due to replication
MSS(t)	=	Mean Sum of squares due to treatment
EMS	=	Error mean sum of squares
SEd	=	Standard error deviation
SE	=	Standard error
n	=	Number of observation

CHAPTER IV

RESULTS AND DISCUSSION

The findings of the present experiment entitled, "Evaluation of different genotypes and methods of planting for rainfed rice (*Oryza sativa* L.) in the context of climate change", are presented and discussed in the following pages under appropriate headings. Data on pre-harvest and post harvest observations were statistically analyzed and discussion on experimental findings in the light of scientific reasoning has been stated.

The experiment was conducted with an 'on farm adaptive research' approach, through active participation of the stake-holders of Project "Building Resilience to Climate Change through Strengthening Adaptive Small Scale Farming System in Rainfed Areas in Bangladesh, India and Nepal" SAFBIN, soliciting the probable cause and promising agronomic solution for rainfed rice of Mandla district.

OBSERVATIONS RECORDED

A. Pre-harvest observations (at 15, 30, 45, 60, 75 and 90 DAS/DAT)

4.1 Plant height (cm)

4.2 Number of tillers hill^{-1} and Number of effective tillers hill^{-1} (at 90 DAS/DAT)

4.3 Plant dry weight (g hill^{-1})

4.4 CGR (g m^{-2} day^{-1}) at 0-15, 15-30, 30-45, 45-60, 60-75 and 75-90 DAS/DAT intervals

4.5 RGR (g g^{-1} day^{-1}) at 15-30, 30-45, 45-60, 60-75 and 75-90 DAS/DAT intervals

B. Post harvest observations

4.6 Panicle length (cm)

4.7 Number of grains panicle^{-1}

4.8 Test weight (g)

4.9 Grain yield (t ha^{-1})

4.10 Straw yield (t ha^{-1})

4.11 Harvest Index (%)

D. Quality parameters

4.12 Protein content in grain (%)

4.13 Carbohydrate content in grain (%)

C. Economics

4.14 Cost of cultivation (₹ ha^{-1})

4.15 Gross return (₹ ha^{-1})

4.16 Net return (₹ ha^{-1})

4.17 Benefit cost ratio

E. Soil fertility status

4.18 pH

4.19 EC (dS m^{-1})

4.20 Organic carbon (%)

4.21 Available N (kg ha^{-1})

4.22 Available P_2O_5 (kg ha^{-1})

4.23 Available K_2O (kg ha^{-1})

GROWTH PARAMETERS OF RICE

A. Pre-harvest findings

4.1 Plant height (cm)

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on plant height are presented in table 4.1 and depicted in fig. 4.1.

The data showed that there was a steady increase in plant height from 15 to 90 DAS/DAT.

Effect of Genotypes

At 30, 45, 60, 75 and 90 DAS/DAT higher plant height (18.11, 24.59, 33.72, 55.74 and 68.63 cm respectively) were observed in the MTU 1010 genotype. At 15 DAS/DAT significantly higher plant height (14.80 cm) was observed in IR 64 genotype. However, at 15 DAS/DAT *Bhadochinga*, *Safari* and MTU 1010 were statistically at par with IR 64 genotype. At 45 and 60 DAS *Bhadochinga* and IR 64 were found to be statistically at par with MTU 1010. At 30, 75 and 90 highest plant height (18.11, 55.74 and 68.63 cm respectively) were recorded in MTU 1010 genotype, which was 18.59, 72.14 and 63.83% higher than lowest value 15.27, 32.38 and 41.89 cm respectively in the *Safari*/*Luchai* genotypes.

This difference in plant height among the indigenous and HYV rice cultivars was generally due to their genetic makeup and adaptability in the favorable environment.

Effect of methods of planting

At 15 DAS/DAT higher plant height (16.72 cm) was registered in the system of rice intensification (SRI), which was 33.54% higher than lowest value 12.52 cm in the direct seeded rice (DSR). At 30 DAS/DAT higher plant height (19.35 cm) was observed in beushening puddled rice (BPR) which was 31.90% higher than lowest 14.67 in direct seeded rice (DSR). At 45, 60, 75 and 90 DAS/DAT highest plant height (22.69, 32.10, 43.77 and 58.27 respectively) were observed in conventional transplanted rice (CTR) and exactly same value of 58.27 cm was recorded with treatment beushening puddled rice at 90 DAS/DAT, which were 36.52, 22.84, 54.77 and 56.47% higher than the lowest value 16.62, 26.13, 28.28 and 37.24 cm respectively in the direct seeded rice (DSR).

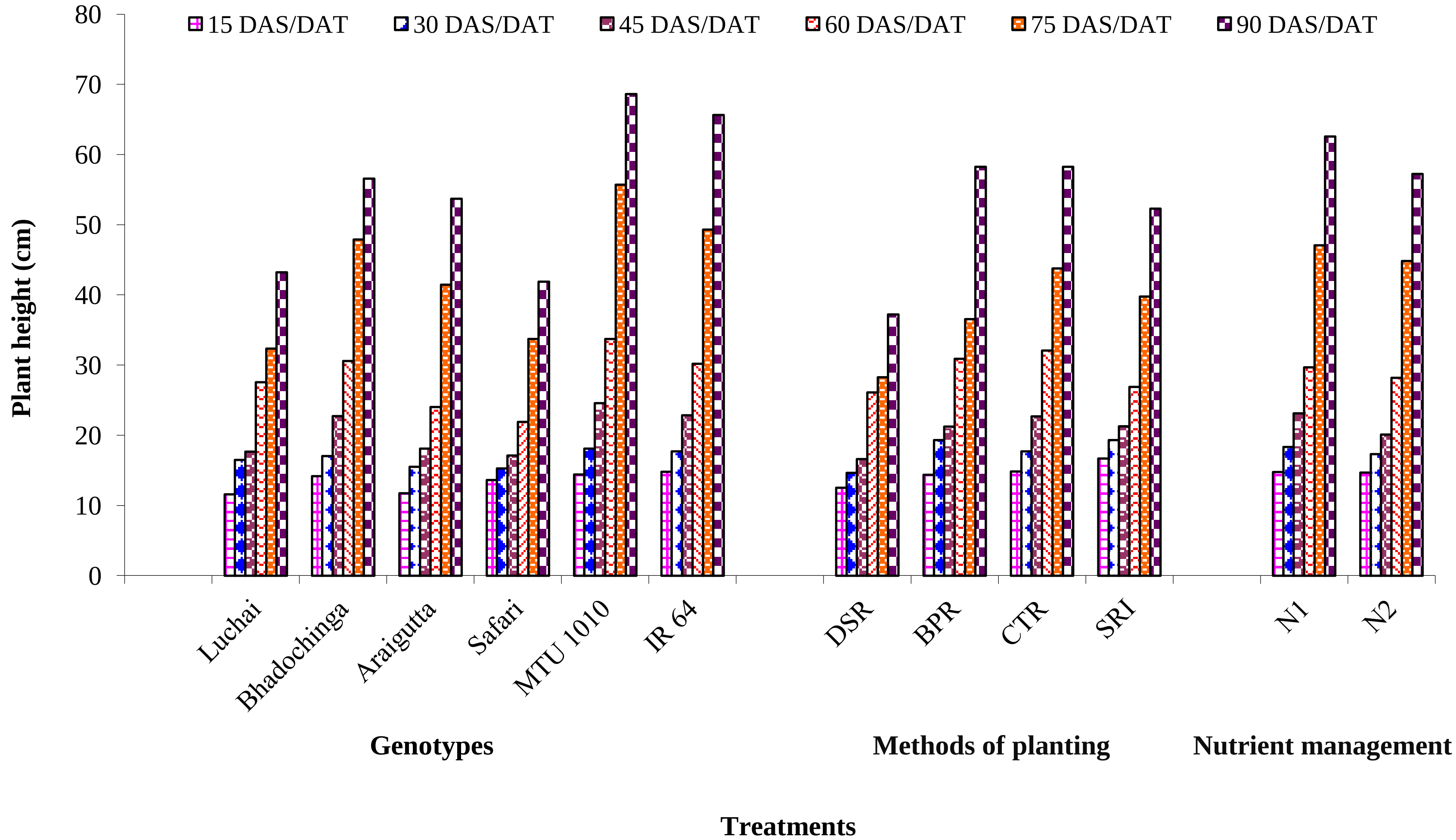
Effect of nutrient management

Plant height was significant influenced by the nutrient management only at 45 DAS/DAT. At all growth stages highest plant height (14.78, 18.33, 23.12, 29.71, 47.10 and 62.60 cm respectively) were recorded in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which were 0.68, 5.89, 15.02, 5.27, 4.99 and 9.30% higher compared to the inferior figures of 14.68, 17.31, 20.10, 28.22, 44.86 and 57.27 cm respectively in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}.

Nitrogen plays an important role in the cell growth and development of the rice plant (Dar *et al*., 2000). The variation in plant height due to nutrient sources may be alluded to the inherent characteristics of these materials. Chemical fertilizer offers nutrients which are readily soluble in soil solution and thereby instantaneously available to plants. Nutrient availability from organic sources is due to microbial action and improves physical condition of soil (Hasanuzzaman *et al*., 2010). Further, the application of organics like FYM releases N slowly to the plants and improves the soil health for better availability of nitrogen (Ikeda and Watanabe, 2002).

Table 4.1 Effect of different genotypes, methods of planting and nutrient management on plant height of rice at different intervals

Treatments	Plant height (cm)					
	15 DAS/DAT	30 DAS/DAT	45 DAS/DAT	60 DAS/DAT	75 DAS/DAT	90 DAS/DAT
Genotypes						
Luchai	11.60	16.51	17.67	27.57	32.38	43.23
Bhadochinga	14.17	17.04	22.73	30.61	47.90	56.58
Araigutta	11.77	15.52	18.10	24.05	41.47	53.72
Safari	13.65	15.27	17.14	21.93	33.75	41.89
MTU 1010	14.44	18.11	24.59	33.72	55.74	68.63
IR 64	14.80	17.72	22.85	30.22	49.34	65.64
SEd (±)	0.51	1.44	1.19	1.69	13.49	13.86
CD (P= 0.05)	1.31	-	3.07	4.35	-	-
CV (%)	3.82	8.64	5.83	6.04	31.07	25.22
Methods of planting						
Direct seeded rice (DSR)	12.52	14.67	16.62	26.13	28.28	37.24
Beushening puddled rice (BPR)	14.37	19.35	21.25	30.93	36.55	58.27
Conventional transplanted rice (CTR)	14.86	17.73	22.69	32.10	43.77	58.27
System of rice intensification (SRI)	16.72	19.34	21.30	26.89	39.78	52.32
SEd (±)	2.01	3.79	5.06	7.54	17.02	11.30
CD (P= 0.05)	-	-	-	-	-	-
CV (%)	13.76	21.34	24.73	26.02	45.88	21.93
Nutrient management						
50 kg N ha^{-1} through FYM + 3% *matka khaad*	14.78	18.33	23.12	29.71	47.10	62.60
100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}	14.68	17.31	20.10	28.22	44.86	57.27
SEd (±)	0.49	0.48	0.81	2.07	3.60	3.55
CD (P= 0.05)	-	-	1.82	-	-	-
CV (%)	2.84	2.53	3.88	8.59	11.85	10.26



N_1: 50 kg N ha^{-1} through FYM + 3% *matka khaad* N_2: 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}

Fig. 4.1 Effect of different genotypes, methods of planting and nutrient management on plant height of rice at different intervals

4.2 Number of tillers hill^{-1} and number of effective tillers hill^{-1} (at 90 DAS/DAT)

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on tillers hill^{-1} and effective tillers hill^{-1} are presented in table 4.2 and depicted in fig. 4.2.

Effect of Genotypes

During the successive intervals of growth, tillers hill^{-1} recorded significant influence by genotypes at 30, 45 and 90 DAS/DAT but at 15, 60 and 75 DAS/DAT it was non-significant. At 30 and 45 DAS/DAT significantly higher number of tillers hill^{-1} (8.30 and 11.83 respectively) were recorded in the IR 64 genotype, which was 230.00 and 281.61% higher than the lowest value 2.50 and 3.10 respectively in the *Safari* genotype. However, at 30 DAS MTU 1010 genotype, while at 45 DAS/DAT *Luchai, Bhadochinga, Araigutta* and MTU 1010 genotypes were statistically at par with IR 64 genotype. At 90 DAS significantly higher number of effective tillers hill^{-1} (7.00) was registered in the *Luchai* genotype, which was 288.88% higher than the lowest value 1.80 in the *Safari* genotype. However, in the *Araigutta*, MTU 1010 and IR 64 genotypes were statistically at par with *Luchai* genotype. At 15 DAS/DAT highest numbers of tillers hill^{-1} (4.20) was recorded in *Bhadochinga* genotype which was 200% higher than lowest value (1.40) in the *Safari* genotype. At 60 and 75 DAS/DAT higher number of tillers hill^{-1} (10.87 and 10.10 respectively) was recorded in MTU 1010 genotype, which was 250.64 and 236.66% higher than lowest value 3.10 and 3.00 respectively in the *Safari* genotype.

This variation may be due to the inherent characters of individual cultivar’s response of varying genetic make up to the environmental condition (Hussain *et al*., 1989).

Effect of methods of planting

Regarding the number of tillers hill^{-1} at successive intervals of growth, *viz*., 15, 30, 45, 60, 75 and 90 DAS/DAT there was no-significant difference recorded between the methods of planting. At 15, 30, 45 and 60 DAS/DAT higher number of tillers hill^{-1} (3.40, 10.40, 14.20 and 13.10 respectively) were observed in the beushening puddled rice (BPR), which was 240.00, 550.00, 787.50 and 773.33% higher than lowest value 1.00, 1.60, 1.60 and 1.50 respectively in the direct seeded rice (DSR)/system of rice intensification (SRI). At 75 DAS/DAT maximum number of tillers hill^{-1} and number of effective tillers hill^{-1} at 90 DAS/DAT (15.50 and 10.40 respectively) in the system of rice intensification (SRI), which was 761.11 and 845.45% higher than the lowest value 1.80 and 1.10 respectively in the direct seeded rice (DSR).

The higher tillering phenomena observed in the beushening puddled rice (BPR) may be due to the indigenous practice, which entails that rice under puddled direct seeded condition can have an improved tillering due to the beneficial effect of nutrient availability and uptake, concurrently enhanced aeration and reduced weed competition (Ghosh *et al.*, 1960).

The careful transplanting of younger seedlings by keeping the roots straight (assuring that the roots do not assume 'J' shape), less trauma to the plants, early recovery from the shock, might have encouraged vigorous and deeper root system, faster root spread to a large volume of soil, which tap more nutrients, thereby preserving the potential of the plant for much greater tillering. These in turn resulted into more vigorous, taller plants and higher number of tillers hill^{-1} (Shekhar *et al*., 2009).

