STUDIES ON INTEGRATED NUTRIENT MANAGEMENT IN DIRECT SEEDED RICE (*Oryza sativa* L.)

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
In partial fulfilment of the requirements
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MASTER OF SCIENCE
IN
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By
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Enrolment Number - OO-1234 **2022**

DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the thesis entitled "**STUDIES ON INTEGRATED NUTRIENT MANAGEMENT IN DIRECT SEEDED RICE (*Oryza sativa* L.) "** or part thereof has neither been submitted for any other degree or diploma of any University nor the data have been derived from any thesis / publication of any University or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

Place: Nagpur (**WALUKAR SHUBHAM GAJANAN)**

Date**: 28 / 12 / 2022** **Enrolment No. OO-1234**

CERTIFICATE

This is to certify that thesis entitled "**STUDIES ON INTEGRATED NUTRIENT MANAGEMENT IN DIRECT SEEDED RICE (*Oryza sativa L.*)"** submitted in partial fulfillment of the requirement for the degree of **Master of Science in Agriculture (Agronomy)** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **WALUKAR SHUBHAM GAJANAN** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

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Date: 28 / 12 / 2022

(Dr. Usha R.Dongarwar)
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THESIS APPROVED BY THE STUDENT'S ADVISORY COMMITTEE INCLUDING EXTERNAL EXAMINER (AFTER VIVA-VOCE)

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(C) ABBREVIATIONS

%	:	Per cent
@	:	At the rate
^{0} C	:	Degree celcius
B:C ratio	:	Benefit: cost ratio
C D	:	Critical difference
cm	:	Centimeter
DAP	:	Di-ammonium phosphate
DAS	:	Days after sowing
day^{-1}	:	Per day
$dS\ m^{-1}$	:	deci Siemens per meter
EC	:	Electrical conductivity
et al.	:	Et alia (and associates)
eve.	:	Evening
Fig.	:	Figure
g	:	Gram
GM	:	General mean
GMR	:	Gross monetary returns
ha	:	Hectare
ha^{-1}	:	Per hectare
HI	:	Harvest index
i.e.	:	That is
K / K_2O	:	Potassium
kg	:	Kilogram
kg^{-1}	:	Per kilogram
KNO_3	:	Potassium nitrate

m ha	:	Million hectare
m t	:	Million tonne
m	:	Metre
m	:	Million
mm	:	Millimeter
m^2	:	Metre square
MAP	:	Mono ammonium phosphate
Max.	:	Maximum
Met.	:	meteorological
Min.	:	Minimum
MOP	:	Muriate of potash
mor.	:	Morning
MPP	:	Mono potassium phosphate
MSL	:	Mean Sea level
N	:	Nitrogen, North
NS	:	Non-significant
NAA	:	Naphthalic acetic acid
NMR	:	Net monetary returns
No. / no.	:	Number
P / P_2O_5	:	Phosphorus
$plant^{-1}$	:	Per plant
q	:	quintal
R	:	Replication
RDF	:	Recommended dose of fertilizer
RH	:	Relative humidity
Rs.	:	Rupees

SE (m)	:	Standard error of mean
SSP	:	Single super phosphate
T	:	Treatment
Temp.	:	Tempreture
viz.	:	Namely
WSF	:	Water soluble fertilizers
$Year^{-1}$	:	Per year

(D) THESIS ABSTRACT

a)	Title of the thesis	:	**STUDIES ON INTEGRATED NUTRIENT MANAGEMENT IN DIRECT SEEDED RICE(*Oryza sativa* L.)**
b)	Full name of student	:	**Walukar Shubham Gajanan**
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d)	Degree to be awarded	:	M.Sc. (Agriculture)
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ABSTRACT

A field experiment entitled Studies on "Integrated nutrient management in direct seeded rice (*Oryza sativa* L)" was conducted at Agronomy Farm, College of Agriculture, Nagpur during *kharif* season of 2021.

Rice *var.* PDKV Sadhana was sown on clay soil, low in available nitrogen, very low in available phosphorus, very high in available potassium, medium in organic carbon and slightly alkaline in reaction. The experiment was laid out in randomized block design with nine treatments replicated thrice. The treatments consisted of T_1 - 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}), T_2 - 100% RDF(125:62.5:62.5 kg NPK ha^{-1}), T_3 - 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}), T_4 - 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t $ha^{-1}$$T_5$ - 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}, T_6 - 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}, T_7 - 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter, T_8 - 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter T_9 - 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter.

Application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9)recorded significantly higher plant height (cm), number of tillers $plant^{-1}$and dry matter accumulation $plant^{-1}$(g).

Yield attributing character *viz*., number of panicles $plant^{-1}$, grain yield $plant^{-1}$ (g) and straw yield $plant^{-1}$ (g) along with grain and straw yield (kg ha^{-1}) and harvest index (%) of rice were also significantly higher with application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9).

In case of protein content in seed (%), the highest protein content recorded in application 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter(T_9) and lowest in 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

Gross monetary returns (Rs ha^{-1}), net monetary returns(Rs ha^{-1}) and B: C ratio were found significantly highest with application 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9).

Chapter I

INTRODUCTION

Rice is the second most widely consumed cereal in the world next to wheat. It is the staple food for two third of the world's population. Among the cereal crops, it serves as the principal source of nourishment for over half of the global population, especially for south-eastern Asia, where 90% of the world production of rice is grown and consumed. It plays a vital role in our national food security, hence, the slogan 'Rice is Life' is most appropriate. In India, rice is cultivated under varied situations that is from below sea level (Kerala) to about 200 m altitude (Himalayan region) from 8°N latitude (Kanyakumari) to 35°N latitude (Kashmir) in annual rainfall from 1250 mm (Assam) to 250 mm (Rajasthan) from sandy loam soils to heavy black cotton soils and from normal to saline alkaline soils.

Rice (*Oryza sativa* L.*)* belongs to poaceae family and genus *oryza* with chromosome number i.e., 2n = 24. Rice is a crop of wet tropical climate and also grown in humid regions of subtropics. It is C3, self-pollinated crop. It is a high caloric food, which contains 75% starch, protein 6-7 % in white rice and 7-9 % in brown rice, 2-2.5 % fat, 0.8% cellulose and 5-9% ash. Rice is an excellent source of carbohydrates and to a certain extent it provides protein to regular human diet. Further, rice has commercial and industrial importance also beside grains,rice straw and rice hulls are used as fodder, mulching, packing and as insulation material etc.

In worldwide, rice is cultivated over an area of about 158.80 million hectares with an annual production of about 700.00 million tones and an average productivity of 4.20 tones per hectare. India occupies a pride place in rice production among the food crops cultivated in the world. India ranks first in area and second in production after China. In India, it is grown over an area of 43.79 million hectares having production of 115.60 million tonnes and average productivity of 2578 kg ha^{-1}. The area under rice cultivation is maximum in Uttar Pradesh while West Bengal is top producing state and Punjab has highest productivity. In Maharashtra state of India, rice is cultivated on 15.13 lakh hectares area in nearly all four regions named Vidharbha (7.95 lakh ha.), Konkan (3.83 lakh ha.), Western Maharashtra (3.23 lakh ha.) and Marathwada (0.12 lakh ha.) with annual production of 41.71 lakh tons un milled and 28.78 lakh tons milled rice. The area (7.95 lakh ha.) and production (16.81 lakh tons un milled rice) of rice crop is more in Vidharbha region and highest productivity was observed in Konkan region (2.75 t ha^{-1}) (Economic survey of maharashtra 2022).

Integrated nutrient management (INM) has an important role which improves efficiency of applied nutrients, maintain rice productivity and production. The increasing demand for rice grain production has to be achieved by using an integration of organic and inorganic sources of fertilizers to maintain the sustainability in crop production (Datta and Singh, 2010).

Integrated nutrient management approach is flexible and minimises use of chemicals but maximise use efficiency and improve the soil health. To meet ever demand of increasing population Integrated nutrient management is the best option. INM has been shown to considerably improve rice yields by minimizing nutrient losses to the environment and managing the nutrient supply for high nutrient use efficiency (Parkinson 2013). Considerable improvement in grain quality of rice has been observed under integrated use of organic and inorganic sources of fertilizers as compared to RDF (recommended dose of fertilizers) applied with inorganic fertilizers.

One of the fastest and effective ways to recycle organic materials is vermicomposting by which the organic wastes can be vermi stabilized into vermicompost. Vermicomposting is an eco-biotechnological process that transforms energy rich and complex organic substances into a stabilized humus like product called vermicompost. In vermicomposting, the capacity of feeding and excretion of earthworms is exploited to degrade organic materials and convert it into high grade manures i.e. Vermicompost. Aristotle called earthworms the “intestine of earths” and considered them as agent to restore soil fertility.Nutrients present in worm casts are readily soluble in water and are easily available to plants. Vermicompost is rich source of macro- and micro-nutrients, vitamins, enzymes, antibodies, growth hormones and immobilized microflora (Bhawalker, 1991).

Vermicompost also stimulate plant growth and help in preventing plant diseases (Szczech and Brzeski, 1994; Surekha and Rao, 2000), besides increasing the quality of produce (Singh and Rai, 1998). The digested casts can be used to improve the fertility and physical characteristics of soil and potting media. The mucus associated with the cast being hygroscopic absorbs water and prevents waterlogging and improves water holding capacity.

Biofertilizer also known as microbial inoculants containing actively living cells of microorganisms used as an important component of INM that supplement fertilizer by biological nitrogen fixation and in addition liberate several growth promoting substances like IAA and GA.