Effect of nutrient management

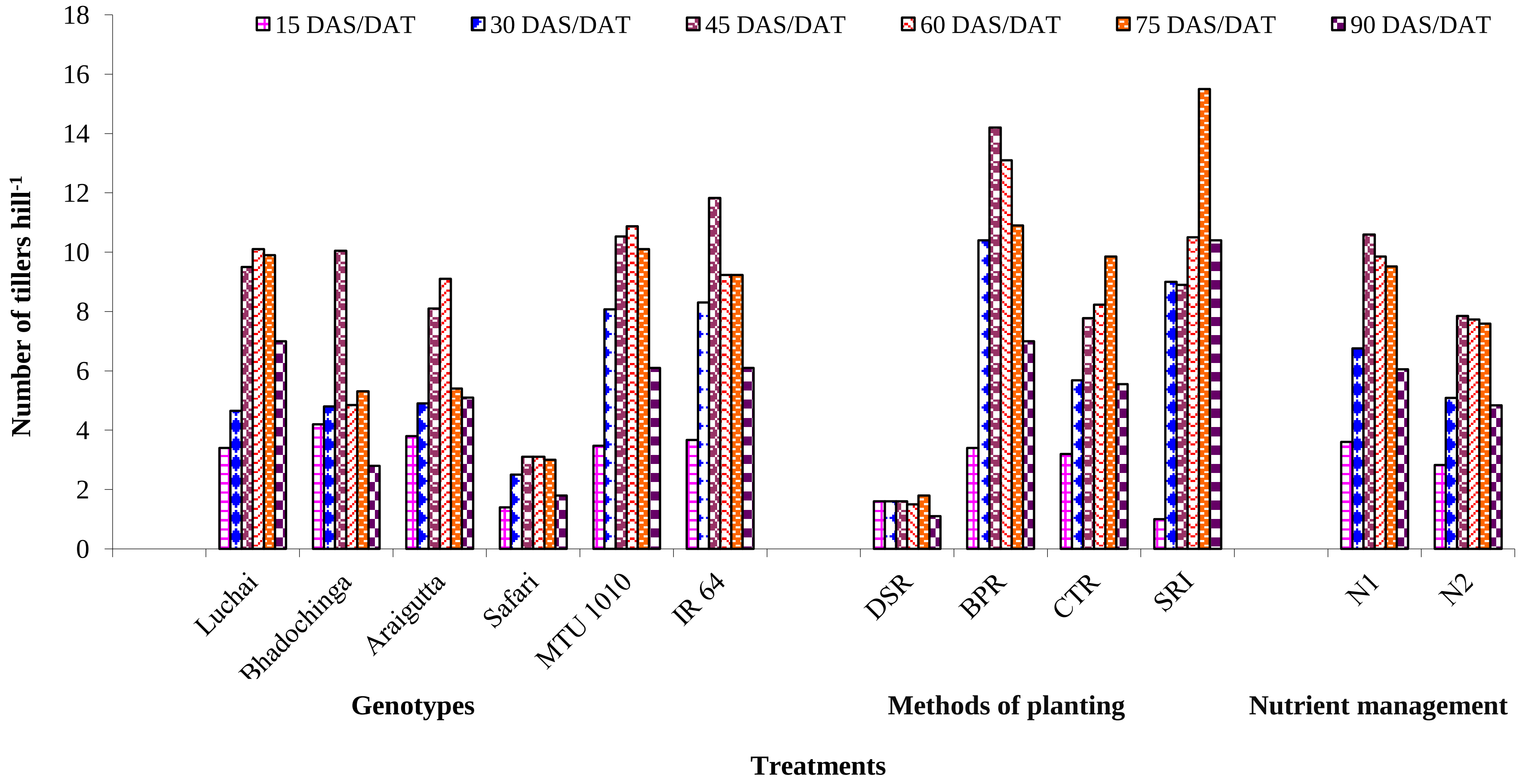
Number of tillers hill^{-1} was significantly influenced by the nutrient management at all successive intervals of growth except at 75 and 90 DAT. Investigation showed that the number of tillers hill^{-1} recorded steady increase from at 15 to 45 DAT and thereafter it showed decline. It was due to the tiller mortality and the senescence of lower tillers because of shading effect in the rice plant. This phenomenon has been reported by Hussain *et al*. (2012). At 15, 30, 45, and 60 DAT significantly higher number of tillers hill^{-1} (3.60, 6.76, 10.59 and 9.85 respectively) were registered in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*. At 75 higher number of tillers hill^{-1} and number of effective tillers hill^{-1} at 90 DAT (9.52 and 6.05 respectively) were observed in treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which was 25.42 and 24.74% higher than the inferior figures of 7.59 and 4.84 respectively in treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}.

Application of FYM may have released essential plant nutrients NPK in a slow manner to the rice crop for and a longer period during its growth stages, which may have resulted in more NPK uptake by the roots for the synthesis of protoplasm responsible for rapid cell division. It may have increased the plant shape and size, ultimately the production of more tillers (Dar *et al*., 2000).

Table 4.2 Effect of different genotypes, methods of planting and nutrient management on number of tillers hill^{-1} of rice at different intervals

Treatments	Number of tillers hill^{-1}					
	15 DAS/DAT	30 DAS/DAT	45 DAS/DAT	60 DAS/DAT	75 DAS/DAT	*90 DAS/DAT
Genotypes						
Luchai	3.40	4.65	9.50	10.10	9.90	7.00
Bhadochinga	4.20	4.80	10.05	4.85	5.31	2.80
Araigutta	3.80	4.90	8.10	9.10	5.40	5.10
Safari	1.40	2.50	3.10	3.10	3.00	1.80
MTU 1010	3.47	8.07	10.53	10.87	10.10	6.10
IR 64	3.67	8.30	11.83	9.23	9.23	6.10
SEd (±)	0.67	0.96	1.93	2.66	2.16	1.26
CD (P= 0.05)	-	2.46	4.95	-	-	3.23
CV (%)	3.70	4.07	6.46	9.49	8.08	5.72
Methods of planting						
Direct seeded rice (DSR)	1.60	1.60	1.60	1.50	1.80	1.10
Beushening puddled rice (BPR)	3.40	10.40	14.20	13.10	10.90	7.00
Conventional transplanted rice (CTR)	3.20	5.68	7.78	8.23	9.85	5.55
System of rice intensification (SRI)	1.00	9.00	8.90	10.50	15.50	10.40
SEd (±)	1.11	3.06	4.09	4.00	4.74	4.83
CD (P= 0.05)	-	-	-	-	-	-
CV (%)	7.31	11.85	14.35	13.84	15.37	19.71
Nutrient management						
50 kg N ha^{-1} through FYM + 3% *matka khaad*	3.60	6.76	10.59	9.85	9.52	6.05
100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}	2.83	5.09	7.85	7.73	7.59	4.84
SEd (±)	0.20	0.51	0.58	0.65	1.12	0.74
CD (P= 0.05)	0.45	1.16	1.32	1.48	-	-
CV (%)	2.48	4.69	4.30	4.94	8.56	7.07

*Effective tillers was counted at 90 DAS/DAT



N_1: 50 kg N ha^{-1} through FYM + 3% *matka khaad* N_2: 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}

Fig. 4.2 Effect of different genotypes, methods of planting and nutrient management on number of tillers hill^{-1} of rice at different intervals

4.3 Plant dry weight (g hill^{-1})

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on plant dry weight are presented in table 4.3 and depicted in fig. 4.3.

During the successive intervals of growth data showed that there was a steady increase in plant dry weight from 15 to 90 DAS/DAT.

Effect of Genotypes

Significant influence on plant dry weight due to genotypes was observed only at 90 DAS/DAT. At 15, 30, 60 and 90 DAS/DAT highest plant dry weight (0.09, 0.89, 5.61 and 21.17 g hill^{-1} respectively) was recorded in the MTU 1010 genotype and exactly same figure of 0.89 g hill^{-1} observed with treatment *Araigutta* genotype at 30 DAS/DAT, which were 125.00, 81.63, 152.70 and 47.11% higher than the lowest value 0.04, 0.49, 2.22 and 14.39 g hill^{-1} respectively in the *Bhadochinga/Luchai* genotype. However, at 90 DAS/DAT *Araigutta* and IR 64 genotypes were statistically at par with MTU 1010 genotype. At 45 and 75 DAS/DAT higher plant dry weight (1.69 and 13.65 g hill^{-1} respectively) was recorded in the *Araigutta* genotype, which was 77.89 and 74.10% higher than lowest value of 0.95 and 7.84 g hill^{-1} respectively in the *Bhadochinga* genotype.

Effect of methods of planting

Significant influence at all growth stages except 15, 30 and 45 DAS/DAT was observed. At 60, 75 and 90 DAS/DAT significantly higher plant dry weight values (6.68, 24.43 and 36.41 g hill^{-1} respectively) were registered in the system of rice intensification (SRI), which were 588.65, 578.61 and 336.04% higher than lowest values of 0.97, 3.60, and 8.35 g hill^{-1} respectively in the direct seeded rice (DSR). At 15, 30 and 45 DAS/DAT higher plant dry weight (0.08, 0.87 and 1.97 g hill^{-1} respectively) was observed in the beushening puddled rice (BPR)/conventional transplanted rice (CTR), which was 100.00, 117.50 and 251.78% higher than lowest values of 0.04, 0.40 and 0.56 g hill^{-1} respectively in the direct seeded rice (DSR)/system of rice intensification (SRI).

The amount of dry matter production depends on effectiveness of photosynthesis of crop and furthermore, on plants whose vital activities are functioning effectively (Jha *et al*., 2004). The factor responsible for increased weight of individual hills' dry matter at wider spacing may be greater number of tillers has also been reported by Thakur *et al.* (2010).

Further, the accelerated growth and development of the crop under SRI at successive stages particularly at advanced phases resulted in higher dry matter accumulation (Sowmya *et al*., 2011).

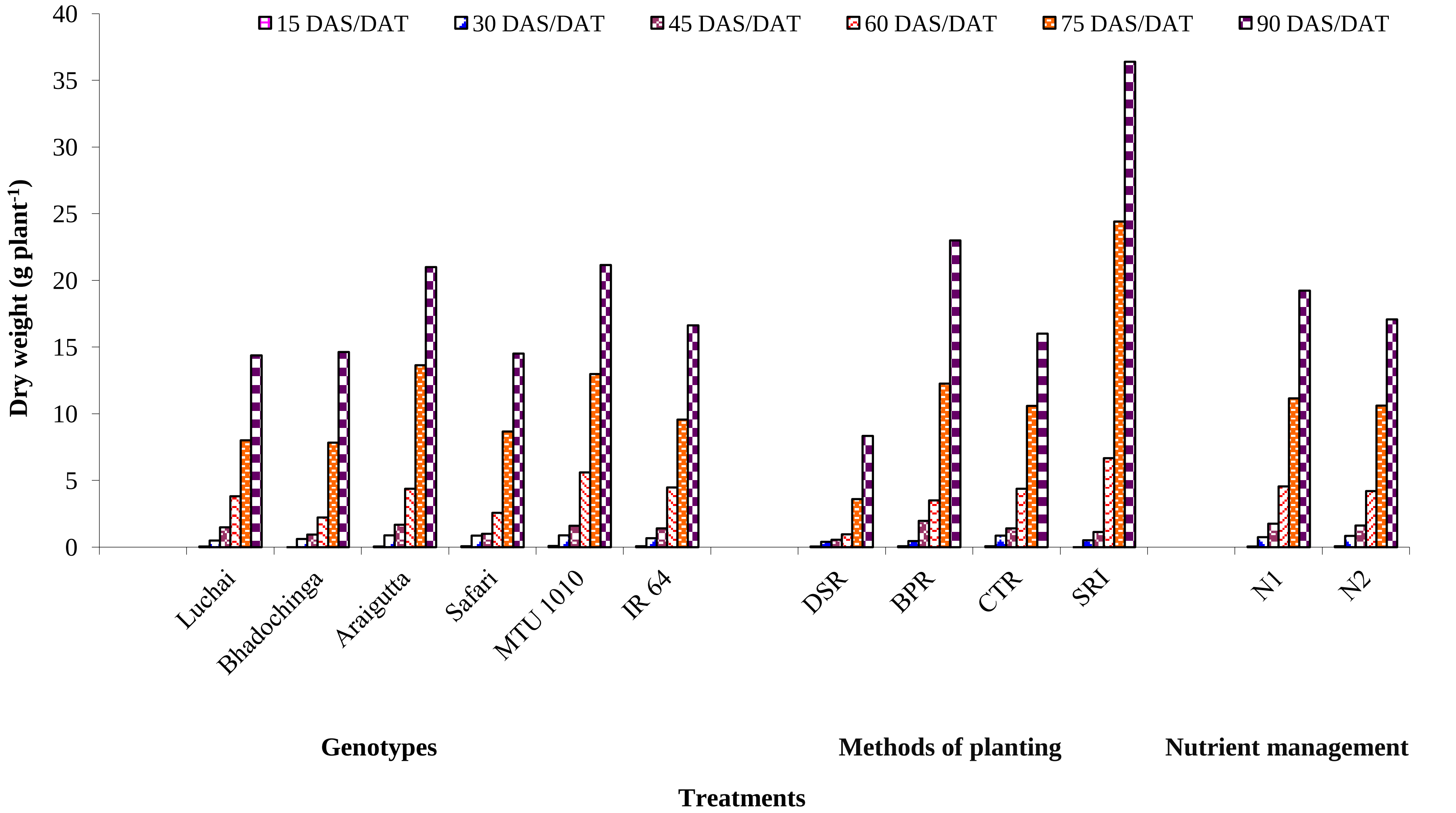
Effect of nutrient management

With reference to the plant dry weight there was no-significant difference between the nutrient management practices at all successive growth stages. At 15 and 30 DAT higher plant dry weight (0.07 g and 0.84 g $hill^{-1}$ respectively) was recorded in treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}, which was 16.66 and 12.00% higher than inferior figures 0.06 and 0.75 g $hill^{-1}$ respectively in the treatment with 50 kg N ha^{-1} through FYM + 3% *matka khaad*. However, at 45, 60, 75 and 90 DAT higher plant dry weight (1.76, 4.56, 11.16 and 19.24 g $hill^{-1}$ respectively) was recorded in the treatment with 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which was 7.97, 8.57, 5.08 and 12.58% higher compare to inferior figures 1.63, 4.20, 10.62 and 17.09 g $hill^{-1}$ respectively in treatment the 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}.

The production of maximum dry matter due to application of FYM, which provide essential nutrients for longer time, and then accounted for the luxuriant growth of plant (Rahman *et al*., 2007).

Table 4.3 Effect of different genotypes, methods of planting and nutrient management on plant dry weight of rice at different intervals

Treatments	Dry weight (g plant^{-1})					
	15 DAS/DAT	30 DAS/DAT	45 DAS/DAT	60 DAS/DAT	75 DAS/DAT	90 DAS/DAT
Genotypes						
Luchai	0.05	0.49	1.49	3.82	8.01	14.39
Bhadochinga	0.04	0.61	0.95	2.22	7.84	14.64
Araigutta	0.05	0.89	1.69	4.39	13.65	21.00
Safari	0.08	0.87	1.01	2.58	8.67	14.53
MTU 1010	0.09	0.89	1.60	5.61	12.99	21.17
IR 64	0.07	0.68	1.41	4.48	9.57	16.63
SEd (±)	0.02	0.16	0.50	1.49	1.62	1.92
CD (P= 0.05)	-	-	-	-	-	4.93
CV (%)	0.94	1.84	4.25	7.57	5.10	4.64
Methods of planting						
Direct seeded rice (DSR)	0.05	0.40	0.56	0.97	3.60	8.35
Beushening puddled rice (BPR)	0.08	0.46	1.97	3.51	12.27	23.01
Conventional transplanted rice (CTR)	0.07	0.87	1.42	4.39	10.60	16.02
System of rice intensification (SRI)	0.04	0.52	1.15	6.68	24.43	36.41
SEd (±)	0.02	0.47	0.54	0.55	3.55	1.94
CD (P= 0.05)	-	-	-	1.75	11.31	6.19
CV (%)	0.80	6.23	4.77	2.79	9.95	4.24
Nutrient management						
50 kg N ha^{-1} through FYM + 3% *matka khaad*	0.06	0.75	1.76	4.56	11.16	19.24
100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}	0.07	0.84	1.63	4.20	10.62	17.09
SEd (±)	0.01	0.15	0.12	0.48	0.64	1.03
CD (P= 0.05)	-	-	-	-	-	-
CV (%)	0.68	3.62	2.13	5.16	4.36	5.39



N_1: 50 kg N ha^{-1} through FYM + 3% *matka khaad* N_2: 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}

Fig. 4.3 Effect of different genotypes, methods of planting and nutrient management on plant dry weight of rice at different intervals

4.4 Crop Growth Rate (g m^{-2} day^{-1})

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on crop growth rate are presented in table 4.4 and depicted in fig. 4.4.

Effect of Genotypes

During the successive intervals of growth data showed that there was a constant increase in CGR from 15 to 90 DAS/DAT. At 0 to 15 DAS/DAT growth interval the significantly highest crop growth rate (0.90 g m^{-2} day^{-1}) was registered in the *Safari* genotype, which was 800% higher than the lowest value of 0.10 g m^{-2} day^{-1} in the *Araigutta* genotype. At 75 to 90 DAS/DAT growth interval significantly higher crop growth rate (38.72 g m^{-2} day^{-1}) was recorded in the *Luchai* genotype, which was 154.90% higher than the lowest value of 15.19 g m^{-2} day^{-1} in IR 64 genotype. However, the *Bhadochinga* and *Safari* genotypes were found to be statistically at par with *Luchai* genotype. At 15 to 30 DAS/DAT growth interval the maximum crop growth rate (7.90 g m^{-2} day^{-1}) was observed in the *Safari* genotype, which was 406.41% higher than the lowest value of 1.56 g m^{-2} day^{-1} in the IR 64 genotype. At 30 to 45 DAS/DAT growth interval the highest crop growth rate (3.41 g m^{-2} day^{-1}) was recorded in the *Luchai* genotype, which was 121.42% higher than the lowest value of 1.54 g m^{-2} day^{-1} in the MTU 1010 genotype. At 45 to 60 and 60 to 75 DAS/DAT growth intervals the highest crop growth rate (10.01 and 29.27 g m^{-2} day^{-1} respectively) was recorded in the MTU 1010 genotype, which was 82.99 and 94.48% higher than the lowest values of 5.47 and 15.05 g m^{-2} day^{-1} respectively in the IR 64 genotype.

Effect of methods of planting

During the successive intervals of growth, data showed fluctuation in CGR at all growth stages and at 0 to 15 and 75 to 90 DAS/DAT significant difference were observed between the methods of planting. At 0 to 15, 15 to 30, 60 to 75 and 75 to 90 DAS/DAT growth intervals the highest crop growth rate (0.60, 4.60, 34.00 and 63.27 g m^{-2} day^{-1} respectively) were recorded in the direct seeded rice (DSR), which was 1400, 820.00, 80.08 and 395.07% higher than the lowest values of 0.04, 0.50, 18.88 and 12.78 g m^{-2} day^{-1} respectively in the system of rice intensification (SRI). At 30 to 45 DAS/DAT growth interval the highest crop growth rate (2.68 g m^{-2} day^{-1}) was recorded in the beushening puddled rice (BPR), which was 300.00% higher than the lowest value of 0.67 g m^{-2} day^{-1} in the system of rice intensification (SRI). At 45 to 60 DAS/DAT growth interval the highest crop growth rate (16.73 g m^{-2} day^{-1}) was observed in the conventional transplanted rice

(CTR), which was 766.83% higher than the lowest value of 1.93 g m^{-2} day^{-1} in the beushening puddled rice (BPR).

Significantly and highest value of CGR recorded in directed seeded rice may be due to the higher and dense plant population per unit area (Bommayasamy *et al*., 2010). However, relatively lower plant population of hills per unit area under SRI shown decreasing CGR. It has been also reported by Wijebandara *et al*. (2009).

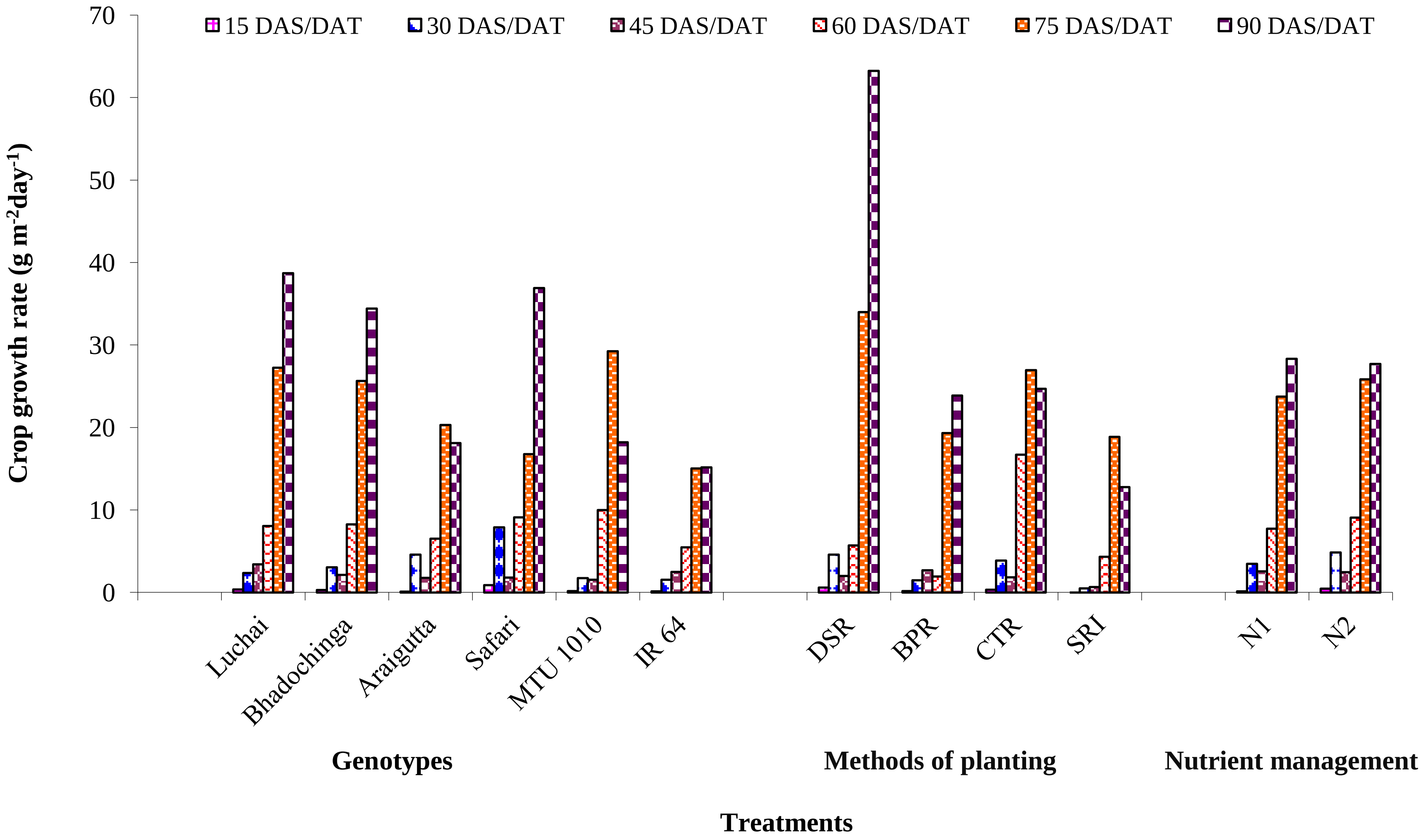
Effect of nutrient management

During the successive intervals of growth, regarding the crop growth nutrient management rate was recorded significant influence only at 0 to15 DAS/DAT. At 0 to 15, 15 to 30, 45 to 60 and 60 to 75 DAS/DAT growth intervals the significant and highest crop growth rate values (0.47, 4.87, 9.09 and 25.84 g m^{-2} day^{-1} respectively) were recorded in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}, which was 261.53, 39.54, 17.59 and 8.75% higher than the inferior figures of 0.13, 3.49, 7.73 and 23.76 g m^{-2} day^{-1} respectively in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*. At 30 to 45 and 75 to 90 DAS/DAT growth intervals highest crop growth rate (2.56 and 28.35 g m^{-2} day^{-1} respectively) was recorded in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which was 4.48 and 2.23% higher than the inferior figures of 2.45 and 27.73 g m^{-2} day^{-1} in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}.

The higher dry matter accumulation may be due to the split application of nitrogen at crucial growth stages, which leading the higher translocation of photosynthates it ultimately results in the higher CGR (Sharma *et al.*, 2007). However, the application of FYM may have supplied the essential major elements (NPK) throughout the growth period, in optimum quantity and quality, which favors in higher photosynthetic and growth activities in rice crop it triggering a higher CGR (Yadav *et al*., 2008 and Singh *et al*., 2003).

Table 4.4 Effect of different genotypes, methods of planting and nutrient management on crop growth rate of rice at different intervals

Treatments	Crop growth rate (g $m^{-2}day^{-1}$) Growth interval					
	0-15 DAS/DAT	15-30 DAS/DAT	30-45 DAS/DAT	45-60 DAS/DAT	60-75 DAS/DAT	75-90 DAS/DAT
Genotypes						
Luchai	0.36	2.37	3.41	8.07	27.25	38.72
Bhadochinga	0.29	3.04	2.15	8.27	25.66	34.42
Araigutta	0.10	4.60	1.77	6.53	20.33	18.12
Safari	0.90	7.90	1.80	9.10	16.77	36.93
MTU 1010	0.18	1.76	1.54	10.01	29.27	18.21
IR 64	0.13	1.56	2.49	5.47	15.05	15.19
SEd (±)	0.18	1.97	1.63	3.10	10.45	5.72
CD (P= 0.05)	0.47	-	-	-	-	14.71
CV (%)	3.17	10.49	11.01	11.03	22.07	11.02
Methods of planting						
Direct seeded rice (DSR)	0.60	4.60	2.00	5.70	34.00	63.27
Beushening puddled rice (BPR)	0.16	1.48	2.68	1.93	19.33	23.88
Conventional transplanted rice (CTR)	0.33	3.86	1.83	16.73	26.96	24.70
System of rice intensification (SRI)	0.04	0.50	0.67	4.32	18.88	12.78
SEd (±)	0.05	1.51	0.92	3.93	6.40	9.17
CD (P= 0.05)	0.15	-	-	-	-	29.18
CV (%)	0.86	9.35	6.90	14.66	12.85	16.42
Nutrient management						
50 kg N ha^{-1} through FYM + 3% *matka khaad*	0.13	3.49	2.56	7.73	23.76	28.35
100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}	0.47	4.87	2.45	9.09	25.84	27.73
SEd (±)	0.05	1.52	0.47	1.63	6.81	6.36
CD (P= 0.05)	0.11	-	-	-	-	-
CV (%)	1.93	16.60	6.58	12.57	30.56	26.84



N_1: 50 kg N ha^{-1} through FYM + 3% *matka khaad* N_2: 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}

Fig. 4.4 Effect of different genotypes, methods of planting and nutrient management on crop growth rate of rice at different intervals

4.5 Relative Growth Rate (g g^{-1} day^{-1})

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on relative growth rate are presented in table 4.5 and depicted in fig. 4.5.

With reference to the relative growth rate there was no significantly influence three factors *viz.*, genotypes, methods of planting and nutrient management practices at all the growth duration.

Effect of Genotypes

At 15 to 30 DAS/DAT growth interval the highest relative growth rate (0.20 g g^{-1} day^{-1}) was observed in the MTU 1010 genotype, which was 33.33% higher than the lowest value of 0.15 g g^{-1} day^{-1} in the *Luchai* genotype. At 30 to 45, 45 to 60 and 60 to 75 DAS/DAT growth intervals the highest relative growth rate (0.17, 0.16, and 0.09 g g^{-1} day^{-1} respectively) in the *Bhadochinga* genotype, which was 1600, 166.67 and 80.00% higher than the lowest value of 0.01, 0.06 and 0.05 g g^{-1} day^{-1} respectively in the *Safari/Araigutta* /IR 64. At 75 to 90 DAS/DAT growth interval the highest relative growth rate (0.06 g g^{-1} day^{-1}) in the *Safari* genotype, which was 100.00% higher than the lowest value of 0.03 g g^{-1} day^{-1} in the *Araigutta* genotype.

Effect of methods of planting

At 15 to 30, 45 to 60 and 60 to 75 DAS/DAT growth intervals the highest relative growth rate (0.18, 0.12 and 0.09 g g^{-1} day^{-1}) was observed in the system of rice intensification (SRI), which was 80.00, 300.00 and 50.00% higher than the lowest value of 0.10, 0.03 and 0.06 g g^{-1} day^{-1} in the direct seeded rice (DSR)/beushening puddled rice (BPR)/ conventional transplanted rice (CTR). At 30 to 45 DAS/DAT growth interval the highest relative growth rate (0.14 g g^{-1} day^{-1}) in the beushening puddled rice (BPR), which was 600.00% higher than the lowest value of 0.02 g g^{-1} day^{-1} in the direct seeded rice (DSR). At 75 to 90 DAS/DAT growth interval higher relative growth rate (0.06 g g^{-1} day^{-1} respectively) in the direct seeded rice (DSR), which was 100.00% higher than the lowest value of 0.03 g g^{-1} day^{-1} in the conventional transplanted rice (CTR) and system of rice intensification (SRI).