1.1 Importance of Study

The low productivity of direct seeded rice is due to soil moisture stress at critical crop growth stage including drought, inadequate plant population and low nutrients status of soil are responsible for lowproductivity of rice in upland areas. Besides, cultivation is fully depend on monsoon with poor management and package of practices. Therefore,productivity of rice is considerably very low.

The cultivation of rice under upland conditions is subjected to different degrees of moisture stress, which affects plant growth (height), tillering capacity, less leaf area, higher sterility, delayed flowering andlower harvest ratio (grain-straw ratio). These factors contribute lower grainyield in upland rice areas. Low plant population in case of broadcast sowing method in rice result in uneven germination (upland and directseeded lowland). Therefore, the productivity of rice is low.

Since rice crop is taken in the area, the knowledge of cost, returnsand its profitability will be useful for the farmers who want to substitute this crop for the traditional transplanted crop grown in the area. The findings of study would be helpful to economic management of rice. Due to limitation and other resources, the study was restricted to limited aspects, hence the findings can not be generalized beyond the limits of the area of study.However, the findings may become applicable in the area where similar condition exist.

Proper nutrient management practices are the most effective means for increasing yield of rice. Farmers have achieved N, P and K efficiency, which still need to be augmented further to meet the challenges of increasing rice production with reduced input of fertilizer. Because of large field to field variability of soil nutrient supply, efficient use of nutrients applied as a fertilizer is not possible when large recommendation of fertilizers are used. Among many factors that influence fertilizer use efficiency, one of important factor is amount of fertilizer nutrient to be applied in a given field. Recovery efficiency of top-dressing urea during panicle initiation stage could be as high as 78%. The strategies for fertilizer management must also be responsive to temporal variation in crop nutrient demand to achieve supply-demand synchrony. When fertilizer application is not synchronized with crop demand, loss of nutrient from the soil-plant system are large, leading to low fertilizer use efficiency.

Nutrient management helps to restore and sustain soil fertility and crop productivity. It may also help to check the emerging deficiency of nutrient. It bring economy and efficiency in fertilizer use and favourably affect the physical, chemical and biological environment of soil, also helps to produce grain having high nutritional quality. Currently, decreasing soil fertility has also raised concerns about the sustainability of agriculture production. Future strategies for increasing agricultural productivity will have to focus on using available nutrient resources more effectively than in past. Integrated nutrient management is needed for proper plant growth, together with effective crop, water, soil and land management.

1.2 Objectives

1) To study the effect of integrated nutrient management on growth and yield of direct seeded rice.
2) To find out optimum nutrient requirement for higher yield of direct seeded rice.
3) To work out the economics.

1.3 Scope and limitations of study

Direct seeded rice is less labour intensive than transplanted paddy. Now a days, labour scarcity problem is everywhere during transplanting period. Due to delayed transplanting the yield significantly reduced due to lesser number of effective tillers, shorter panicle length and lesser number of grains panicle. Till now fertilizer doses mainly recommended for puddled paddy only, but for drilled paddy no such concrete recommendation is there. Therefore it is needed to explore broad spectrum concrete fertilizer dose for the drilled paddy.

New challenges are emerging in the world's upland rice farming areas, where already some of the world's poorest farmer try to wrest a living from fragile soils that are fast being degraded. Population growth, demand of urbanism and industry and increasing adoption of high value cash crop farming in the surrounding, lowlands are leading to strong competition to upland rice.

The major Constraints are:

1. Major constraints are water stress during the critical growth stages, which directly affect on growth and yield.
2. Rodent and termites were the problems encountered by some of the respondent area. Similarly, there were termite's problem in farmers field, especially during moisture stress period.
3. The first and foremost socioeconomic constraints raised by the respondent was requirement of heavy weed management.
4. In upland rice, there is no permission of supplementary irrigation, also low water retention of soil.
5. Deposition of nutrient at substrate due to infiltration and percolation.
6. Nutrient management is unbalanced and it results in low yields.

Upland rice mostly depends upon irrigation, that's why germination per cent is low in upland rice and due to low germination rate production is low as compare to lowland rice. In upland rice high input of human labour, fossil energy, fertilizer and herbicide is used and most important problem in upland rice is weed infestation. It is very difficult to control weed in upland rice.

Due to limitations and other resources, the study was restricted to limited aspects, hence the findings can not be generalized beyond the limits of the area of study. However, the findings may become applicable in the area where similar condition exist.

1.4 Hypothesis

Due to labour scarcity, higher cost of cultivation transplanted paddy replace by direct seeded rice. Direct seeded rice saves and minimises production cost.

Continuous use of inorganic fertilizers leads to deterioration in chemical, physical and biological properties and soil health (Mahajan *et al.* 2008).

Application of organic materials as fertilizers provides growth regulating substances and improves the physical, chemical and microbial properties of the soil Belay *et al*. (2001)

Rice plant heights with inorganic fertilizer and a complementary application of organic and inorganic fertilizers were observed to be similar and were significantly greater than those from sole organic fertilizer application. Comparable rice yield from both complementary application of organic and inorganic fertilizers and from sole inorganic fertilizer is a further indication that the nutrients supplied from the complementary application were effective enough to those supplied with sole inorganic fertilizer. A similar study on maize had reported grain yields from sole inorganic fertilizer and from complementary application of inorganic and organic fertilizers to be comparable and significantly higher than yields from sole organic fertilizer application (Makinde *et al.* 2001).

Complementary application of organic and inorganic fertilizers increase nutrient synchrony and reduces losses by converting inorganic nitrogen to organic forms Kramer *et al.* (2002).

The adoption of modern farming practices and integrated nutrient management are essential to produce crops in line with the observed global standards of quantity and quality. In present day high yielding cultivars, which have higher nutrient requirements, the use of inorganic fertilizers has increased considerably leading to decline in the use of organic materials (Hossain and Singh, 2000).

in order to make the soil well supplied with all the plant nutrients in the readily available form and to maintain good soil health, it is necessary to use organic manures in conjunction with inorganic fertilizers to obtain optimum yields (Ramalakshmi *et al.*2012)

Chapter II

REVIEW OF LITERATURE

2.1 Effect of recommended dose of fertilizer (RDF)

2.1.1 On growth attributes

Murali and Setty (2001) obtained significant increase in total dry matter production with the application of NPK up to 150-75-75 kg ha^{-1}at all the growth stages of rice.

Prasad *et al.*(2001) reported that the application of 100% recommended dose of nitrogen, phosphorus and potassium i.e. 80-40-20 $kgha^{-1}$ in rice obtained maximum plant height, number of tillers, leaf area index and dry weight over 50 and 75% of RDF.

Azad and Leheriya (2001) reported that the application of FYM at 10 t ha^{-1} combinations with fertilizers exhibited a significant increase in effective tillers m^{-2} row, grain, and straw yield of rice over fertilizer treatments alone.

Kundu and Kundu (2002) recorded maximum plant height, number of tillers and dry-matter accumulation with the application of 180-90-90 $kgha^{-1}$ NPK. Plant height, $tillershill^{-1}$ and leaf area index considerably increased with the application of 150-50-50 kgNPK $ha^{-1.}$

Banik and Bezbaruha (2004) conducted a field experiment on sandy loam soils of Giridhi and Jharkhand and concluded that application of recommended dose of fertilizer i.e. 45-13-25 kg $NPKha^{-1}$ registered significant increase in productive tillers m^{-2} of rice crop.

Singh *et al.* (2005) conducted an experiment at Srinagar to evaluate the effect of fertilizer levels (control, 50-25-12.5, 100-50-25, 150-75-37.5 and 200-100-50 kg $NPKha^{-1}$) on the growth of rice seedlings and result revealed that fresh weight, dry weight and growth of seedlings increased significantly with increasing NPK levels up to 200-100-50 kg $NPKha^{-1}$.

Mankotia (2007) reported that application of 5 tonnes FYM ha^{-1} + 50% NPK gave significantly taller rice plants on silty loam soils.

Mubarak (2008) conclude that significantly higher values of growth parameters in hybrid rice cultivars i.e. PHB-71, KRH-2, and CNHR-3 was found with N-P-K).

Raikar *et al.* (2009) reported that 50% RDN through farmyard manure + 50:50:50 kg NPK ha^{-1} resulted in the highest plant height at 30, 60 and 90 days after transplanting and during harvesting i.e. 32.3, 66.2, 69.3 and 71.8 cm respectively.

Devi and Manimaran (2012) reported that the significantly higher plant height, number of tillers m^2 and DMP was recorded in treatments applied with 25% N through effective microorganism inoculated poultry manure compost + 75% recommended dose of fertilizer N.

Saidu *et al.* (2012) revealed that the application of 80 kg N ha^{-1} resulted in highest plant height at 60 DAS and 90 DAS.

Priyanka *et al.* (2013) conducted a field experiment to find out the effect of integrated nutrient management and spacing on productivity and economics of rice under system of rice intensification (SRI) in Palampur, Himachal Pradesh during Kharif 2009-10 and revealed that the dry matter accumulation per plant at 120 DAT was highest (23.5 g) with the application of FYM @ 20 tha^{-1} and was followed by (22.3 g) with FYM application @ 10 $tha^{-1}$and lowest (18.5 g) was observed when no FYM was applied.

Sakariyawo *et al.* (2013) reported that the inorganic fertilizer source at recommended rate recorded significantly ($P <0.05$) higher effect on all growth parameters compared to organic sources. Growth characters and grain yield were significantly higher at higher application rates of poultry and swine manure comparative to inorganic fertilizers at recommended rate.

Nagendra (2015) reported the application of 100% RDF recorded significantly maximum plant height and highest number of tillersbut, it was on par with 100% RDF + 50% VC (353) and 75% RDF + 25% VC . The lowest number tillers m^{-2} was recorded in control.

Awang *et al.* (2016) revealed that the poultry manure of 20 t ha^{-1} produced the highest plant height (127.75 cm), culm height and dry weight (464.44 g) in rice .

Moe *et al.* (2017) reported that the poultry manure at 5 t ha^{-1} produced the best growth parameters including total dry matter, yield, and yield components. Combining inorganic and organic fertilizers demonstrated that 50% NPK together with poultry manure (5 t ha^{-1}) provided similar growth paramerers, total dry matter, and yield parameters to 100% NPK.

Verma *et al.* (2017) revealed that the maximum value of numbers of tillers $hill^{-1}$, plant height (cm), dry matter accumulation (g $plant^{-1}$), number of days to panicle initiation and days taken to physiological maturity were recorded under 150% RDF (180:90:90 kg NPK ha^{-1}) + 25 kg zinc sulphate and it was recorded maximum growth attributes, grain and straw yield.

Chavan *et al*. (2017) conducted afield investigation during *kharif* season of 2015-2016 at Agronomy farm of Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli to study the influence of nutrient management on yield and economics of upland drilled rice (*Oryza sativa* L.). and revealed that application of 150% RDF recorded significantly higher grain yield, straw yield and net returns followed by 125% RDF, 100% RDF and 75% RDF.

Akter *et al.* (2020) conducted the experiment at Rahmatpur, Barishal, during the period from April, 2020 to August, 2020 to investigate the effect of nitrogen on the yield of transplanted Aus rice cv. Binadhan-19. The experiment comprised four levels of nitrogen viz (a) N_0 (zero nitrogen), (b) N_1 (90 kg N ha^{-1}), (c) N_2 (110 kg N ha^{-1}) and

(d) N_3 (130 kg N ha^{-1}). and results revealed that plant height, effective tiller, non-effective tiller, flag leaf length, filled grain, unfilled grain and 1000 grain weight were increased with increasing nitrogen doses till 110 kg N ha^{-1}. Furthermore, the highest grain weight was recorded in 110 kg N ha^{-1} due to superior performance of yield contributing characters of Binadhan-19.

2.1.2 On yield attributes and yield.

Chaunabasappa *et al.* (1998) reported that the application of 150-75-75 $kgha^{-1}$N-P_2O_5-K_2O in rice cv. IR-64 significantly increased the panicles/m^2, grain and straw yield.

Setty *et al.* (1999). revealed that application of recommended NPK level (100-60-40 kg $NPKha^{-1}$) produced significantly higher $paniclesm^{-2}$, panicle weight, grain and straw yield as compared with their lower rates of application.

Singh and Jain (2000) studied the morpho-physiological analysis of growth and yield in traditional and improved rice cultivars grown at moderate (100-50-40 $kgha^{-1}$ NPK) and high NPK levels (200-100-80 $kgha^{-1}$ NPK) and reported that high level of NPK fertilization in all rice cultivars gave significantly higher economic and biological $productivityha^{-1}$, panicles m^{-2}, grain and straw yields. However, grains $panicle^{-1}$was reduced drastically under high level of NPK.

Prasad *et al.* (2001) registered that the highest panicles m^{-2}, filled grains $panicle^{-1}$, test weight , grain and straw yield was obtained with recommended NPK application (80-40-20 N-P-K $kgha^{-1}$) in transplanted rice over 50% and 75% of recommended NPK.

Begum *et al.* (2001) investigated the application of poultry manure alone or in combination with urea-N significantly increased the panicle length, numbers of grains $panicle^{-1}$ and filled grain per panicle, whereas, test weight varied nonsignificantly.

Dikshit and Khatik (2002) revealed that application of 10 t FYM ha^{-1} gave significantly highest seed yield (14.30 q ha^{-1}) and straw yield (28.30 q ha^{-1}) compared to control (13.05 q ha^{-1} and 26.55 q ha^{-1}respectively) in rice.

Kumar and Prasad (2002) observed that significant increase in the yields of grain and straw of rice was obtained up to recommended level of 100-50-50 kgNPKha^{-1}.

Kundu and Kundu (2002) recorded higher panicles per unit area as well as a higher percentage of filled grains $panicle^{-1}$ and yield with 150% of the recommended fertilizer (180-90-90 kg NPKha^{-1}).

Subbaiah *et al.* (2002) reported that rice hybrid KRH-2 recorded the maximum grain yield at 150-60-80 NPK kgha^{-1}whereas, the high yielding varieties gave best result at 150-60-40 kgha^{-1}.

Upadhyay *et al.* (2002) observed significant increase in the yields of rice grain and straw with the application of 125-75-50 kg NPKha^{-1}.

Usman *et al.* (2003) investigated that the application of NPK at 50: 37.5: 30 Kgha^{-1} along with poultry manure at 20 t ha^{-1} produced maximum number of tillers $hill^{-1}$, number of grains $panicle^{-1}$, test weight and straw yield which was at par with NPK at 50: 37.5: 30 kg ha^{-1}along with FYM at 20 t $ha^{-1}$was applied.

Banik and Bezbaruha (2004) conducted a field experiment on sandy loam soils of Giridih, Jharkhand and concluded that significant increase in filled grains $panicles^{-1}$, test weight and grain yield of rice crop was found with the application of recommended dose of fertilizer i.e. 45-13-25 kg NPKha^{-1}.

Swarup and Yaduvanshi (2013) reported the long term effect of sodic irrigation water with organic (FYM) and inorganic (NPK) on the soil properties and yield of rice. The treatment comprised with 120 kg N

+ 26 kg P + 42 kg K + 10 t FYM ha^{-1}gave the highest mean rice grain yield (5.41 t ha^{-1}).

Krishnakumar *et al.* (2005) stated that application of FYM + neem cake gave significantly higher grain yield (5675 kg ha^{-1}, 5175 kg ha^{-1}) and straw yield (6520 kg ha^{-1}, 6020 kg ha^{-1}) in rice during *kharif* and *rabi* at TNAU, Coimbatore.

Mandal *et al.* (2005) reported that the effective tillers hill^{-1}, number of grains panicle^{-1}, test weight and grain yield of rice were significantly higher with the treatment receiving 50% N through chemical fertilizer and 50% N through FYM followed by the treatment receiving 75% N through chemical fertilizer and 25% N through FYM. However, highest straw yield with the treatment receiving 75% N through chemical fertilizer and 25% N through FYM was also reported by authors.

Uma Shankar *et al.* (2005) reported that enriched FYM + neem cake blended urea + potassium in combination with seed soaking of Penshibao and Azospirillum favourably increased the yield attributes such as number of panicles m^{-2} (287.6), number of filled grains panicle^{-1}(108) of rice on clay soils at Annamalai University, Annamalai nagar.

Kumar *et al.* (2007) studied that the highest rice equivalent yield (37.62 qtha^{-1}) was recorded with 20 t PM ha^{-1} to preceding rice along with 100% RDF.

Kumar *et al.* (2008) reported that the application of 160 kg N and 60 kg K_2O ha^{-1} significantly influenced the growth, yield attributes of hybrid rice and produced higher grain and straw yield.

Singh *et al.* (2009) reported that application of 120-60-80 kgha^{-1}of NPK recorded significantly higher grain yield followed by 120-60-40 kg of NPK ha^{-1} in hybrid rice.

Raikar *et al.* (2009) reported that 50% RDN through farmyard manure + 50:50:50 NPK kg ha^{-1} resulted in the highest plant height as well as numbers of productive tillers (7.98), panicle length (25.54 cm) and numbers of branches panicles^{-1} (9.57).

Sangeetha *et al.*, (2010) investigated that application of enriched poultry manure compost recorded higher grain yield (4675 and 4953 kg ha^{-1} in 2007 and 2008, respectively), which was on par with composted poultry manure. The increase in grain yield due to enriched poultry manure compost was 7.7% during 2007 and 9.1% during 2008 over recommended NPK fertiliser on clay loam soils of Tamil Nadu.

Siavoshi (2010) studied that maximum grain yield in 2008 (4335.88 kg ha^{-1}) was noted in plants treated with 2 t ha^{-1} organic fertilizer and it was (4662.71 kg ha^{-1}) for 2009 for plant treated with combination of chemical fertilizer + 1.5 t ha^{-1} organic fertilizer, in two consecutive years. An increase in the grain yield at the above-mentioned treatments was may be due to the increase of 1000 seed weight, panicle number, number of fertile tillers, flag leaf length, number of spikelets, panicle length and decrease number of hollow spikelets per panicle.

Bezbaruha *et al.* (2011) reported from a study that the application of RDF (160-60-60 kg NPK ha^{-1}) recorded significantly higher panicle length, panicle weight, test weight, grain and straw yields as well as harvest index.

Deshpande and Devasenapathy (2011) reported that the Poultry manure recorded highest grain and straw yield with high yield attributing characters viz., panicle length, total number of grains panicle^{-1}, number of filled grains per panicle and lesser sterility percentage as compared to other treatments.

Devi and Manimaran (2012) recorded highest panicle number m^{2}, grain and straw yield of 5350 kgha^{-1} and 6788 kg ha^{-1}with the application of 25% N through effective microorganism inoculated

Poultry manure compost + 75% recommended dose of fertilizer N, whereas, the lowest yield was recorded in control (2170 kg ha^{-1}grain and 3472 kg ha^{-1}straw yield).