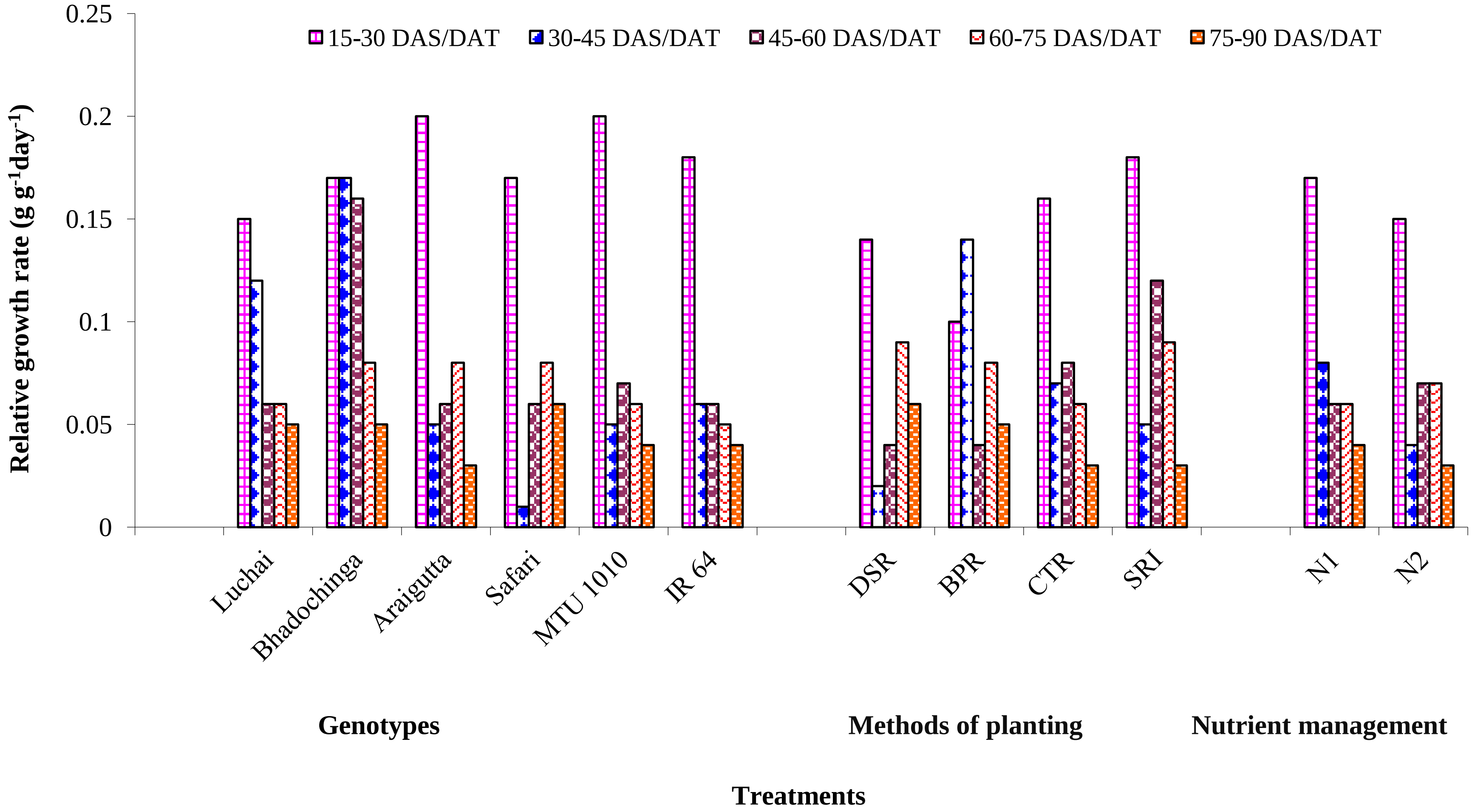
Effect of nutrient management

At 15 to 30, 30 to 45 and 75 to 90 DAS/DAT growth intervals the highest relative growth rate (0.17, 0.08 and 0.04 g g^{-1} day^{-1} respectively) was recorded in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which was 13.33, 100.00 and 0.33% higher than the inferior figures of 0.15, 0.04 and 0.03 g g^{-1} day^{-1} respectively in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}. At 45 to 60 and 60 to 75 DAS/DAT growth intervals the highest relative growth rate (exactly same figure of 0.07 g g^{-1} day^{-1} at both intervals) was recorded in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}, which was 16.66% higher than exactly same lower figure of 0.06 g g^{-1} day^{-1} (at both 45 to 60 and 60 to 75 DAS/DAT intervals) respectively in treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*.

Irrespective of treatments the RGR values were more at early stages of the crop and showed a decreasing trend with the advancement of plant age. The decreased RGR was probably due to the increase of metabolically active tissue (photosynthetic) and as obtained less to the plant growth (Alam *et al*., 2009). However, the higher RGR could be attributed to better nutrition especially availability of N to the rice crop and zinc synthesis of enzymes and hormones along with the metabolization of major nutrients, which in turn promoted growth components (Hussain *et al*., 2012; Singh *et al*., 2003 and Srinivasan and Naidu, 1998).

Table 4.5 Effect of different genotypes, methods of planting and nutrient management on relative growth rate of rice at different intervals

Treatments	Relative growth rate (g $g^{-1}day^{-1}$)				
	Growth interval				
	15-30 DAS/DAT	30-45 DAS/DAT	45-60 DAS/DAT	60-75 DAS/DAT	75-90 DAS/DAT
Genotypes					
Luchai	0.15	0.12	0.07	0.06	0.05
Bhadochinga	0.17	0.17	0.16	0.09	0.05
Araigutta	0.19	0.05	0.06	0.08	0.03
Safari	0.17	0.01	0.06	0.07	0.06
MTU 1010	0.20	0.05	0.07	0.06	0.04
IR 64	0.18	0.06	0.06	0.05	0.04
SEd (±)	0.05	0.10	0.06	0.01	0.01
CD (P= 0.05)	-	-	-	-	-
CV (%)	1.29	3.62	2.07	0.48	0.62
Methods of planting					
Direct seeded rice (DSR)	0.14	0.02	0.03	0.08	0.06
Beushening puddled rice (BPR)	0.10	0.14	0.04	0.08	0.05
Conventional transplanted rice (CTR)	0.16	0.07	0.08	0.06	0.03
System of rice intensification (SRI)	0.18	0.05	0.12	0.09	0.03
SEd (±)	0.07	0.07	0.02	0.01	0.01
CD (P= 0.05)	-	-	-	-	-
CV (%)	1.93	2.75	0.74	0.47	0.73
Nutrient management					
50 kg N ha^{-1} through FYM + 3% *matka khaad*	0.17	0.08	0.06	0.06	0.04
100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}	0.15	0.04	0.07	0.07	0.03
SEd (±)	0.02	0.02	0.01	0.01	0.01
CD (P= 0.05)	-	-	-	-	-
CV (%)	1.14	1.38	0.59	0.53	0.66



N_1: 50 kg N ha^{-1} through FYM + 3% *matka khaad* N_2: 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}

Fig. 4.5 Effect of different genotypes, methods of planting and nutrient management on relative growth rate of rice at different intervals

B. Post-harvest findings

4.6 Panicle length (cm)

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on panicle length are presented in table 4.6.

Effect of Genotypes

Between the genotypes found that there was no significant difference in values of the panicle length. The maximum panicle length (20.20 cm) was recorded in the *Araigutta* genotype, which was 20.23% higher than the lowest value of 16.80 cm in the *Safari* genotype.

Effect of methods of planting

Panicle length was observed to be no significant due to the methods of planting. The maximum panicle length (21.08 cm) was recorded in the conventional transplanted rice (CTR), which was 23.27% higher than the lowest value of 17.10 cm in the direct seeded rice (DSR).

Effect of nutrient management

There was no significant influence on the panicle length due to the nutrient management practices. The highest panicle length (20.22 cm) was recorded in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}, which was only 2.79% higher than the inferior figure of 19.67 cm in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad* .

It may be due to the application of both sources (organic and inorganic), which provides the essential nutrients mainly N and Zn. It ultimately increased the vigour, photosynthate accumulation and better translocation of photosynthates (Khanda and Dixit, 1995).

4.7 Number of grains panicle^{-1}

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on number of grains panicle^{-1} are presented in table 4.6 and depicted in fig. 4.6.

Effect of Genotypes

Genotypes was significantly influenced the number of grains panicle^{-1} of rainfed rice. The significantly higher number of grains panicle^{-1} (144.00) was recorded in the *Araigutta* genotype, which was 25.76% higher than the lowest value of 114.50 in the *Safari* genotype. However, *Luchai* genotype with 133.50 number of grains panicle^{-1} was statistically at par with *Araigutta* genotype.

Effect of methods of planting

Between the methods of planting no significant influence was observed in the number of grains panicle^{-1} of rainfed rice. The maximum number of grains panicle^{-1} (128.50) was recorded in the system of rice intensification (SRI), which was 16.81% higher than the lowest value of 110.00 cm in the beushening puddled rice (BPR).

This behavior might be due to the transplanting of younger seedlings (10 to 12 days old), which preserves the potential for higher tillering and rooting. Better vegetative growth and assimilate translocation leads to increased number of grains panicle^{-1} (Raj *et al*., 2012).

Effect of nutrient management

Significant influence of nutrient management was not evident in the number of grains panicle^{-1} of rainfed rice. The maximum number of grains panicle^{-1} (128.50) was recorded in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which was 1.42% higher than the inferior figure of 126.70 cm in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}.

Both the nutrient management practices seem to be acceptable and statistically at par, and this may be reduced the organic and biological formulation along with the reduced the dose of inorganic sources of nitrogen is a potentially sustainable practice.

4.8 Test weight (g)

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on test weight are presented in table 4.6.

Effect of Genotypes

Statistical analysis regarding the test weight figure indicates that genotypes were non-significantly different. However, the highest two values of test weight 26.85 and 26.55 g respectively were recorded in the *Araigutta* and *Safari* genotypes, which was 9.81 and 8.58% higher than the lowest value of 24.45 g in the *Bhadochinga* genotype.

Production and potential of the indigenous genotype have in evident this attribute.

Effect of methods of planting

Statistical analysis of the data indicated that the test weight was non-significant as influenced by the methods of planting. The maximum test weight (26.65 g) was recorded in the conventional transplanted rice (CTR), which was only 4.92% higher than the lowest value of 25.40 g in the beushening puddled rice (BPR).

Effect of nutrient management

The nutrient management practice did not show any significant difference regard to the test weight was as influenced by. The maximum test weight (26.80 g) was recorded in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which was only 0.44% higher than the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1} with a figure of 26.68 g.

4.9 Grain yield (t ha^{-1})

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on grain yield are presented in table 4.6 and depicted in fig. 4.7.

Effect of Genotypes

There was no significant difference among the genotypes with reference to grain yield. However, the indigenous genotypes performed better than HYVs. The highest three values of grain yield (9.76, 8.50 and 7.54 t ha^{-1}) were recorded in the *Luchai,* than *Araigutta* followed by *Safari* genotype, which was 278.29, 229.45 and 192.24% higher than the lowest value of 2.58 t ha^{-1} in the IR 64.

The adaptability of indigenous genotype to the change in climate is inactive to such a phenomenon of enhanced yield. This may be due to the positive genotypic environment interaction (Jamal, 2009).

Effect of methods of planting

Grain yield was not significantly influenced by the methods of planting. Further the higher grain yield (3.30 t ha^{-1}) was recorded in the system of rice intensification (SRI), which was 22.22% higher than the lowest value of 2.70 in the conventional transplanted rice (CTR). While second best grain yield (3.25 t ha^{-1}) was registered in the beushening puddled rice (BPR), which was 14.84% higher than the second lowest value of (2.83 t ha^{-1}) in direct seeded rice (DSR).

During the critical peek vegetative and reproductive stages of rainfed rice in conventional transplanted rice (CTR), did not perform well because of water stress (no rainfall) condition for prolonged period may have negatively influenced these performance, so its ultimately lower grain yield.

In the SRI due to younger seedling, which holds the potential (for higher yield) and wider spacing subjected plants this to less competitions environment both above and below the soil, which may have that promote better root growth and higher canopy and development, leading to higher nutrient uptake, better grain filling and ultimately enhanced yield (Menete *et al*., 2008).

The indigenous methods of rice cultivation, the stirring of soil and seedlings 30 to 37 DAS improved the tillering, nutrient uptake and causes better root development, which ultimately processes facilitate stabilize rice yields (Ghosh *et al.,* 1960).

Effect of nutrient management

The data of grain yield did not show any significant difference due to the nutrient management practices. The higher grain yield (5.31 t ha^{-1}) was recorded in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which was 2.31% higher than inferior figure of 5.19 t ha^{-1} in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}.

It may be attributed to the adequate supply of nutrients, higher uptake and recovery of applied nutrient with application of FYM, which in turn must have improved synthesis and translocation of metabolites to various reproductive structures of the plant. Apart from dry matter accumulation the better translocation of it to the reproductive parts resulted in higher grain yield (Shekara *et al.*, 2010). Further the inorganic sources of nutrients also showed parity in their performance, thereby leaving a choice of alternative for these features.

4.10 Straw yield (t ha^{-1})

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on straw yield are presented in table 4.6 and depicted in fig. 4.7.

Effect of Genotypes

Statistical analysis of the data indicated the straw yield was not significantly different among the genotypes. The highest two values of straw yield (19.92 and 18.09 t ha^{-1} respectively) were recorded in the *Araigutta* and *Luchai* genotype, which were 201.36 and 173.67% higher compared to the lowest value of 6.61 t ha^{-1} in the *Bhadochinga* genotype.

Effect of methods of planting

The data indicated that the straw yield was not significantly influenced by methods of planting. The highest two values of straw yield (8.68 and 8.20 t ha^{-1}) were recorded in the direct seeded rice (DSR) and system of rice intensification (SRI), which were 48.63 and 40.41% higher than the lowest value of 5.84 t ha^{-1} in the conventional transplanted rice (CTR).

Highest straw yield in DSR may be due to more plant population per unit area but lesser number of hills per unit area in the other methods may have had its direct effect on productivity of straw.

Effect of nutrient management

Statistical analysis of the data showed that there was no significant difference in straw yield due to the nutrient management practices. The highest straw yield (11.78 t ha^{-1}) was recorded in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which was 8.37% higher than the inferior figures of 10.87 t ha^{-1} in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}.

The application of N through FYM is known to promote tillering, improve length and width of leaves, which in turn increases the plant height and dry matter and are responsible for increase in straw yield (Wijebandara *et al*., 2009). Further, Yoshida, 1981 stated that the nitrogen absorbed at early growth stages is used to produce more straw than grain.

4.11 Harvest index (%)

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on harvest index are presented in table 4.6 and depicted in fig. 4.8.

Effect of Genotypes

Genotypes did not evince any significant influence on the harvest index of rainfed rice. However, the highest two values of harvest index (38.45 and 34.59 respectively) were recorded in the indigenous genotypes (*Safari* and *Luchai* genotype), which was 50.84 and 35.70% higher than the lowest value of 25.49 in the *Araigutta* genotype.

Effect of methods of planting

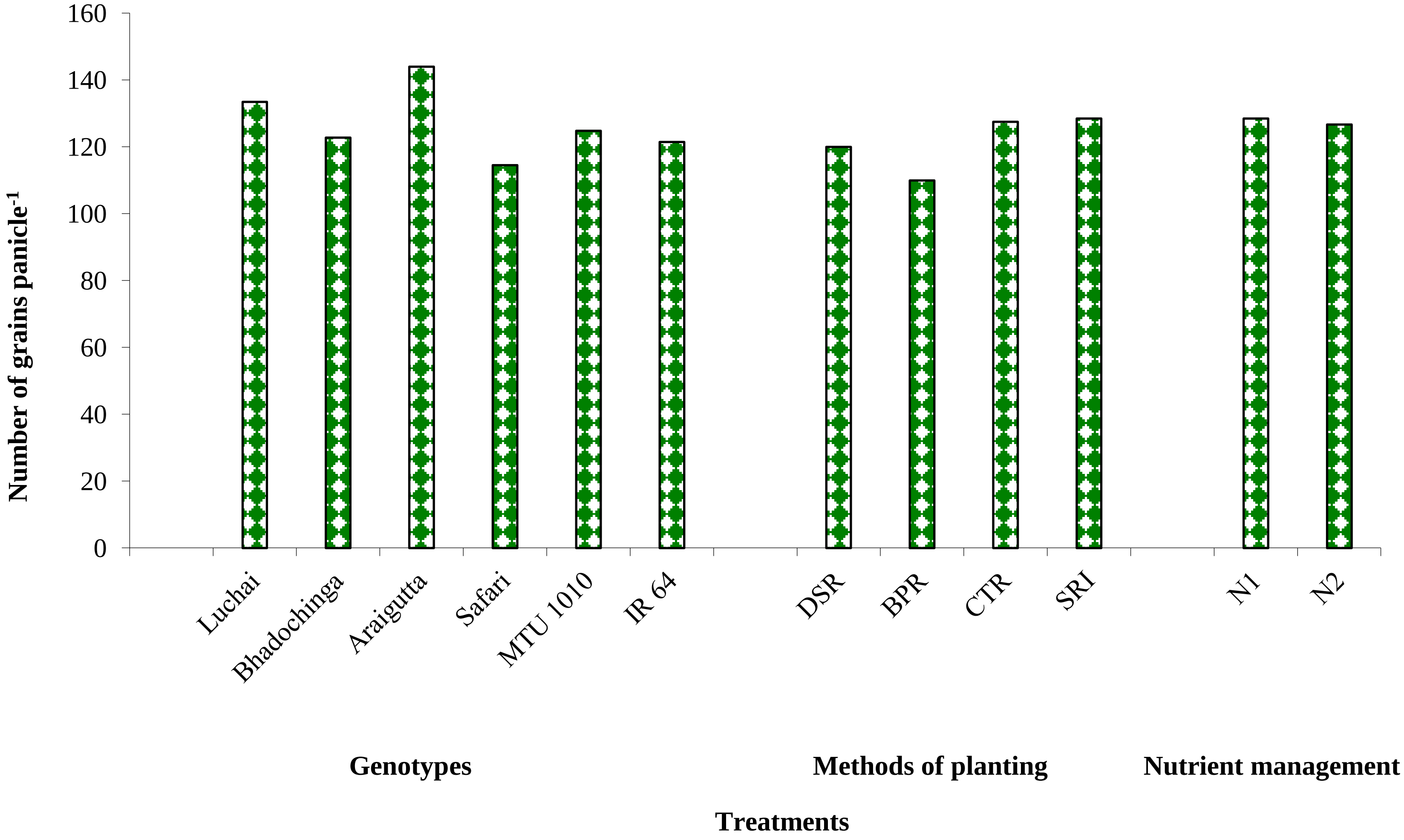
Methods of planting were observed to be non-significant as far as on the harvest index values of rainfed rice. Nonetheless, the highest two values of harvest index (33.39 and 31.42 respectively) was recorded in the beushening puddled rice (BPR) and conventional transplanted rice (CTR), which were 49.46 and 40.64% higher than the lowest value of 22.34 in the direct seeded rice (DSR). The SRI also observed 28.69% higher compared to the DSR.

Effect of nutrient management

Nutrient management practices did not show any significant difference on the harvest index values of rainfed rice. Marginal higher harvest index (31.61 t ha^{-1}) was recorded in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}, which was only 3.16% higher compared with lowest value of 30.64 t ha^{-1} in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*.

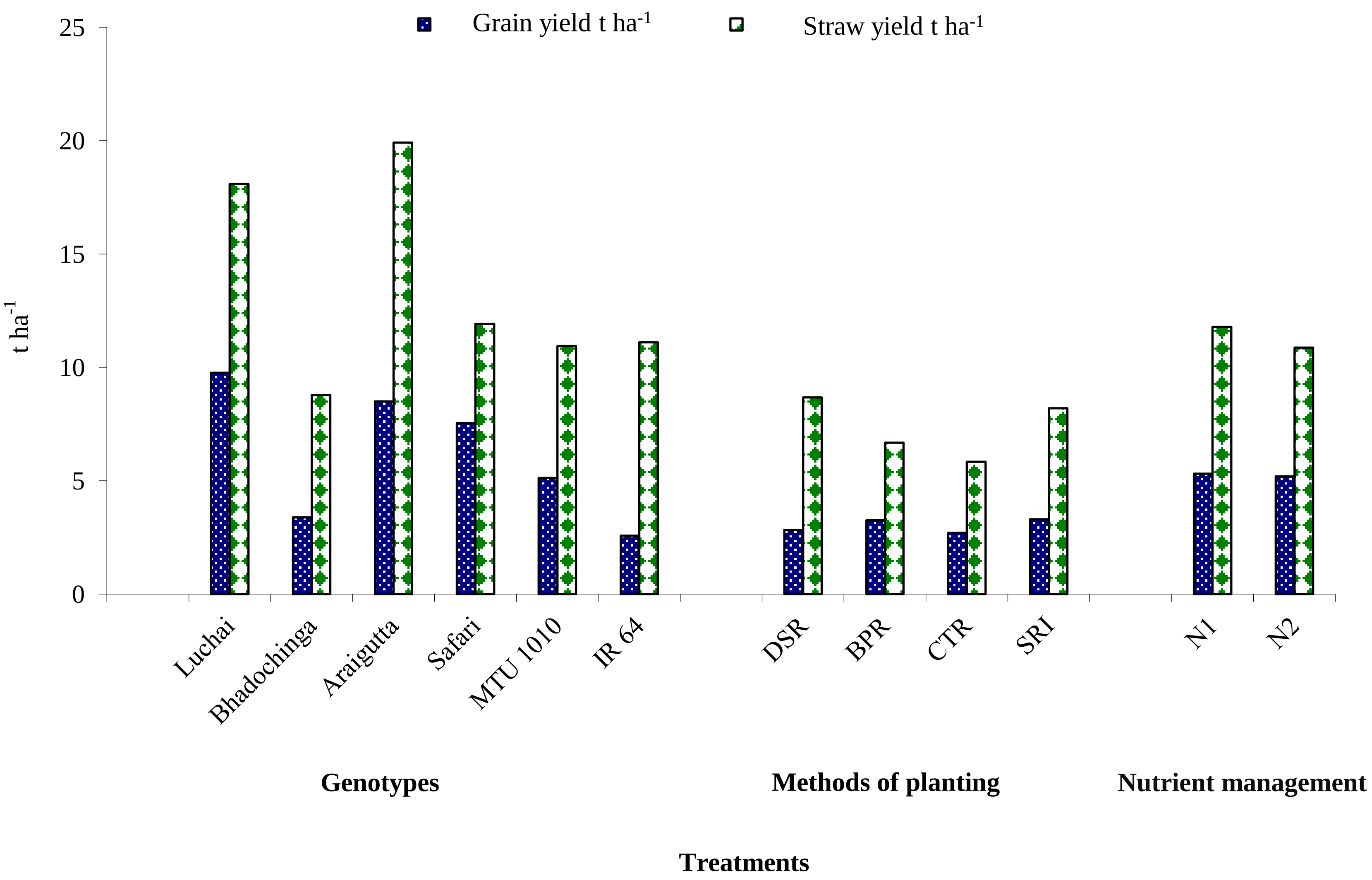
Table 4.6 Effect of different genotypes, methods of planting and nutrient management on yield and yield attributes of rice

Treatments	Yield attributes					
	Panicle length (cm)	Number of grains $panicle^{-1}$	Test weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index (%)
Genotypes						
Luchai	18.53	133.50	25.13	9.76	18.09	34.59
Bhadochinga	18.15	122.75	24.45	3.38	8.78	27.62
Araigutta	20.20	144.00	26.85	8.50	19.92	25.49
Safari	16.80	114.50	26.55	7.54	11.92	38.45
MTU 1010	19.07	124.83	26.17	5.13	10.94	32.95
IR 64	18.77	121.50	26.25	2.58	6.61	27.20
SEd (±)	1.77	6.37	1.20	4.39	7.42	5.98
CD (P= 0.05)	-	16.37	-	-	-	-
CV (%)	4.11	5.65	2.35	17.70	19.63	11.12
Methods of planting						
Direct seeded rice (DSR)	17.10	120.00	25.80	2.83	8.68	22.34
Beushening puddled rice (BPR)	19.30	110.00	25.40	3.25	6.68	33.39
Conventional transplanted rice (CTR)	21.08	127.50	26.65	2.70	5.84	31.42
System of rice intensification (SRI)	18.40	128.50	25.85	3.30	8.20	28.75
SEd (±)	1.35	6.17	1.81	1.15	1.61	10.09
CD (P= 0.05)	-	-	-	-	-	-
CV (%)	3.10	5.59	3.55	6.61	5.75	18.90
Nutrient management						
50 kg N ha^{-1} through FYM + 3% *matka khaad*	19.67	128.50	26.80	5.31	11.78	30.64
100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}	20.22	126.70	26.68	5.19	10.87	31.61
SEd (±)	0.89	3.82	0.41	0.70	1.63	1.16
CD (P= 0.05)	-	-	-	-	-	-
CV (%)	4.45	7.57	1.76	6.84	10.81	4.65



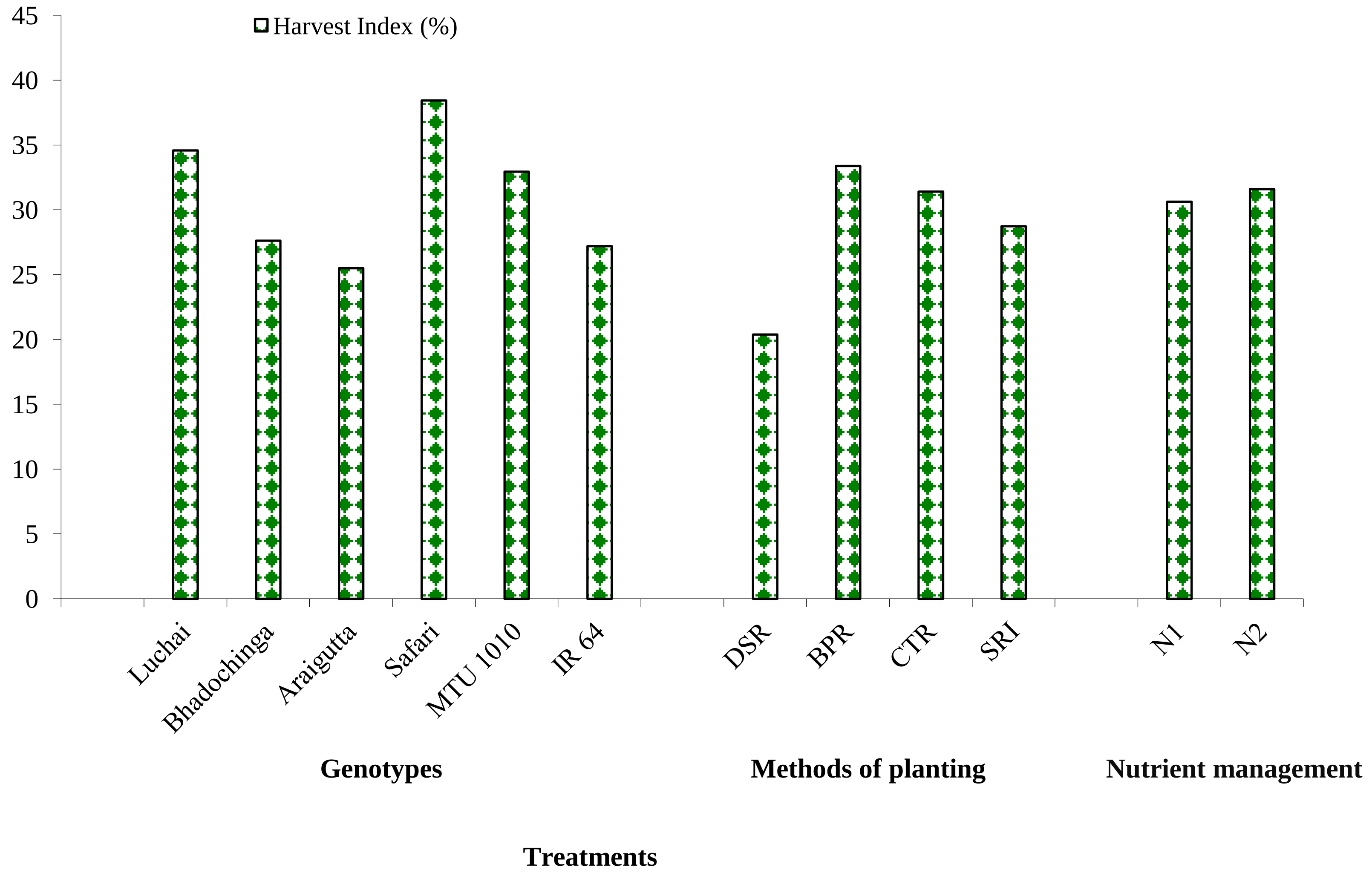
N_1: 50 kg N ha^{-1} through FYM + 3% *matka khaad* N_2: 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}

Fig. 4.6 Effect of different genotypes, methods of planting and nutrient management on number of grains panicle^{-1} of rice



N_1: 50 kg N ha^{-1} through FYM + 3% *matka khaad* N_2: 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}

Fig. 4.7 Effect of different genotypes, methods of planting and nutrient management on grain yield and straw yield of rice



N_1: 50 kg N ha^{-1} through FYM + 3% *matka khaad* N_2: 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}

Fig. 4.8 Effect of different genotypes, methods of planting and nutrient management on harvest index of rice

C. Quality parameters

4.12.1 Protein content in grain (%)

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on protein content are presented in table 4.7.

Effect of Genotypes

The indigenous genotypes was recorded higher protein contain compare to high yielding varieties (HYVs). The subsidiary higher protein contain grain (8.87%) was recorded in the *Luchai* genotype, the marginal difference observed only 5.09% higher than the lowest value (8.44%) in the MTU 1010 genotype.

Effect of methods of planting

The subsidiary higher protein content (8.86) was recorded in the system of rice intensification (SRI), which was only 4.97% higher than the lowest value of 8.44 in the beushening puddled rice (BPR).