Subehia and Sepehya (2012) observed that the nitrogen substitution through different organics increased significantly the productivity of rice with the increasing levels of NPK. The authors also recorded the maximum yield of rice (3.62 t ha^{-1}) under 50% NPK along with 50% N through FYM during Kharif. Though the chemical sources of nutrients increased crop yields over control, these failed to improve the soil properties combined use of the organics and inorganics. The improvement of soil fertility with respect to available macronutrients and micronutrient cations was also prominent with the application of 50% NPK + 50% N through FYM in Kharif followed by 100% NPK in Rabi.

Islam *et al.* (2013) revealed that the 50% RDF + 4 ton poultry manure ha^{-1} produced the highest effective tillers $hill^{-1}$, plant height, panicle length, 1000 grain weight, grain yield (5.92 kg $plot^{-1}$) and straw yield (5.91 kg $plot^{-1}$). The higher grain and straw yields were obtained where organic manure plus inorganic fertilizers was applied than full dose of chemical fertilizer and manure.

Sangeeta *et al.* (2013) found that the application of enriched poultry manure compost on 2.3 t ha^{-1}N basis recorded higher yield attributes and grain yield of rice (4675 kg ha^{-1}in 2007 and 4953 kg ha^{-1}in 2008) in two consecutive years.

Liza *et al.*(2014) reported that the 50% RDf + residual effect of cow dung 2.5 t ha^{-1},poultry manure 1.5 t ha^{-1} and compost 2.5 t ha^{-1}produced the highest grain yield (6.87 ha^{-1}) and straw yield(7.24 tha^{-1}).

Sharma *et al.* (2001) reported that the integrated use of inorganic fertilizers in conjunction with organic manures increased pH, organic carbon, CEC, rice grain and straw yield over inorganically treated plots. Highest grain and straw yield of rice was recorded when

50% N was substituted through FYM. Pre-transplant incorporation of 50% through FYM produced 76.70 qtrice grain yieldha^{-1}, which was statistically at par with yield obtained under its 25% N substitution.

Rajiv *et al.* (2014) conducted field experiments at Krishi Nagar Research farm, Jawaharlal Nehru Krishi Vishwavidyalaya Jabalpur with an aim to find out the effect of various nutrient management on crop productivity, water productivity and soil properties under various rice based cropping system during 2004-05 to 2007-08. They found that the crop productivity of all cropping system was maximum (127.44 qha^{-1}) with 100% inorganic (120-60-40 kg NPK ha^{-1}) nutrient management.

Wahlang *et al.* (2015) investigated that the integrated application of RDF (80:660:40 kg NPKha^{-1}) + 5 t FYM ha^{-1} followed by 50% RDF + 10 t FYM ha^{-1} gave higher value of all the yield attributing parameters and yield of rice.

Awang *et al.* (2016) revealed that the chicken manure at the rate of 20 t ha^{-1}produced the highest percentage of filled grains (83.73 %), 1000 grains weight (25.81 g), extrapolated yield (11.16 tons ha^{-1}).

Thulasi *et al.* (2016) reported that Integrated Nutrient Management recorded higher grain and straw yields in rice-rice system and in situ green manuring was identified as a cost effective and farmer friendly technology.

Moe *et al.* (2017) reported that the combining inorganic and organic fertilizers demonstrated that 50% NPK together with poultry manure (5 t ha^{-1}) provided similar growth, total dry matter, and yield parameters to 100% NPK.

2.1.3 On nutrient content and uptake

Dwivedi and Thakur (2000) observed that the application of 100-60-40 kg NPK ha^{-1} recorded significant improvement in NPK uptake by rice as compared to its lower rates of application (75% and 50% NPK).

Sharma *et al.* (2001) observed that Application of NPK up to 150-75 75 kgha^{-1} caused a significant increase in the total N uptake by rice. The total NPK uptake by rice increased with corresponding increase in NPK levels up to 150-33-41.4 kgha^{-1}.

Yaduvanshi (2001) also found that 150% of recommended NPK application enhanced the uptake of these nutrients by rice crop.

Kundu and Kundu (2002) reported that the maximum N, P and K uptake at 150% of the recommended fertilizer rate i.e. 180-90-90 kg NPKha^{-1}.

Singh *et al.* (2005) conducted a field experiment on wet season rice at Srinagar and reported that application of NPK up to the level of 200-100-50 kgha^{-1} in rice increased the nitrogen content and uptake.

Kumar *et al.* (2007) found that N, P and K uptake by grain and straw and total nutrient uptake increased significantly as the level of N increased from 50 to 150 kgha^{-1}.

Bezbaruha *et al.* (2011) reported from a study that the application of RDF (160-60-60 NPK kgha^{-1}) recorded significantly higher nutrient uptake of nitrogen, phosphorus and potassium.

Bal *et al.* (1993) studied that the application of FYM @ 5 t ha^{-1} alone gave rice seed yield of 2.36 t ha^{-1} compared to the control (1.49 t ha^{-1}). While, combined application of FYM and N fertilizer increased the nutrient uptake.

Singh *et al.* (2007) reported that the uptake of NPK and soil fertility could be enhanced by combined application of 50 % dose of recommended NPK + FYM (10 t ha^{-1}). Available N, P and organic C contents of the soil in the entire situation were increased significantly due to application of FYM, either alone or in combination with NPK fertilizer.

Mondal *et al.* (2003) revealed that application of FYM at 10 t ha^{-1} with and 100% NPK could increase the available N status of soil and plant.

Majumdar *et al.* (2007) investigated that the uptake of N, P, and K by paddy and various form of N in soil increased significantly by application of N fertilizer along with farmyard manure.

Kumar *et al.* (2008) reported that in the hybrid rice field combined use of crop residues, organic amendments and chemical fertilizers significantly increased the availability of N, P, K, S and micronutrients in soil over chemical fertilizers alone.

Liu *et al.* (2008) suggested that the nitrogen uptake from poultry manure was higher than that from ammonium sulphate.

Bezbaruha *et al.* (2009) recorded maximum nitrogen and phosphorus uptake by rice when grown with the application of 100% NPK through fertilizers.

Meena *et al.*(2010) reported that application of 150% recommended nitrogen dose through poultry manure resulted in highest NPK uptake (231.28, 74.98, 286.81 kg ha^{-1}) in rice over 100% recommended nitrogen dose through urea during 2003-05 on sandy clay loam soils of Varanasi, Uttar Pradesh.

Sunitha *et al.* (2010) reported the maximum uptake of N, P and K in the rice field which received organic manures viz., glyricidia or FYM in combination with 50% RDF as compared to farmer's practice and 100% N applied through urea.

Ghosh *et al.* (2014) investigated that the uptake of N, P, K, S, Ca and Mg by both grain and straw of rice were statistically significant due to use of integrated nutrient management. They suggested that the integrated nutrient management can be used as an alternate option of chemical fertilization to achieve maximum yield, nutrient uptake and cost of return for rice.

Chesti *et al.* (2015) observed that the three years of conjoint use of 10 t FYM ha^{-1} with 100% NPK recorded significantly higher total N,P,K uptake by rice 96.3, 20.4 and 109.5 kg ha^{-1}, respectively while application of 100% NPK alone recorded N,P,K uptake 86.5, 18.1 and 96.8 kg ha^{-1} respectively.

Sultana *et al.* (2015) evaluated that the highest amount of nitrogen (1.092%), phosphorus (0.297 %), potassium (0.374 %) in grain and the highest amount of potassium (1.213 %), sulfur (0.091 %) in straw were observed in T_3 (90 kg N from urea + 30 kg N hard from vermicompost). The highest sulfur (0.124 %) content in grain and the highest nitrogen (0.742 %), the highest phosphorus (0.182 %) in straw was recorded in treatment T_2 (120 kg N $ha^{-1}$from urea). The highest amount of nitrogen (93.81 kg ha^{-1}), phosphorus (26.07 kg ha^{-1}), potassium (32.82 kg ha^{-1}) and sulfur (10.79 kg ha^{-1}) uptake by grains and the highest amount of nitrogen (55.70 kg ha^{-1}), phosphorus (13.79 kg ha^{-1}), potassium (92.43 kg ha^{-1}) and sulfur (6.91 kg ha^{-1}) uptake by straw of rice were observed in T_3 treatment.

Latha *et al.* (2019) conducted a field experiment during the kharif season of two years 2015 and 2016 and reported that the Nitrogen uptake was ranged from 49.48 to 156.23 kg ha^{-1} and 49.70 to 135.2 kg ha^{-1}, phosphorus uptake ranged from 10.84 to 36.31 kg ha^{-1} and potassium uptake ranged from 55.03 to 146.94 kg ha^{-1}during 2015 and 2016 years, respectively .

2.1.4 On Available nutrients

Kumar and Prasad (2002) a field study was conducted on University farm of Pusa during kharif and revealed that significantly highest value for soil organic carbon, available nitrogen, phosphorus and potassium was obtained with the application of 100% NPK i.e. 100-26.7-33.2 NPK kgha^{-1}in the soil as compared to control, 25, 50 and 75% of NPK levels.

2.1.5 On economics

Yadav (2001) concluded from on farm experiments conducted in rice wheat cropping systems at Jalandhar (Punjab) and Ghaziabad (UP) that net monetary returns were greater with the use of fertilizer NPK alone.

Singh and Subbiah (2007) found that mean maximum net returns of 25,981ha^{-1} was recorded under 120-60-30 kg NPK level with green manure application, while 120-60-30 kg NPK ha^{-1}green manure recorded net returns of Rs. 19,769ha^{-1}, which was almost comparable with 120-60-30 kg NPK ha^{-1}application without organic manure (Rs. 18596ha^{-1}).