Effect of nutrient management

The marginal higher protein content (8.74) was recorded in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which was only 0.34% higher than the inferior figures of 8.71 in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}.

The acceptable grain quality pertaining to protein due to both the nutrient sources (organic and inorganic) may be accorded to better availability of nutrient and its uptake by rice crop, which may have lead to the accumulation of higher quantities of seed components like calcium carbonate and increased lipid metabolism, ultimately enhancing the protein content in the (Deshpande and Deshpande, 2010).

4.12.2 Carbohydrate content in grain (%)

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on carbohydrate content are presented in table 4.7.

Effect of Genotypes

The slightly higher carbohydrate content (77.72%) was recorded in the IR 64 genotype, which was only 1.92% higher compare to the inferior figures (76.25%) in the *Bhadochinga* genotype.

Effect of methods of planting

The marginal higher carbohydrate content (77.37%) was recorded in the beushening puddled rice (BPR), which was only 1.33% higher than the lowest value (76.35%) in the direct seeded rice (DSR).

Effect of nutrient management

The subsidiary higher carbohydrate content (77.56%) was recorded in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which was only 1.04% higher compare to the lowest value (76.76%) in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}.

The marginal alteration in carbohydrate content in rice grain due to the organic and inorganic sources of nutrients, which may have lead to the higher alpha amylase activity (Deshpande and Deshpande, 2010).

Table 4.7 Effect of different genotypes, methods of planting and nutrient management on quality parameters of rice*

Treatments	Protein content (%)	Carbohydrate (%)
Genotypes		
Luchai	8.87	77.64
Bhadochinga	8.83	76.25
Araigutta	8.80	76.30
Safari	8.86	76.66
MTU 1010	8.44	77.37
IR 64	8. 62	77.72
Methods of planting		
Direct seeded rice (DSR)	8.83	76.35
Beushening puddled rice (BPR)	8.44	77.37
Conventional transplanted rice (CTR)	8.70	77.16
System of rice intensification (SRI)	8.86	76.66
Nutrient management		
50 kg N ha^{-1} through FYM + 3% *matka khaad*	8.74	77.56
100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}	8.71	76.76

*Data was not subjected to be statistical analysis

D. Economics

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on economics of rainfed rice are presented in table 4.11 and depicted in fig. 4.11.

Effect of Genotypes

The highest gross return, net return and benefit cost ratio (₹ 140090.00 ha^{-1}, ₹ 102835.00 ha^{-1} and 3.76 respectively) were registered in the *Luchai* genotype, which were 260.49, 2261.30 and 232.74% higher compared to the lowest value of ₹ 38860.00, ₹ 4355.00 ha^{-1} and 1.13 respectively in the IR 64 genotype.

Effect of methods of planting

The maximum gross return and net return (₹ 49450.00 and 18450.00 ha^{-1} respectively) were registered in the system of rice intensification (SRI), which were 24.90 and 213.49% higher compared to the lowest value (₹ 39590.00 ha^{-1} and ₹ 5885.50 ha^{-1} respectively) in the conventional transplanted rice (CTR). While, highest two values of benefit cost ratio (1.62 and 1.60 respectively) were registered in the beushening puddled rice (BPR) and system of rice intensification (SRI), which were 38.46 and 36.75% compared to the lowest value (1.17) in the conventional transplanted rice (CTR).

Effect of nutrient management

The highest gross return, net return and benefit cost ratio (₹ 78155.00, 41425.00 ha^{-1} and 2.13 respectively) were registered in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which were 3.18, 15.41 and 12.10% higher compared to the inferior figures of ₹ 75745.00 ha^{-1}, ₹ 35891.10 ha^{-1} and 1.90 respectively in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}.

The higher returns treated with organic manure as compared to chemical fertilizers may be mainly due to the better soil health, which resulted in enhanced plant growth, yield, yield components and higher prices of organic produce (Yadav *et al*., 2009).

Table 4.8 Effect of different genotypes, methods of planting and nutrient management on economics of rainfed rice[#]

Treatments	Gross return* (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C Ratio
Genotypes				
Luchai	140090.00	37255.00	102835.00	3.76
Bhadochinga	51030.00	33805.00	17225.00	1.51
Araigutta	126170.00	33805.00	92365.00	3.73
Safari	106170.00	36403.90	69766.10	2.92
MTU 1010	75065.00	34505.00	40560.00	2.18
IR 64	38860.00	34505.00	4355.00	1.13
Methods of planting				
Direct seeded rice (DSR)	44055.00	31655.00	12400.00	1.39
Beushening puddled rice (BPR)	47305.00	29230.00	18075.00	1.62
Conventional transplanted rice (CTR)	39590.00	33704.50	5885.50	1.17
System of rice intensification (SRI)	49450.00	31000.00	18450.00	1.60
Nutrient management				
50 kg N ha^{-1} through FYM + 3% *Matka khaad*	78155.00	36730.00	41425.00	2.13
100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}	75745.00	39853.90	35891.10	1.90

*Sale price of grain ₹ 12,500 t^{-1} Sale price of straw ₹ 1000 t^{-1}

[#]Data was not subjected to be statistical analysis

E. Soil fertility status

Data pertaining to the effect of different genotypes, methods of planting and nutrient management on soil fertility status are presented in table 4.11.

Moderate changes in soil fertility values were observed in the 3 clusters, *viz.,* 1st cluster (Ghota, Khamariya and Katighan) and 2nd cluster (Bijatola, Tikariya, Kheri and Kurela) and 3rd cluster (Jaitpuri, Bhadvar and Begakeda) after the harvest of crop. The post harvest analysis recorded decrease in the available N, K_2O and OC (13.68, 10.70 and 16.0% respectively in 1st cluster) and (27.61, 8.89 and 28.00% respectively in 3nd cluster) compared with the initial values. However, the available P_2O_5 recorded rising value (8.73% 1st cluster) and (2.44% 2nd cluster) compared with pre experimental stage, while, pH was recorded reduce value 2.50% in 1st cluster and 0.68% in 3nd cluster and EC was observed rising value (5.55% 1st cluster and 12.50% in 2nd cluster) compared with the initial values. On the other hand, rising values of N, K_2O and OC observed higher value in 2nd cluster which was 14.93, 6.75 and 13.05% compare with initial value. However, pH was observed higher value 0.80% and EC observed reduce in 6.67% compare with initial value.

In the soil the losses of nutrients applied through chemical fertilizers is very common in rice field as in form of volatilization, leaching *etc.* Hence, FYM can maintain plant nutrients in the available forms for longer periods due to improved soil organic matter (SOM) and soil physico-chemical and biological characteristics (Singh and Singh, 2000).

Table 4.9 Effect of different genotypes, methods of planting and nutrient management on nutrient status of soil

Parameter	Experimental soil analysis value*					
	1st cluster (Ghota, Khamariya and Katighan)		2nd cluster (Bijatola, Tikariya, Kheri and Kurela)		3rd cluster (Jaitpuri, Bhadvar and Begakeda)	
	Pre-experimental	Post-harvest	Pre-experimental	Post-harvest	Pre-experimental	Post-harvest
Available N (kg ha^{-1})	245.00	215.50	195.00	224.12	275.00	215.50
Available P_2O_5 (kg ha^{-1})	12.60	13.70	12.51	11.45	13.50	13.83
Available K_2O (kg ha^{-1})	293.00	264.67	274.78	293.33	313.25	287.67
Organic carbon (%)	0.29	0.25	0.23	0.26	0.32	0.25
pH	7.66	7.47	7.53	7.47	7.72	7.67
EC (dS m^{-1})	0.18	0.19	0.16	0.15	0.16	0.16

*Data was not subjected to be statistical analysis

CHAPTER V

SUMMARY AND CONCLUSION

The present investigation entitled, "Evaluation of different cultivars and methods of planting on growth and yield for rainfed rice (*Oryza sativa* L.) in the context of climate change", was carried out during *kharif* season of 2012 at 62 farmers' fields in Mandla district. The on farm research trial was laid out in Randomized Block Design (RBD) consisting of 3 factors, *viz*., six genotypes, four methods of planting and two options of nutrient management. The treatments with options of nutrient management had 10 replications, but the treatments consisting genotypes and methods of planting were replicated only twice. The experiment was conducted with active participation of the Research Officer (RO), District Project Officer (DPO), 10 VRAs and the farming community, small holding farming community (SHFC), who are part of an on-going "Strengthening Adaptive Farming in Bangladesh, India and Nepal (SAFBIN)", project entitled. The experimental findings are summarized based on the factors and are stated as follows.

Factor I: Genotypes

A. Growth parameters

Plant height was significantly affected by among the genotypes at 15, 45 and 60 DAS/DAT. At all growth stages except at 15 DAS/DAT, highest plant height was recorded the in the MTU 1010 genotype. Number of tillers hill^{-1} significantly affected by genotypes at 30, 45 and 90 DAS/DAT, higher tillers hill^{-1} was observed in the *Bhadochinga,* IR 64 and MTU 1010. However, higher number of effective tillers hill^{-1} (7.00) was recorded in the indigenous genotype *Luchai* at 90 DAS/DAT. At 90 DAS/DAT significantly higher dry weight (21.17 g hill^{-1}) was recorded in MTU 1010 genotype. However, at 90 DAS/DAT *Araigutta* and IR 64 genotypes were statistically at par with MTU 1010 genotype. At all stages significantly highest, CGR (38.72 g m^{-2} day^{-1}) was observed in *Luchai* genotype. However, *Bhadochinga* and *Safari* genotypes were statistically at par with *Luchai* genotype. Highest RGR (0.20 g g^{-1} day^{-1}) was recorded in MTU 1010 genotype followed by *Araigutta* genotype (0.19 g g^{-1} day^{-1}).

B. Yield, quality parameters and economics

Among the genotypes, except number of grains panicle^{-1} did not significantly varied. However, regardless the yield traits indigenous genotypes perform well. The maximum panicle length, number of grains panicle^{-1} and test weight was recorded in *Araigutta* genotype. The highest grain yield and straw yield three values of 9.76 and 18.09 t ha^{-1}, 8.50 and 19.92 t ha^{-1}, 7.54 and 11.92 t ha^{-1} was observed in the *Luchai* genotype followed by *Araigutta* then *Safari* genotypes. Highest harvest index was observed in the *Safari* genotype.

The maximum protein content was recorded in the indigenous genotypes (*Luchai*, *Bhadochinga*, *Araigutta* and *Safari*), which was 4.26 to 5.09% higher compared to the lowest value in the IR 64 genotype. The highest carbohydrate content observed in MTU 1010 genotype. Indigenous genotype *Luchai* followed by *Araigutta* then *Safari* genotype recorded highest gross return (144.85 to 234.61%), net return (687.87 to 1117.78%) and benefit cost ratio (166 to 208.73%) when compare with lowest value in the IR 64 genotype.

Factor II: Methods of planting

A. Growth parameters

Highest plant height was observed in the conventional transplanted rice (CTR). Regarding methods of planting the higher number of tillers hill^{-1} was observed at 15 to 60 DAS/DAT in beushening puddled rice (BPR), which was 240.00 to 787.50% higher compare to lowest value. While at 75 and 90 DAS/DAT higher number of tillers hill^{-1} (15.50 and 10.40) observed in the system of rice intensification (SRI). Between the methods of planting significantly influence dry weight at 60, 75 and 90 DAS/DAS. At 60, 75 and 90 DAS/DAS significantly higher dry weight (6.68, 24.43 and 36.41 g plant^{-1} respectively) was recorded in system of rice intensification (SRI). 90 DAS/DAS significantly superior CGR (63.27 g m^{-2} day^{-1}) was registered in the direct seeded rice (DSR). At different interval highest RGR (0.18 g g^{-1} day^{-1}) was recorded at initial stage of growth at 15 DAS/DAT in the system of rice intensification (SRI).

B. Yield, quality parameters and economics

There was non-significant difference observed in the yield traits of rainfed rice, between the methods of planting. The maximum panicle length and test weight was recorded in conventional transplanted rice (CTR). The highest grain yield and number of grains panicle^{-1} and protein content was recorded in the system of rice intensification (SRI). However, the highest straw yield was recorded in the direct seeded rice (DSR). The highest harvest index was observed in beushening puddled rice (BPR).

The highest gross return and net return was recorded in the system of rice intensification (SRI). The maximum carbohydrate content and highest benefit cost ratio was recorded in the beushening puddled rice (BPR).

Factor III: Nutrient management

A. Growth parameters

Regardless the nutrient management, growth parameters *viz*., highest plant height, number of tillers hill^{-1}, dry weight, CGR and RGR was observed at most of the growth intervals in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*.

B. Yield, quality parameters and economics

It was recorded highest yield attributes *viz*., grains panicle^{-1}, test weight, grain yield and straw yield (128.50, 26.80 g, 5.31 t ha^{-1} and 11.78 t ha^{-1} respectively), as well as higher quality parameters *viz*., protein contain and carbohydrate contain (8.74% and 77.56% respectively) were recorded in the treatment 50 kg N ha^{-1} through FYM + 3% *matka khaad*.

The maximum gross return net return and benefit cost ratio (₹ 78155.00 ha^{-1}, ₹ 41425.00 ha^{-1} and 2.13 respectively) was recorded in the 50 kg N ha^{-1} through FYM + 3% *matka khaad*, which was 3.18, 15.42 and 12.10% higher compare to lowest value in the treatment 100 kg N ha^{-1} through urea + 25 kg zinc sulphate ha^{-1}.

CONCLUSION

It may be concluded that among the three factors, *viz*., genotypes, methods of planting and nutrient management was found to be best for obtaining grain yield, gross return, net return and benefit cost ratio in rainfed rice of Mandla. Since the findings are based on the research done in one season it may be repeated for confirmation.

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APPENDIX I

ANOVA TABLES

Factor I: Genotypes

ANOVA Table 1 Plant height (cm) of rice at 15 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.03	0.03	0.11	6.61	NS
Treatment	5	19.26	3.85	14.66	5.05	S
Error	5	1.31	0.26			
Total	11	20.61	1.87			

ANOVA Table 2 Plant height (cm) of rice at 30 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.03	0.03	0.11	6.61	NS
Treatment	5	19.26	3.85	14.66	5.05	S
Error	5	1.31	0.26			
Total	11	20.61	1.87			

ANOVA Table 3 Plant height (cm) of rice at 45 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.03	0.03	0.11	6.61	NS
Treatment	5	19.26	3.85	14.66	5.05	S
Error	5	1.31	0.26			
Total	11	20.61	1.87			

ANOVA Table 4 Plant height (cm) of rice at 60 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.03	0.03	0.11	6.61	NS
Treatment	5.	19.26	3.85	14.66	5.05	S
Error	5	1.31	0.26			
Total	11	20.61	1.87			

ANOVA Table 5 Plant height (cm) of rice at 75 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.03	0.03	0.11	6.61	NS
Treatment	5	19.26	3.85	14.66	5.05	S
Error	5	1.31	0.26			
Total	11	20.61	1.87			

ANOVA Table 6 Plant height (cm) of rice at 90 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.03	0.03	0.11	6.61	NS
Treatment	5	19.26	3.85	14.66	5.05	S
Error	5	1.31	0.26			
Total	11	20.61	1.87			

Factor II: Methods of planting

ANOVA Table 7 Plant height (cm) of rice at 15 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	7.29	7.29	1.80	10.13	NS
Treatment	3	17.88	5.96	1.47	9.28	NS
Error	3	12.15	4.05			
Total	7	37.32	5.33			

ANOVA Table 8 Plant height (cm) of rice at 30 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	2.98	2.98	0.21	10.13	NS
Treatment	3	29.14	9.71	0.67	9.28	NS
Error	3	43.19	14.40			
Total	7	75.31	10.76			

ANOVA Table 9 Plant height (cm) of rice at 45 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.37	0.37	0.01	10.13	NS
Treatment	3	42.14	14.05	0.55	9.28	NS
Error	3	76.87	25.62			
Total	7	119.39	17.06			

ANOVA Table 10 Plant height (cm) of rice at 60 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	74.08	74.08	1.30	10.13	NS
Treatment	3	52.08	17.36	0.30	9.28	NS
Error	3	170.94	56.98			
Total	7	297.10	42.44			

ANOVA Table 11 Plant height (cm) of rice at 75 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.07	0.07	0.0003	10.13	NS
Treatment	3	255.03	85.01	0.2950	9.28	NS
Error	3	864.41	288.13			
Total	7	1119.52	159.93			

ANOVA Table 12 Plant height (cm) of rice at 90 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	1.76	1.76	0.01	10.13	NS
Treatment	3	591.64	197.21	1.54	9.28	NS
Error	3	383.24	127.75			
Total	7	976.64	139.51			

Factor III: Nutrient management

ANOVA Table 13 Plant height (cm) of rice at 15 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	10.06	1.12	0.94	3.18	NS
Treatment	1	0.05	0.05	0.04	5.12	NS
Error	9	10.73	1.19			
Total	19	0.05	0.00			

ANOVA Table 14 Plant height (cm) of rice at 30 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	19.53	2.17	1.90	3.18	NS
Treatment	1	5.28	5.28	4.63	5.12	NS
Error	9	10.26	1.14			
Total	19	5.28	0.28			

ANOVA Table 15 Plant height (cm) of rice at 45 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	46.50	5.16	1.58	3.17	NS
Treatment	1	45.74	45.74	14.05	5.11	S
Error	9	29.28	3.25			
Total	19	45.74	2.40			

ANOVA Table 16 Plant height (cm) of rice at 60 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	253.65	28.18	1.32	3.18	NS
Treatment	1	11.16	11.16	0.52	5.12	NS
Error	9	192.53	21.39			
Total	19	11.16	0.59			

ANOVA Table 17 Plant height (cm) of rice at 75 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	1190.68	132.30	2.05	3.18	NS
Treatment	1	25.12	25.12	0.39	5.12	NS
Error	9	581.65	64.63			
Total	19	25.12	1.32			

ANOVA Table 18 Plant height (cm) of rice at 90 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	770.34	85.59	1.36	3.18	NS
Treatment	1	142.12	142.12	2.25	5.12	NS
Error	9	568.11	63.12			
Total	19	142.12	7.48			

Factor I: Genotypes

ANOVA Table 19 Number of tillers hill^{-1} of rice at 15 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.23	0.23	0.51	6.61	NS
Treatment	5	9.68	1.94	4.25	5.05	NS
Error	5	2.28	0.46			
Total	11	12.19	1.11			

ANOVA Table 20 Number of tillers hill^{-1} of rice at 30 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.64	0.64	0.69	6.61	NS
Treatment	5	49.98	10.00	10.89	5.05	S
Error	5	4.59	0.92			
Total	11	55.21	5.02			

ANOVA Table 21 Number of tillers hill^{-1} of rice at 45 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	1.02	1.02	0.28	6.61	NS
Treatment	5	94.44	18.89	5.10	5.05	S
Error	5	18.53	3.71			
Total	11	113.99	10.36			

ANOVA Table 22 Number of tillers hill^{-1} of rice at 60 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	3.59	3.59	0.51	6.61	NS
Treatment	5	98.40	19.68	2.77	5.05	NS
Error	5	35.48	7.10			
Total	11	137.47	12.50			

ANOVA Table 23 Number of tillers hill^{-1} of rice at 75 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	8.42	8.42	1.80	6.61	NS
Treatment	5	88.57	17.71	3.79	5.05	NS
Error	5	23.38	4.68			
Total	11	120.37	10.94			

ANOVA Table 24 Number of effective tillers hill^{-1} of rice at 90 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	3.93	3.93	2.49	6.61	NS
Treatment	5	42.62	8.52	5.39	5.05	S
Error	5	7.90	1.58			
Total	11	54.45	4.95			

Factor II: Methods of planting

ANOVA Table 25 Number of tillers hill^{-1} of rice at 15 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.25	0.25	0.20	10.13	NS
Treatment	3	8.40	2.80	2.27	9.28	NS
Error	3	3.69	1.23			
Total	7	12.34	1.76			

ANOVA Table 26 Number of tillers hill^{-1} of rice at 30 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	25.74	25.74	2.75	10.13	NS
Treatment	3	92.07	30.69	3.28	9.28	NS
Error	3	28.10	9.37			
Total	7	145.91	20.84496			

ANOVA Table 27 Number of tillers hill^{-1} of rice at 45 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	25.38	25.38	1.52	10.13	NS
Treatment	3	160.41	53.47	3.19	9.28	NS
Error	3	50.21	16.74			
Total	7	236.00	33.71			

ANOVA Table 28 Number of tillers hill^{-1} of rice at 60 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	51.26	51.26	3.21	10.13	NS
Treatment	3	148.24	49.41	3.09	9.28	NS
Error	3	47.90	15.97			
Total	7	247.40	35.34			

ANOVA Table 29 Number of tillers hill^{-1} of rice at 75 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	3.78	3.78	0.17	10.13	NS
Treatment	3	194.74	64.91	2.89	9.28	NS
Error	3	67.42	22.47			
Total	7	265.95	37.99			

ANOVA Table 30 Number of effective tillers hill^{-1} of rice at 90 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	2.10	2.10	0.09	10.13	NS
Treatment	3	89.14	29.71	1.27	9.28	NS
Error	3	70.12	23.37			
Total	7	161.37	23.05			

Factor III: Nutrient management

ANOVA Table 31 Number of tillers hill^{-1} of rice at 15 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	2.89	0.32	1.62	3.18	NS
Treatment	1	3.02	3.02	15.20	5.12	S
Error	9	1.79	0.20			

Total	19	3.02	0.16			

ANOVA Table 32 Number of tillers hill^{-1} of rice at 30 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	42.81	4.76	3.65	3.18	S
Treatment	1	13.94	13.94	10.69	5.12	S
Error	9	11.73	1.30			
Total	19	13.94	0.73			

ANOVA Table 33 Number of tillers hill^{-1} of rice at 45 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	85.53	9.50	5.57	3.17	S
Treatment	1	37.62	37.62	22.07	5.11	S
Error	9	15.34	1.70			
Total	19	37.62	1.98			

ANOVA Table 34 Number of tillers hill^{-1} of rice at 60 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	50.40	5.60	2.61	3.17	NS
Treatment	1	22.54	22.54	10.51	5.11	S
Error	9	19.29	2.14			
Total	19	22.54	1.18			

ANOVA Table 35 Number of tillers hill^{-1} of rice at 75 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	75.32	8.37	1.33	3.18	NS
Treatment	1	18.62	18.62	2.97	5.12	NS
Error	9	56.46	6.27			
Total	19	18.62	0.98			

ANOVA Table 36 Number of effective tillers hill^{-1} of rice at 90 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	20.11	2.23	0.81	3.17	NS
Treatment	1	7.36	7.36	2.70	5.11	NS
Error	9	24.52	2.72			
Total	19	7.36	0.38			

Factor I: Genotypes

ANOVA Table 37 Plant dry weight (g) of rice at 15 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.0013	0.0013	2.3633	6.61	NS
Treatment	5	0.0034	0.0007	1.2481	5.05	NS
Error	5	0.0028	0.0006			
Total	11	0.0075	0.0007			

ANOVA Table 38 Plant dry weight (g) of rice at 30 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.53	0.53	21.03	6.61	S
Treatment	5	0.28	0.06	2.26	5.05	NS
Error	5	0.13	0.03			
Total	11	0.94	0.09			

ANOVA Table 39 Plant dry weight (g) of rice at 45 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.05	0.05	0.20	6.61	NS
Treatment	5	0.95	0.19	0.77	5.05	NS
Error	5	1.23	0.25			
Total	11	2.22	0.20			

ANOVA Table 40 Plant dry weight (g) of rice at 60 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.39	0.39	0.18	6.61	NS
Treatment	5	16.10	3.22	1.46	5.05	NS
Error	5	11.04	2.21			
Total	11	27.53	2.50			

ANOVA Table 41 Plant dry weight (g) of rice at 75 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	8.70	8.70	3.30	6.61	NS
Treatment	5	65.55	13.11	4.98	5.05	NS
Error	5	13.18	2.64			
Total	11	87.42	7.95			

ANOVA Table 42 Plant dry weight (g) of rice at 90 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.02	0.02	0.00	6.61	NS
Treatment	5	104.07	20.81	5.66	5.05	S
Error	5	18.40	3.68			
Total	11	122.49	11.14			

Factor II: Methods of planting

ANOVA Table 43 Plant dry weight (g) of rice at 15 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.004	0.004	1.844	10.13	NS
Treatment	3	0.354	0.118	56.581	9.28	S
Error	3	0.006	0.002			
Total	7	0.365	0.052			

ANOVA Table 44 Plant dry weight (g) of rice at 30 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	4.13	4.13	1.81	10.13	NS
Treatment	3	22.53	7.51	3.29	9.28	NS
Error	3	6.84	2.28			
Total	7	33.49	4.78			

ANOVA Table 45 Plant dry weight (g) of rice at 45 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.83	0.83	0.97	10.13	NS
Treatment	3	4.17	1.39	1.63	9.28	NS
Error	3	2.56	0.85			
Total	7	7.56	1.08			

ANOVA Table 46 Plant dry weight (g) of rice at 60 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	6.55	6.55	0.42	10.13	NS
Treatment	3	258.47	86.16	5.58	9.28	NS
Error	3	46.29	15.43			
Total	7	311.31	44.47			

ANOVA Table 47 Plant dry weight (g) of rice at 75 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	3.24	3.24	0.08	10.13	NS
Treatment	3	308.63	102.88	2.51	9.28	NS
Error	3	122.99	41			
Total	7	434.87	62.12			

ANOVA Table 48 Plant dry weight (g) of rice at 90 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	152.47	152.47	1.81	10.13	NS
Treatment	3	2927.02	975.67	11.60	9.28	S
Error	3	252.29	84.10			
Total	7	3331.78	475.96			

Factor III: Nutrient management

ANOVA Table 49 Plant dry weight (g) of rice at 15 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	0.0043	0.0005	1.5239	3.17	NS
Treatment	1	0.0001	0.0001	0.0120	5.11	NS
Error	9	0.0028	0.0003			
Total	19	0.0001	0.0001			

ANOVA Table 50 Plant dry weight (g) of rice at 30 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	1.98	0.22	2.10	3.18	NS
Treatment	1	0.05	0.05	0.43	5.12	NS
Error	9	0.95	0.11			
Total	19	0.05	0.00			

ANOVA Table 51 Plant dry weight (g) of rice at 45 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	1.60	0.17	2.30	3.17	NS
Treatment	1	0.08	0.08	1.14	5.11	NS
Error	9	0.69	0.07			
Total	19	0.08	0.004			

ANOVA Table 52 Plant dry weight (g) of rice at 60 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	12.50	1.39	1.19	3.18	NS
Treatment	1	0.63	0.63	0.54	5.12	NS
Error	9	10.49	1.17			
Total	19	0.63	0.03			

ANOVA Table 53 Plant dry weight (g) of rice at 75 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	25.82	2.87	1.38	3.18	NS
Treatment	1	1.47	1.47	0.71	5.12	NS
Error	9	18.67	2.07			
Total	19	1.47	0.08			

ANOVA Table 54 Plant dry weight (g) of rice at 90 DAS/DAT

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	39.27	4.36	0.82	3.17	NS
Treatment	1	23.15	23.15	4.38	5.11	NS
Error	9	47.53	5.28			
Total	19	23.15	1.21			

Factor I: Genotypes

ANOVA Table 55 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 0 to 15 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.03	0.03	1.01	6.61	NS
Treatment	5	0.89	0.18	5.45	5.05	S
Error	5	0.16	0.03			
Total	11	1.09	0.10			

ANOVA Table 56 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 15 to 30 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	10.98	10.98	2.82	6.61	NS
Treatment	5	57.74	11.55	2.97	5.05	NS
Error	5	19.47	3.89			
Total	11	88.19	8.02			

ANOVA Table 57 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 30 to 45 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.80	0.80	0.30	6.61	NS
Treatment	5	4.64	0.93	0.35	5.05	NS
Error	5	13.30	2.66			
Total	11	18.74	1.70			

ANOVA Table 58 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 45 to 60 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	39.07	39.07	4.06	6.61	NS
Treatment	5	27.72	5.54	0.58	5.05	NS
Error	5	48.16	9.63			
Total	11	114.95	10.45			

ANOVA Table 59 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 60 to 75 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	1.02	1.02	0.01	6.61	NS
Treatment	5	342.77	68.55	0.63	5.05	NS
Error	5	545.54	109.11			
Total	11	889.32	80.85			

ANOVA Table 60 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 75 to 90 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	8.80	8.80	0.27	6.61	NS
Treatment	5	1173.32	234.66	7.17	5.05	S
Error	5	163.75	32.75			
Total	11	1345.87	122.35			

Factor II: Methods of planting

ANOVA Table 61 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 0 to 15 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.00	0.00	1.84	10.13	NS
Treatment	3	0.35	0.12	56.58	9.28	S
Error	3	0.01	0.00			
Total	7	0.36	0.05			

ANOVA Table 62 Crop Growth Rate (g m^{--2} day^{-1}) of rice at 15 to 30 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	4.13	4.13	1.81	10.13	NS
Treatment	3	22.53	7.51	3.29	9.28	NS
Error	3	6.84	2.28			
Total	7	33.49	4.78			

ANOVA Table 63 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 30 to 45 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.83	0.83	0.97	10.13	NS
Treatment	3	4.17	1.39	1.63	9.28	NS
Error	3	2.56	0.85			
Total	7	7.56	1.08			

ANOVA Table 64 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 45 to 60 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	6.55	6.55	0.42	10.13	NS
Treatment	3	258.47	86.16	5.58	9.28	NS
Error	3	46.29	15.43			
Total	7	311.31	44.47			