Jayadeva and Shetty (2008) conducted the experiment at Agricultural Research Station, Bangalore, Kathalagere, Karnataka to study the influence of the sources of nutrients, application of FYM + recommended NPK recorded higher grain and straw yield (8871 and 9938 kg ha^{-1}, respectively), total energy output (254629 MJ ha^{-1}) and gross income (Rs. 58196 ha^{-1}), whereas application of recommended NPK recorded significantly higher energy output

Gawate*etal*. (2020) conducted a field experiment during kharif 2018-19 at Research Farm of College of Agriculture, Nagpur to study the “Influence of seed sowing and nutrient management in drilled paddy (*Oryza sativa*)”. The yield attributing character viz. number of panicle plant^{-1}, length of panicle, number of grains panicle^{-1} and weight of grains panicle^{-1} recorded maximum in drilling soaked seed at 30 cm . Grain yield, straw yield, biological yield (q ha^{-1}) and harvest index were significantly highest in drilling of soaked seed at 20 cm application of 125:62.5:62.5 kg NPK ha^{-1}. GMR and NMR (Rs. 26876 ha^{-1}) recorded maximum in Drilling soaked seed at 20 cm and application of 125:62.5:62.5 kg NPK ha^{-1}. B:C ratio recorded maximum in drilling of soaked seed at 20 cm and application of 100:50:50 kg NPK ha^{-1}.

2.2. Effect of Organic sources + RDF

Vermicompost is a potential source of nutrient with the presence of readily available plant nutrients, growth enhancing substances and number of beneficial microorganisms like N fixing, P solubulising and cellulose decomposing organisms. About 10 % bacteria, 10% fungi and 10% actinomycetes population were reported to be present in vermicompost.

2.2.1 On growth attributes

Sudha and Chandini (2003) observed that application of vermicompost at 5 tha^{-1} had positive influences on growth and growth attributes of rice in combination with NPK dose of 105:52.5:52.5 kg ha^{-1}supplied through inorganic sources.

Bezbaruha *et al.* (2011) reported from a study that plant height and productive tillers m^{-2} was significantly higher with the application of 75% RDF along with 25% vermicompost.

Dekhane *et al.* (2014) observed that application of 50% N through RDF + 50% N through vermicompost recorded significantly higher growth attributes like plant height, number of tillers plant^{-1}at 45 DAT and at harvest stage.

Paramesh *et al.* (2014) concluded that significantly maximum total dry matter (84.78 g), tillers hill^{-1} at harvest stage (30.04) and leaf area hill^{-1} (2220.77 cm^2 hill^{-1}) at 90 DAS was recorded with application of 50% RDN through chemical fertilizer + 50% RDN through vermicompost.

Kulkarni *et al*. (2015) planned and executed investigation at Soil and Water Management Research Unit (SWMRU) Farm, Navsari Agricultural University, Navsari during the *kharif* season of year 2011-12with two inorganic treatments of 100% RDF and 75% RDF in combinations with FYM, Biocompost, vermicompost and azospirillum as sources of 25 per cent of RDN. The results revealed that, supplementation of 75% N through Urea + 25% N through vermicompost performed significantly superior for growth, yield and quality attributes along with macro and micro nutrient content and uptake in grain and straw with transplanted growing condition of rice.

Shrivastava *et.al.* (2015) Studied combine application of a biofertilizer and a chemical fertilizer. Azotobacter alone and with the combination of 100%, 75%, 50% and 25% urea is applied to rice seedsand effect on the seed germination and plant growth have been recorded and it is observed that inoculation of chemical and biofertilizers improves the growth of plant.

Biswakarma *et.al.* (2018) conducted a field experiment during *kharif* season 2014 at P.S.B. Agriculture farm, Visva-Bharati, Sriniketan, West Bengal to study the effect of phosphate solubilizing bacteria on growth and productivity of rice. The results revealed that at harvest, highest (1101.11 g) dry matter was accumulated with NPK+PSB and was statistically at par with 7.9%, 8.6%, 13.27% higher values than NP_0K, NP_0K+PSB and NPK, respectively. NP_0K+PSB gave the highest (442.22) number of panicles m^{-2} which was significantly 40.70% and 37.68% higher over NPK+PSB and NPK, respectively. NPK+PSB proved best in influencing growth and productivity, which however at par with NPK, NPK, NP_0K+PSB, and NPK+PSB+RP except NPK+PSB+RP for dry matter at harvest. NPK+PSB recorded highest (Rs. 52,750) gross returns but NPK resulted maximum (Rs.19,466) net returns.

Hanamantet. al (2019) conducted a field experiment during kharif 2018 at AHRS, Bhavikere to study the effect of integrated nutrient management in direct seeded rice (*Oryza sativa* L.) in Southern Transitional Zone of Karnataka. The results revealed that application of 100% recommended NPK + FYM + plant growth promoting rhizobacteria (PGPR) + 20:20:20 water soluble fertilizers recorded significantly higher grain yield (49.16 q ha^{-1}) and yield parameters like number of panicles per plant (17.18) and panicle weight (3.20 g). Similar trend was noticed in growth parameters like plant height (73.94 cm) and number of tillers (22.56) which contributed to the yield. The lowest yield was recorded with the control plot (16.47q ha^{-1}).

Pandit *et al*. (2020) conducted a field experiment during kharif 2018-19 and 2019-20 at the farm of Regional Research station, Old Alluvial Zone, Uttar Banga Krishi Viswa Vidyalaya, Majhian, Dakshin Dinajpur, West Bengal to study the performance of direct seeded rice (var. GB-1) under integrated nutrient practices. Highest number of effective tillers $plant^{-1}$ (17.81), panicle length (29.56 cm) and number of filled grains $panicle^{-1}$ (262.15) as well as seed yield (3051.89 kg ha^{-1}) in the direct seeded rice crop was noted with the application of 75% of the recommended dose of fertilizers, FYM @ 5t ha^{-1} and brown manuring with dhaincha.

2.2.2 On yield attributes and yield

Murali and Setty (2001) reported that application of vermicompost @ 5 tha^{-1}combined with NPK at 150-75-75 $kgha^{-1}$ recorded significantly highest grain yield (4889 kg ha^{-1}) as compared to single application of RDF (4070 $kgha^{-1}$). Increase in grain yield with vermicompost was because of significantly higher yield attributes like number of panicles $hill^{-1}$(10.91) and number of grains $panicle^{-1}$ (186.82) with increased availability of nutrients in vermicompost treatment.

Sudha and Chandini (2003) observed that application of NPK dose of 105:52.5:52.5 kgha^{-1} supplied through inorganic sources along with vermicompost @ 5 tha^{-1} had positive influence on growth and yield attributes of rice and resulted in better grain yield of 4.54 tha^{-1} and straw yield of 5.15 tha^{-1}.

Barik *et al.* (2008) registered from a study conducted at West Bengal on sandy loam soils that significantly higher number of grains panicle^{-1} and grain yield were obtained with the application of 60% recommended nitrogen through urea and 40% nitrogen through vermicompost as compared with 100% nitrogen through urea only.

Bezbaruha *et al.* (2011) reported from a study that the application of 75% RDF and 25% vermicompost recorded significantly highest panicle length, panicle weight, test weight, grain and straw yields as well as harvest index.

Ranjitha *et al.* (2013) studied the different nutrient management options and noted that application of 50% recommended dose of nitrogen through urea and remaining 50% RDN through vermicompost resulted in significantly higher grain (5520.8 kgha^{-1}) and straw yields (6264.9 kgha^{-1}) followed by 100% RDN through urea application.

Dekhane *et al.* (2014) observed that application of 50% N through RDF + 50% N through vermicompost recorded significantly higher yield attributes and yield like panicle length (22.3 cm), grains panicle^{-1} (128.0), 1000 grain weight (19.7 g) and grain (4.97 tha^{-1}) and straw yields (5.77 tha^{-1}) of rice variety GR 11.

Kumar *et al.* (2014) evaluated control and different combinations of RDF (75, 100 and 125%) with 2.5 tha^{-1} and 5 tha^{-1} of vermicompost. They reported that 125% RDF + 5 tha^{-1} vermicompost recorded significantly higher panicle length, grains panicle^{-1}, 1000 grain weight and grain and straw yields of rice followed by 100% RDF + 5 tha^{-1} vermicompost.

Paramesh *et al.* (2012) concluded that supplying 50 % N through vermicompost and remaining 50% N through chemical fertilizers has recorded significantly higher grain and straw yields (39.48 q ha^{-1}) and (52.90 q ha^{-1}) respectively as compared to 50% RDN through chemical fertilizers + 50% RDN through poultry manure (35.38 qha^{-1}).

Jana *et al.* (2015) reported that the highest grain yield of aerobic rice was obtained with the application of inorganic fertilizers viz., 80-40-40 $kgha^{-1}$NPK in combination with vermicompost at 2.5 tha^{-1}.

Venkatesha *et al.* (2015) reported from a study conducted at Karnataka that significantly maximum test weight and grain yield was found with application of 50% nitrogen through inorganic fertilizers + 50% through vermicompost as compared to other treatment combinations.

Sharma *et al*. (2016) conducted a field experiment at College of Agriculture, Kolhapur on medium black soils during kharif, 2014 to study the effect of integrated nitrogen management on growth, yield, nutrient uptake and economics of upland paddy. The organic fertilizers viz., FYM, vermicompost, castor cake, neem cake were combined with inorganic fertilizers. The result revealed that application of 75% RDN through inorganic fertilizer + 25% N through castor cake recorded significantly higher values of growth and yield attributing characters resulting into higher grain and straw yields.

Sandhu and Walia (2016) conducted a field experiment at Punjab Agriculture University, Ludhiana to develop suitableintegrated nutrient supply system for rice-wheatcropping system. Over the 30 years of study period, highest riceyield was obtained when 25% of nitrogen wassupplied through green manuring (GM). When25% N was supplied through farmyardmanure (FYM), it produced at par rice yieldwith the treatment of 100% NPK application through chemical fertilizers.

2.2.3 On nutrient content and uptake

Jadhav *et al.* (1997) observed that the application of vermicompost increased the uptake of primary and secondary nutrients such as N, P, K, Ca and Mg by rice and maximum nitrogen uptake was recorded by the conjunctive use of 75 kg Nha^{-1} through urea along with 25 kg Nha^{-1} through vermicompost.

Murali and Setty (2001) revealed that application of vermicompost at 5 tha combined with NPK at 150-75-75 $kgha^{-1}$ recorded maximum total nitrogen uptake (168 $kgha^{-1}$) as compared to no vermicompost treatment (152 $kgha^{-1}$).

Banik and Bezbaruha (2004) conducted a field experiment on sandy loam soils of Girid, Jharkhand and concluded that application of 15 $kgha^{-1}$ nitrogen through vermicompost in combination with recommended dose of fertilizer i.e. 45-13-25 $kgha^{-1}$ N-P-K registered significant increase in nutrient uptake i.e. N, P and K by rice crop.

Bezbaruha *et al.* (2011) reported from a study that the application of 75% RDF and 25% vermicompost recorded significantly higher nutrient uptake of nitrogen, phosphorus and potassium as compared to control, RDF (160-60-60), 100% RDF through vermicompost and 50% RDF and 50% vermicompost.

Kumar *et al.* (2014) evaluated control (where no fertilizer applied) and different combinations of RDF (75, 100 and 125%) with 2.5 tha^{-1} and 5 tha^{-1} vermicompost. They reported that 125% RDF + 5 tha^{-1} vermicompost recorded significantly higher nutrient uptake of rice followed by 100% RDF + 5 tha^{-1} vermicompost.

2.2.4 On Available nutrients

Sudhakar *et al.* (2002) concluded that vermicompost with rich micro sites in available carbon and nitrogen increase aeration and porosity of soil. .

Barik *et al.* (2006) conducted a field study on sandy soils at Agriculture research farm, institute of agriculture.visva bharti Sriniketan, West Bengal and observed that the application of vermicompost in combination with recommended dose of fertilizer resulted in significant increase in organic carbon, available nitrogen, phosphorus and potassium.

Jana *et al.* (2015) reported from a study conducted at Rice Research Station, Bankura, West Bengal that the highest value of organic carbon, available nitrogen, phosphorus and potassium of aerobic rice was obtained with the application of inorganic fertilizersviz., 80-40-40 NPKkgha^{-1}.in combination with vermicompost at 2.5 tha^{-1}.

2.2.5 On economics

Barik *et al.* (2006) observed that the highest gross returns, net returns and benefit cost ratio were recorded in rice cv. IR-36 with the application of 50% RDF in combination with vermicompost 10 tha^{-1}.

Barik *et al.* (2008) reported that application of 60% recommended dose of N from Urea and 40% recommended dose of N from vermicompost recorded significantly highest net return (Rs. 15245ha^{-1}) and return per rupee investment (92.11) which were closely followed by use of 40% and 60% recommended dose of nitrogen from urea and vermicompost, respectively.

Yadav *et al.* (2008) Conducted an experiment at Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani and study concluded that application of recommended dose of fertilizer (80: 50: 50 kg NPK ha^{-1}) has recorded the significantly higher production and economic efficiency in case of inorganic nutrient levels. While Glyricidia @ 10 t ha^{-1} recorded maximum production efficiency and gross monetary returns, but treatment of biofertilizers (Azospirillum @ 1.5 kg + PSB 5 kg ha^{-1}) recorded higher net monetary returns and economic efficiency among organic sources. In case of interaction, treatment RDF +

Glyricidia @ 10 t ha^{-1} recorded significantly more grain yield, production efficiency and gross monetary returns, while treatment M3S3 - RDF + biofertilizers (Azospirillum @ 1.5 kg ha^{-1} + PSB @ 5 kg ha^{-1}) recorded higher net monetary returns and economic efficiency

Venkatesha *et al.* (2015) reported from a study conducted at department of agronomy college of agriculture dharwad Karnataka that the application of 50% nitrogen through inorganic fertilizers + 50% through vermicompost recorded significantly higher nutrient uptake of nitrogen, phosphorus and potassium as compared to other treatment combinations.

Jadhav *et al.* (2014) concluded from a study conducted at Vasantrao naik agriculture university Parbhani to assess the ferrous and zinc nutrient management practices on aerobic rice and reported that significantly maximum net monetary returns were obtained with the supply of 80-50-50 kg $NPKha^{-1}$with the soil application of micronutrients $FeSO_4$ and $ZnSO_4$ at 10 $kgha^{-1}$ than rest of nutrient management practices.

Meena *et al.* (2019) a field experiment was conducted during rainy season at Department of agronomy BHU Varanasi, UP, to study the effect of nitrogen levels and zinc application on yield in direct seeded rice and reported that 150 $kgha^{-1}$ nitrogen and 0.3% $ZnSO_4.H_2O$ at anthesis recorded significantly maximum.

Chapter III

MATERIALS AND METHODS

The present field investigation entitled "Studies on integrated nutrient management in direct seeded rice".was carried out during*kharif* season of 2021. The details of the material and methods adopted during the course of investigation are given in this chapter under following heads and sub-heads.

3.1 Details of the experimental material and methods

3.1.1 Experimental site

The experimental site was selected on the basis of suitability of land for rice cultivation during *kharif* season with rich in fertility and uniform topography. With this consideration, the experiment was conducted in plot no.10 at the Agronomy Farm, College of Agriculture, Nagpur, Maharashtra State, India, during *kharif* season of 2021.

3.1.2 Soil characteristics

The soil of experimental plot was vertisol, having uniform and levelled topography. A soil sample was collected randomly from selected spots of experimental plot upto depth 20 cm with the help of screw auger. A mixture of sample taken from "V" shaped layer of dug by thoroughly cross mixing of soil, then sample was air and oven dried and grind in a mortar then properly sieved and make upto half kg for the analysis of important physio-chemical properties of soil.

The soil of the experimental plot was clayey in texture, low in available nitrogen (N) and available phosphorous (P) and very high in available potash (K). Organic carbon (C) content was medium and soil reaction was slightly alkaline in nature.

Table 1. Physical and chemical properties of soil

Sr.	Particulars	Result of analysis	Method adopted and reference
A	**Mechanical / Physical composition**		
1.	Coarse sand (%)	13.12	Standard International pipette method (Piper,1966)
2.	Fine sand (%)	8.25	
3.	Silt (%)	22.5	
4.	Clay (%)	55.62	
5.	Textural class	Clayey	
B	**Chemical composition**		
1.	Available N (kg ha^{-1})	206.12	Alkaline permanganate method (Subbiah and Asija, 1956)
2.	Available P(kg ha^{-1})	14.17	Olsen's method (Jackson, 1962)
3.	Available K(kg ha^{-1})	383.8	Flame emission spectrometer(Jackson, 1967)
4.	Soil reaction (pH)	7.9	Blackman’s glass electrode pH meter (Jackson, 1973)
5.	Organic carbon (%)	0.51	Walkey and Black Rapid titration method (Walkey and Black,1934)
6.	Electrical conductivity (dSm^{-1})	0.24	Conductivity meter methods (Jackson 1974)

3.1.3 Climatic and weather condition

Experiment was conducted during *kharif* season of 2021 at Nagpur, which is located under Central *Vidarbha* regionof Maharashtra. Nagpur have a subtropical climatic condition along with variable rainfall during *kharif*season. Nagpur is situated at 21°14′ North latitude and 79°08′ East longitude with elevation of 310.5 meter above mean sea level.

In order to get an idea about the climatic conditions (maximum and minimum temperature, relative humidity, amount of rainfall, number of rainy days and evaporation) duringthe period of experimentation and the meteorological data on weather parameters wereobtained from the Meteorological Observatory, College of Agriculture, Nagpur. The meteorological data recorded during the crop growth period (sowing to harvesting) of experimentation from 04/07/2021 to 07/11/2021 is presented in Table 2 and graphically depicted in Fig. 1.

From the given weekly metrological data recorded during crop growth period of *kharif*2021, observed that the mean weekly maximum and minimum temperature rangedbetween 30.5 to 35.5°Cand 17.5 to 24.7°C, respectively.The mean relative humidity during morning and evening hours ranged between 48 to 95 % and 33 to 79 %, respectively and Total rainfall received during crop growthperiodmainlyconcentratedinJune,July,August, Septemberand Octoberwas 1194.2 mm in 49 rainy days. The average evaporation during crop growth period was between 1.6 to 5.6 mm.