ANOVA Table 65 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 60 to 75 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	3.24	3.24	0.08	10.13	NS
Treatment	3	308.63	102.88	2.51	9.28	NS
Error	3	122.99	41.00			
Total	7	434.87	62.12			

ANOVA Table 66 Crop Growth Rate (g $m^{-2}$$day^{-1}$) of rice at 75 to 90 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	152.47	152.47	1.81	10.13	NS
Treatment	3	2927.02	975.67	11.60	9.28	S
Error	3	252.29	84.10			
Total	7	3331.78	475.97			

Factor III: Nutrient management

ANOVA Table 67 Crop Growth Rate (g $m^{-2}day^{-1}$) of rice at 0 to 15 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	0.09	0.01	0.91	3.18	NS
Treatment	1	0.59	0.59	52.49	5.12	S
Error	9	0.10	0.01			
Total	19	0.59	0.03			

ANOVA Table 68 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 15 to 30 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	100.69	11.19	0.97	3.18	NS
Treatment	1	9.53	9.53	0.83	5.12	NS
Error	9	103.69	11.52			
Total	19	9.53	0.50			

ANOVA Table 69 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 30 to 45 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	4.940	0.548	0.505	3.17	NS
Treatment	1	0.066	0.066	0.061	5.11	NS
Error	9	9.771	1.085			
Total	19	0.066	0.003			

ANOVA Table 70 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 45 to 60 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	126.68	14.07	1.05	3.17	NS
Treatment	1	9.21	9.21	0.69	5.11	NS
Error	9	119.64	13.29			
Total	19	9.21	0.48			

ANOVA Table 71 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 60 to 75 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	2495.03	277.23	1.20	3.18	NS
Treatment	1	21.45	21.45	0.09	5.12	NS
Error	9	2085.28	231.70			
Total	19	21.45	1.13			

ANOVA Table 72 Crop Growth Rate (g m^{-2} day^{-1}) of rice at 75 to 90 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	1420.47	157.83	0.78	3.17	NS
Treatment	1	1.90	1.90	0.01	5.11	NS
Error	9	1818.64	202.07			
Total	19	1.90	0.10			

Factor I: Genotypes

ANOVA Table 73 Relative Growth Rate (g g^{-1} day^{-1}) of rice at 15 to 30 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.004	0.004	1.366	6.610	NS
Treatment	5	0.004	0.001	0.263	5.050	NS
Error	5	0.015	0.003			
Total	11	0.023	0.002			

ANOVA Table 74 Relative Growth Rate (g g^{-1} day^{-1}) of rice at 30 to 45 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.01	0.01	0.66	6.61	NS
Treatment	5	0.03	0.01	0.67	5.05	NS
Error	5	0.05	0.01			
Total	11	0.09	0.01			

ANOVA Table 75 Relative Growth Rate (g g^{-1} day^{-1}) of rice at 45 to 60 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.006	0.006	1.822	6.610	NS
Treatment	5	0.015	0.003	0.879	5.050	NS
Error	5	0.017	0.003			
Total	11	0.038	0.003			

ANOVA Table 76 Relative Growth Rate (g g^{-1} day^{-1}) of rice at 60 to 75 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.0003	0.0003	1.8358	6.61	NS
Treatment	5	0.0015	0.0003	1.8826	5.05	NS
Error	5	0.0008	0.0002			
Total	11	0.0025	0.0002			

ANOVA Table 77 Relative Growth Rate (g g^{-1} day^{-1}) of rice at 75 to 90 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.0018	0.0018	10.3456	6.61	S
Treatment	5	0.0012	0.0002	1.3551	5.05	NS
Error	5	0.0009	0.0002			
Total	11	0.0039	0.0004			

Factor II: Methods of planting

ANOVA Table 78 Relative Growth Rate (g g^{-1} day^{-1}) of rice at 15 to 30 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.0012	0.0012	0.2274	10.13	NS
Treatment	3	0.0066	0.0022	0.4082	9.28	NS
Error	3	0.0161	0.0054			
Total	7	0.0239	0.0034			

ANOVA Table 79 Relative Growth Rate (g g^{-1} day^{-1}) of rice at 30 to 45 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.0001	0.0001	0.0019	10.13	NS
Treatment	3	0.0151	0.0050	0.9147	9.28	NS
Error	3	0.0165	0.0055			
Total	7	0.0316	0.0045			

ANOVA Table 80 Relative Growth Rate (g $g^{-1}$$day^{-1}$) of rice at 45 to 60 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.0003	0.0003	0.7767	10.13	NS
Treatment	3	0.0085	0.0028	7.3530	9.28	NS
Error	3	0.0012	0.0004			
Total	7	0.0099	0.0014			

ANOVA Table 81 Relative Growth Rate (g g^{-1} day^{-1}) of rice at 60 to 75 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.0001	0.0001	0.0185	10.13	NS
Treatment	3	0.0007	0.0002	1.2680	9.28	NS
Error	3	0.0005	0.0002			
Total	7	0.0012	0.0002			

ANOVA Table 82 Relative Growth Rate (g g^{-1} day^{-1}) of rice at 75 to 90 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.0001	0.0001	0.5515	10.13	NS
Treatment	3	0.0013	0.0004	2.0383	9.28	NS
Error	3	0.0006	0.0002			
Total	7	0.0021	0.0003			

Factor III: Nutrient management

ANOVA Table 83 Relative Growth Rate (g $g^{-1}day^{-1}$) of rice at 15 to 30 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	0.026	0.003	1.334	3.179	NS
Treatment	1	0.001	0.001	0.585	5.117	NS
Error	9	0.019	0.002			
Total	19	0.001	0.000			

ANOVA Table 84 Relative Growth Rate (g $g^{-1}day^{-1}$) of rice at 30 to 45 DAS/DAT interval

SV	Df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	0.011	0.001	0.972	3.17	NS
Treatment	1	0.005	0.005	4.142	5.11	NS
Error	9	0.011	0.001			
Total	19	0.005	0.001			

ANOVA Table 85 Relative Growth Rate (g $g^{-1}day^{-1}$) of rice at 45 to 60 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	0.00226	0.00025	1.10245	3.17889	NS
Treatment	1	0.00030	0.00030	1.31530	5.11736	NS
Error	9	0.00205	0.00023			
Total	19	0.00030	0.00002			

ANOVA Table 86 Relative Growth Rate (g g^{-1} day^{-1}) of rice at 60 to 75 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	0.0020	0.0002	1.2128	3.17	NS
Treatment	1	0.0003	0.0003	1.5646	5.11	NS
Error	9	0.0017	0.0002			
Total	19	0.0003	0.0001			

ANOVA Table 87 Relative Growth Rate (g g $^{-1}$ day^{-1}) of rice at 75 to 90 DAS/DAT interval

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	0.0018	0.0002	1.2690	3.1789	NS
Treatment	1	0.0001	0.0001	0.1247	5.1174	NS
Error	9	0.0014	0.0002			
Total	19	0.0000	0.0000			

Factor I: Genotypes

ANOVA Table 88 Panicle length (cm) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	1.46	1.46	0.46	6.61	NS
Treatment	5	12.51	2.50	0.80	5.05	NS
Error	5	15.71	3.14			
Total	11	29.68	2.70			

Factor II: Methods of planting

ANOVA Table 89 Panicle length (cm) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.81	0.81	0.45	10.13	NS
Treatment	3	16.72	5.57	3.05	9.28	NS
Error	3	5.48	1.83			
Total	7	23.01	3.29			

Factor III: Nutrient management

ANOVA Table 90 Panicle length (cm) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	28.01	3.11	0.79	3.18	NS
Treatment	1	1.51	1.51	0.38	5.12	NS
Error	9	35.50	3.94			
Total	19	1.51	0.08			

Factor I: Genotypes

ANOVA Table 91 Number of grains panicle^{-1} of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	430.00	430.00	10.61	6.61	S
Treatment	5	1080.73	216.15	5.33	5.05	S
Error	5	202.68	40.54			
Total	11	1713.41	155.76			

Factor II: Methods of planting

ANOVA Table 92 Number of grains panicle^{-1} of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	16.53	16.53	0.43	10.13	NS
Treatment	3	439	146.33	3.85	9.28	NS
Error	3	114.09	38.03			
Total	7	569.63	81.38			

Factor III: Nutrient management

ANOVA Table 93 Number of grains panicle^{-1} of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	801.02	89.00	1.22	3.18	NS
Treatment	1	16.20	16.20	0.22	5.12	NS
Error	9	657.36	73.04			
Total	19	16.20	0.85			

Factor I: Genotypes

ANOVA Table 94 Test weight (g) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	5.14	5.14	3.58	6.61	NS
Treatment	5	8.44	1.69	1.18	5.05	NS
Error	5	7.17	1.43			
Total	11	20.75	1.89			

Factor II: Methods of planting

ANOVA Table 95 Test weight (g) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	0.26	0.26	0.08	10.13	NS
Treatment	3	1.65	0.55	0.17	9.28	NS
Error	3	9.84	3.28			
Total	7	11.75	1.68			

Factor III: Nutrient management

ANOVA Table 96 Test weight (g) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	14.05	1.56	1.89	3.18	NS
Treatment	1	0.08	0.08	0.10	5.12	NS
Error	9	7.44	0.83			
Total	19	0.08	0.00			

Factor I: Genotypes

ANOVA Table 97 Grain yield (t ha^{-1}) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	18.61	18.61	0.97	6.61	NS
Treatment	5	84.05	16.81	0.87	5.05	NS
Error	5	96.30	19.26			
Total	11	198.96	18.09			

Factor II: Methods of planting

ANOVA Table 98 Grain yield (t ha^{-1}) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	2.93	2.93	2.22	10.13	NS
Treatment	3	0.54	0.18	0.14	9.28	NS
Error	3	3.96	1.32			
Total	7	7.43	1.06			

Factor III: Nutrient management

ANOVA Table 99 Grain yield (t ha^{-1}) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	166.43	18.49	7.53	3.18	S
Treatment	1	0.06	0.06	0.03	5.12	NS
Error	9	22.11	2.46			
Total	19	0.06	0.00			

Factor I: Genotypes

ANOVA Table 100 Straw yield (t ha^{-1}) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	94.30	94.30	1.71	6.61	NS
Treatment	5	332.94	66.59	1.21	5.05	NS
Error	5	275.40	55.08			
Total	11	702.64	63.87			

Factor II: Methods of planting

ANOVA Table 101 Straw yield (t ha^{-1}) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	3.31	3.31	1.28	10.13	NS

Treatment	3	25.16	8.39	3.25	9.28	NS
Error	3	7.75	2.58			
Total	7	36.22	5.17			

Factor III: Nutrient management

ANOVA Table 102 Straw yield (t ha^{-1}) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	454.55	50.51	3.82	3.18	S
Treatment	1	4.13	4.13	0.31	5.12	NS
Error	9	119.08	13.23			
Total	19	4.13	0.22			

Factor I: Genotypes
ANOVA Table 103 Harvest index (%) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	5.55	5.55	0.16	6.61	NS
Treatment	5	342.27	68.45	1.92	5.05	NS
Error	5	178.58	35.72			
Total	11	526.40	47.85			

Factor II: Methods of planting
ANOVA Table 104 Harvest index (%) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	1	22.51	22.51	0.22	10.13	NS
Treatment	3	196.73	65.58	0.64	9.28	NS
Error	3	305.47	101.82			
Total	7	524.71	74.96			

Factor III: Nutrient management

ANOVA Table 105 Harvest index (%) of rice

SV	df	SS	MSS	F Cal	F Tab (5%)	Result
Replication	9	420.70	46.74	6.96	3.18	S
Treatment	1	4.78	4.78	0.71	5.12	NS
Error	9	60.46	6.72			
Total	19	4.78	0.25			

Appendix II- a

Cost of different genotypes, methods of planting and nutrient management of rice (fixed cost for all treatments)

S. No.		Particulars	Unit	Qty.	Rate unit^{-1} (₹)	Cost (₹ ha^{-1})
1		Land preparation				
	a	Ploughing and planking	Bullocks	15	300.00	4500.00
	b	Layout	Labour	14	135.00	1890.00
2		Interculture				
	a	Gap filling and thinning	Labour	3	135.00	405.00
3		Plant protection measures				
	a	Neem oil spray (1%)	Liter	6	45.00	270.00
4		Foliar spray of $ZnSO_4$ (0.3%)	kg	2	105.00	210.00
5		Harvesting and threshing	Labour	18	135.00	2430.00
6		Rental value of land	Months	5	650.00	3250.00
7		Supervision charge	Months	5	1200.00	6000.00
8		Transport charges	Truck	2	2000.00	2000.00
					Total fixed cost =	20955.00

Appendix II- b

Variable cost for different genotypes, methods of planting and nutrient management of rice

Treatments	Ploughing and planking ₹ ha^{-1}	Seed [@ ₹ 45/65 kg^{-1}] ₹ ha^{-1}	Transplanting/Sowing cost ₹ ha^{-1}	Interculture hand weeding (2 times)	FYM (10 t ha^{-1}) @ 100 t^{-1}	Urea 217.39 kg ha^{-1} @ ₹ 10 kg^{-1}	Zinc Sulphate (25 kg ha^{-1}) @ ₹ 105 kg^{-1}	*Gomutra* culture 3% @ 2 l^{-1} totals 600 l. (4 times)	Total variable cost
Genotypes									
Luchai	2100.00	4500.00	1500.00	6000.00	1000.00			1200.00	16300.00
Bhadochinga	2100.00	1575.00	1500.00	6000.00	1000.00			1200.00	13375.00
Araigutta	2100.00	1575.00	1500.00	6000.00	1000.00			1200.00	13375.00
Safari	2100.00	1575.00	1500.00	6000.00		2173.90	2625		15973.90
MTU 1010	2100.00	2275.00	1500.00	6000.00	1000.00			1200.00	14075.00
IR 64	2100.00	2275.00	1500.00	6000.00	1000.00			1200.00	14075.00
Methods of planting									
DSR		4500.00		4000.00	1000.00			1200.00	10700.00
BPR		5200.00		1400.00	1000.00			1200.00	8800.000
CTR		2275.00	1500.00	6000.00	500.00	1086.95	1312.50	600.00	13274.50
SRI		270.000	1600.00	6500.00	1000.00			1200.00	10570.00
Nutrient management									
N_1	2100.00	4500.00	1500.00	6000.00	1000.00			1200.00	16300.00
N_2	2100.00	4500.00	1500.00	6000.00		2173.90	2625.00		18898.90

DSR: Direct seeded rice, BPR: Beushening puddled rice, CTR: Conventional transplanted rice, SRI: System of rice intensification;
N_1: 50 kg N ha^{-1} through FYM + 3% *Gomutra* culture, 100 kg N ha^{-1} through Urea + 25 kg Zinc Sulphate ha^{-1}
Ploughing 7 pair bullocks @ ₹ 300; Seed rate: (i) SRI @ 6 kg ha^{-1}, (ii) BPR @ 80 kg ha^{-1}, (iii) CTR @ 35 kg ha^{-1}, (iv) DSR @ 100 kg ha^{-1}