Table2. Weekly meteorological data recorded at meteorological observatory, Agronomy Farm, College of Agriculture, Nagpur (June 2021 to October 2021)

Date and Month		Met. Week	Temp ^{0}c		Relative Humidity (%)		Total Rainfall (mm)	No. of Rainy days	Evaporation (mm)
			Max	Min	Morn	Eve			
18-24	Jun 21	25	33.3	23.3	88	71	83.8	3	2.4
25-01		26	33.5	24.7	87	67	83.6	3	2.5
02-08	Jul 21	27	35.5	24.7	78	54	16.2	1	3.0
09-15		28	33.9	23.9	89	69	155.6	4	1.7
16-22		29	32.9	23.7	86	76	90.8	2	2.2
23-29		30	32.3	23.5	89	74	88.4	2	1.9
30-05		31	30.5	23.9	89	79	38.2	4	1.6
06-12	Aug 21	32	33.7	24.1	83	63	13.8	1	2.5
13-19		33	33.5	23.5	90	70	178.2	4	2.0
20-26		34	32.5	23.5	89	65	21.4	1	2.9
27-02		35	32.5	23.1	93	71	82.4	3	2.3
03-09	Sept 21	36	32.1	23.1	95	70	141.4	5	2.0
10-16		37	31.5	23.1	95	66	90.4	6	1.6
17-23		38	31.7	22.1	93	64	64.6	6	2.3
24-30		39	31.9	22.5	93	70	45.4	3	3.2
01-07	Oct 21	40	32.3	23.3	83	63	0.0	0	4.3
08-14		41	33.6	21.1	68	45	0.0	0	5.6
15-21		42	32.8	21.1	70	44	0.0	0	4.9
22-28		43	30.8	19.3	58	37	0.0	0	4.4
29-04		44	31.1	17.5	48	33	0.0	0	4.5
							1194.2	49	

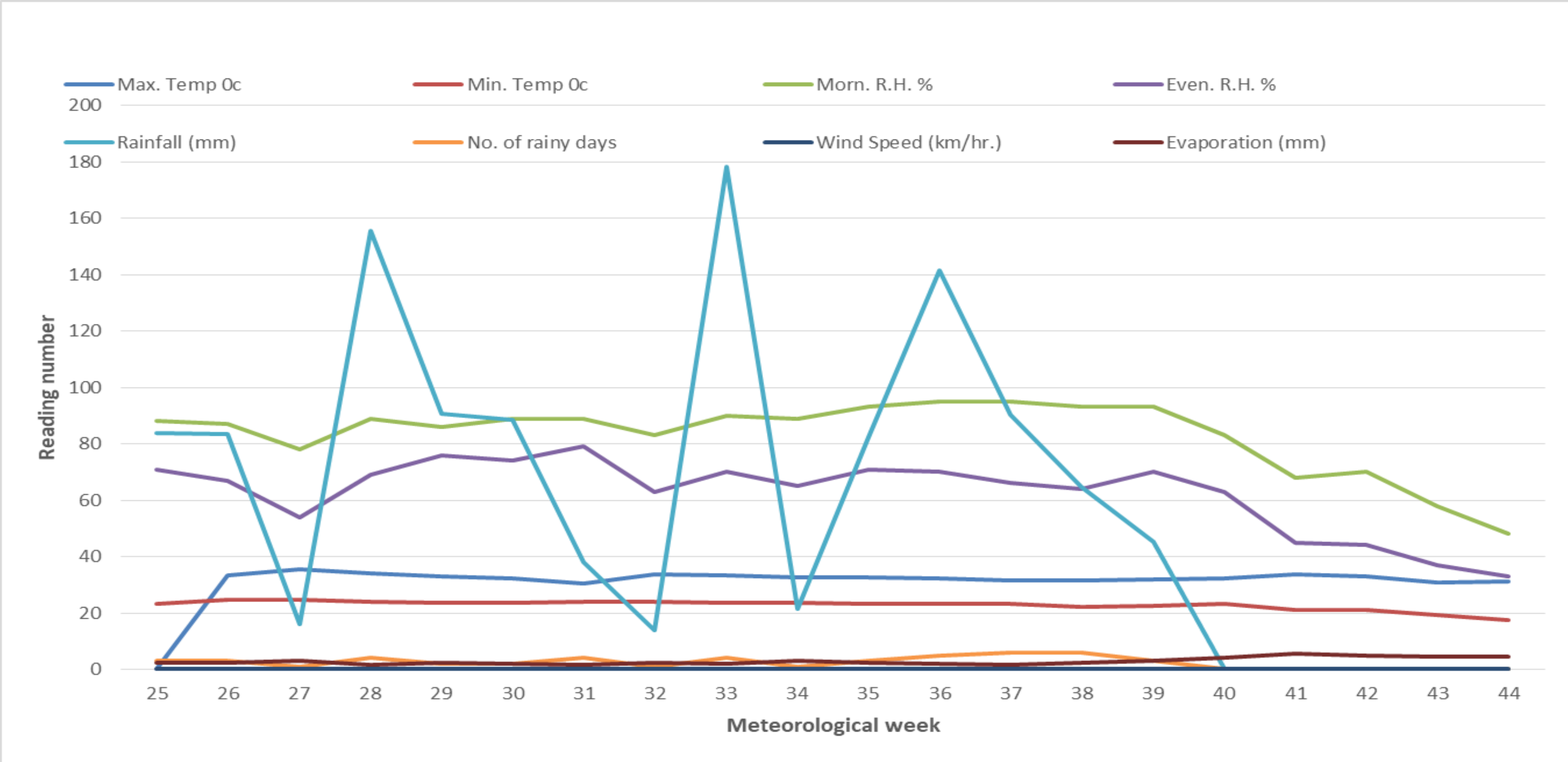


Fig.1 Weekly meteorological data from June 2021 to October 2021 recorded at Meteorological Observatory, College of Agriculture, Nagpur

Table 3.Cropping history of experimental plot

Year	Season		
	Kharif	***Rabi***	***Summer***
2018-2019	-	Wheat	-
2019-2020	-	Linseed	-
2020-2021	-	Musturd	-
2021-2022	Drill Rice*	-	-

* Present experiment

3.2 Experimental details.

The Experimental details described in Table. 4

Table 4.Experimental details

Sr.No.	Particulars	Details
1.	Experimental Design	Randomized Block Design
2.	No. of treatment	Nine
3.	No. of replication	Three
4.	Total no. of plots	27
5.	Plot size	Gross plot : 3.4 m x 3.0 m Net plot : 3.0 m × 2.4 m
6.	Crop	Drill Rice
7.	Variety	PDKV Sadhana
8.	fertilizer dose	As per treatment
9.	Experimental year and season	*kharif* - 2021
10.	Method of sowing	Drilling
11.	Spacing	20×10 cm
12.	Seed rate	75 kg ha^{-1}
13.	Place of research work	Agronomy Research Farm, College of Agriculture, Nagpur.

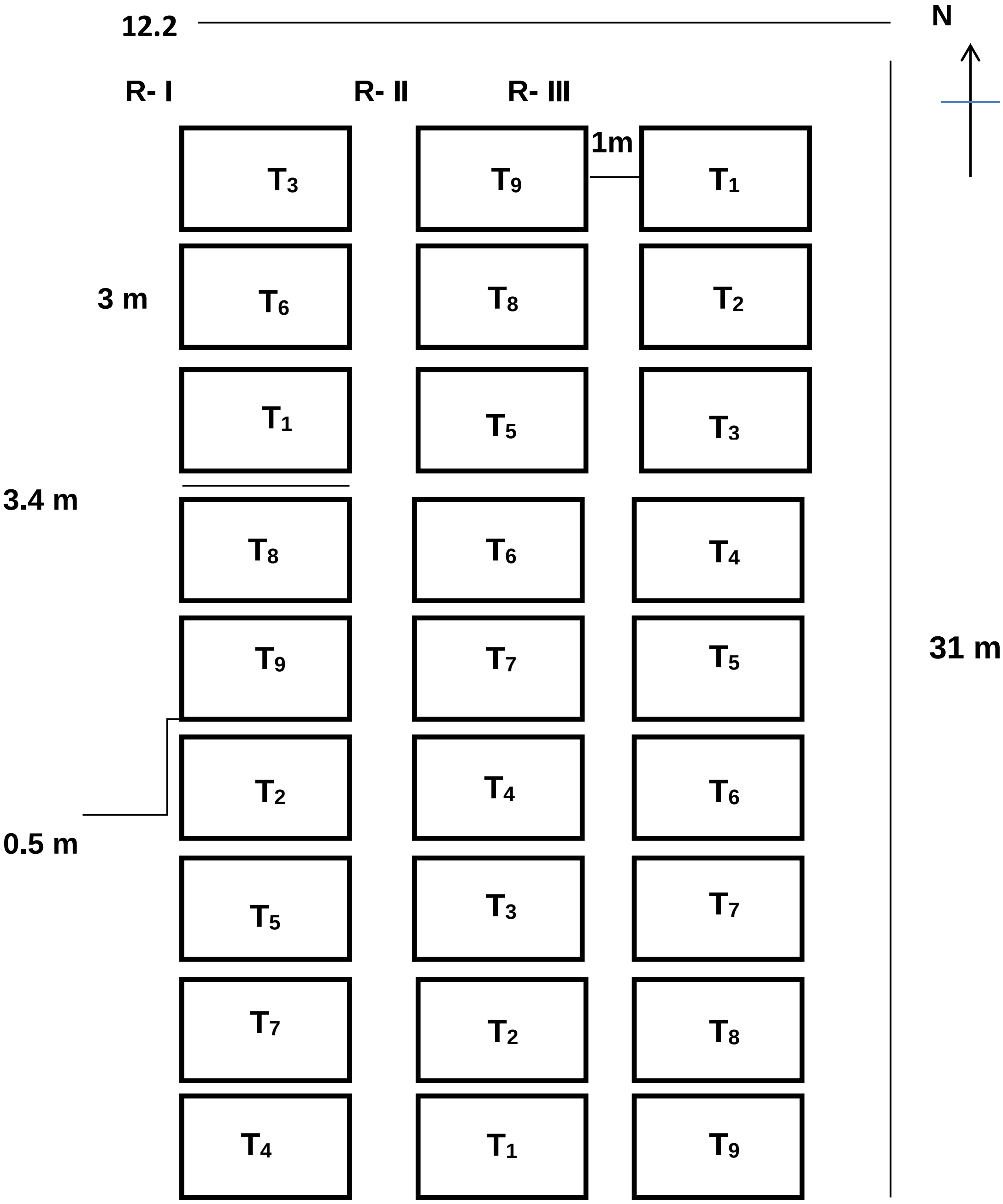
3.2.1. Experimental design and treatments.

The experiment was laid out in randomized block design with three replications and nine treatments. The details of treatment with symbol and experimental treatment details are given below in Table.5

Table 5.Details of experimental treatment

Sr.No	Treatments	Treatments details
1	T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})
2	T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})
3	T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})
4	T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}
5	T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}
6	T_6	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}
7	T_7	75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter
8	T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter
9	T_9	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter

3.2.2.Layout of the experiment.



Design: Randomized Block Design (RBD)

No.of Treatments : Nine

No.of Replication :Three

Plot Size: Gross plot :3.4 m x 3.0 m
Net plot : 3.0 m x 2.4 m

Fig2. Plan of Experiment

The experimental field was laid out in twenty seven plots by three replications and nine treatments with gross plot size 3.4 m x 3.0 m and net plot size 3.0 m x 2.4 m and the distance between two replications was 1.0 m. The plan of layout of the experimental units is given in fig.2.

3.3. Cultural operations

Table 6. Details of cultural operation schedule carried out in an experimental plot

Sr. No.	Field operations	Frequency	Date of operation
A	**Preparatory tillage**		
1.	Ploughing	1	25/05/2021
2.	FYM application	1	30/05/2021
3.	Harrowing	2	15/06/2021, 20/06/2021
4.	Levelling	1	23/06/2021
B.	**Preparation of layout**	1	02/07/2021
C.	**Seed and sowing**		
1.	Seed treatment	1	03/07/2021
2.	Sowing and fertilizer application	1	04/07/2021
D.	**Post sowing**		
1.	Gap filling	1	13/07/2021
2.	Hoeing	2	27/07/2021 22/08/2021
3.	Hand weeding	1	06/07/2021
4.	Foliar spraying	2	22/07/2021, 21/08/2021
E.	**Harvesting**	1	07/11/2021
F.	**Threshing**	1	10/11/2021

3.3.1 Land preparation

The land was prepared by one ploughing with the help of tractor drawn mould board plough and then it was smoothened by two harrowing to crush the clods and levelled the field with planker.

3.3.2 Vermicompost application

Vermicompost was applied before sowing as per treatment.

3.3.3 Seed variety

PDKV Sadhana variety of rice was used for experiment having duration of 118-120 days.Its a dwarf variety having 91-106 cm height, long slender grain, test weight 25.7 g. Slightly resistent to stem borer, plant hoppers and blast disease. Average yield 50 q ha^{-1}.,contains medium amaylose (24.28%).

3.3.4 Seed treatment.

Before sowing the seed is treated with 3% brine solution and also the seeds were inoculated with Thirum @ 3 gm for each one 1 kg of seed to control seed borne fungal diseases. Inoculated seeds were shade dried for about one hour and then used for sowing.

3.3.5 Seeds and sowing

Sowing of rice was done on 04/07/2021 by drilling method by maintaining spacing 20 cm in rows and 10 cm between plants with 75 kg seed ha^{-1}upto depth of 3- 4 cm.

3.3.6 Fertilizer application

Half dose of N and full dose of P_2O_5 and K_2O was applied as basal application through urea, single super phosphate and muriate of potash. The basal of all the fertilizers applied manually at the time of sowing in the furrows. The recommended dose of fertilizer was

125:62.5:62.5 kg NPK ha^{-1}. The remaining dose of 50% N was applied in two splits at 30 DAS and 50 DAS.

3.3.7 Gap filling and thinning

To maintain the optimum plant population the gap filling was done after 8-10 days after sowing respectively.

3.3.8. Hoeing and hand weeding

Hoeing and hand weeding was done to control the weed population, hoeing after 15-16 days to loose the soil and porous for good aeration and one hand weeding after 20-25 DAS and next at 40-45 days after sowing.

3.3.9. Foliar spraying

Foliar spraying of insecticide along with fungicide to control pest attack and fungal disease as per pest incidence.

3.3.10.Harvesting and threshing

The crop was harvested when the foliage of the rice plants turned yellowish brown to brown in colour. The harvesting of net plot area was done plot wise separately with the help of sickle. The harvested produce of net plot was tied into bundles and tagged with luggage label then threshing done after 10 days and cleaned by winnowing. Weight of biological and grain yield were recorded separately for each net plot.

3.4. Biometric observations

Table 7.Biometric observations

S.N.	Observation	Frequency	Stages of observation
A	**Pre-harvest observations**		
1	Initial plant stand	**1**	15 DAS
2	Final plant stand	**1**	At harvest
3	Plant height (cm)	**4**	30, 60, 90 DAS & at harvest
4	Number of Leaves Plant^{-1}	**4**	30, 60, 90 DAS & at harvest
5	Leaf Area Index	**4**	30, 60, 90 DAS & at harvest
6	Number of tillers plant^{-1}	**4**	30, 60, 90 DAS & at harvest
7	Dry matter accumulation plant^{-1} (g)	**4**	30, 60, 90 DAS & at harvest
B	**Post-harvest observations**		
1	No. of effective tillers plant^{-1}	**1**	At harvest
2	Length of panicle (cm)	**1**	At harvest
3	Number of grains panicle^{-1}	**1**	At harvest
4	Grain yield plant^{-1} (g)	**1**	At harvest
5	Straw Yield plant $^{-1}$ (g)	**1**	At harvest
6	Test weight (g)	**1**	After harvest
7	Grain yield (kg ha^{-1})	**1**	After harvest
8	Straw Yield (kg ha^{-1})	**1**	After harvest
9	Harvest index (%)	**1**	After harvest
C	**Quality study**		
1	Protein content (%)		
2	Protein yield (kg ha^{-1})		
D	**Economic studies**		
	GMR, NMR, BC ratio	**1**	After harvest
E	**Chemical studies**		
1	NPK content in grain and straw (%)	**1**	After harvest
2	NPK uptake (kg ha^{-1})	**1**	After harvest
3	Initial nutrient status	**1**	Before sowing
4	Residual fertility status	**1**	After harvest

3.4.1 Sampling technique

To record the various growth observations, five plants were selected at random in each net plot, which were marked with tag to wooden pegs for easier identification and observation. Biometric observations were recorded periodically from these five observational plants.

3.4.2 Plant stand

3.4.2.1Initial plant stand

The initial plant stand, count after emergence of crop was recorded by counting all the plants from each net plot at 15 DAS.

3.4.2.2 Final plant stand

The final plant population was recorded by actually counting the number of plants at the time of harvesting of crop in each net plot.

3.4.3 Studies on growth attributes

3.4.3.1Plant height (cm)

Five plants per plot were selected randomly in each plot and tagged for recording various observations during experiment. The height of marked plants was taken from the base (ground surface) to the tip of fully open leaf of main stem with the help of meter scale. This observation were recorded at 30, 60, 90DAS and at harvest and then mean was determined for each treatment at all growth stages.

3.4.3.2 Number of tillers plant^{-1}

The number of tillers arising from main shoot were recorded on selected five plants at 30, 60, 90 DAS and at harvest. The number of tillers plant^{-1} were recorded from the five selected plants which are tagged and then mean number of tillers plant^{-1} were worked out.

3.4.3.3 Number of leaves plant^{-1}

The number of leaves per plant were recorded from one plant of each plot after 30, 60 &90 DAS.

3.5.2.4 Leaf area (dm^2)

Leaf area of functional leaves was periodically recorded from five spot of each net plot at 30, 60, 90 DAS and average value recorded as mean leaf area and recorded in dm^2.

3.5.2.5Leaf area index

Leaf area index of functional leaves was periodically calculated from five reading of leaf area at 30, 60, 90 DAS by dividing the leaf area by area occupied by each plant .

3.4.3.6 Dry matter production plant^{-1} (gm)

Five plants were uprooted randomly from each plot at 30, 60, 90 DAS and at harvest. The weight of freshly uprooted plants of each plot was also recorded. After this the plants of each plot were tied and marked with luggage label. These labeled plant samples were sun dried and then dried in oven at 105°C for few hours then at 70°C till constant weight was achieved. The weight of oven dried sample was recorded for each plot on electronic balance. After this the mean values were determined.

3.4.4 Studies on yield attributes

3.4.4.1 Number of panicles plant^{-1}

Randomly five plant from each plot were selected to record the number of Panicles plant^{-1}at harvest stage, from that basis average value calculated.

3.4.4.2 Weight of grains plant^{-1}(g)

The grains from five randomly selected plants were separated by threshing and then weight grain per plant recorded on electronic weighing balance after that average weight calculated.

3.4.4.3 Test weight (g)

One thousandgrains were randomly taken from the finally cleaned produce of each net plot for recording test weight (g).

3.4.4.4 Grain and straw yieldplot^{-1} and ha^{-1}(kg)

The grains from each net plot were separated by threshing and their mean weight of grain and straw was taken on electronic weighing balance in gram then in converted on hectare basis.

3.4.4.5 Grain and straw yieldplant^{-1} (g)and ha^{-1}(kg)

Weight of straw yield plant^{-1} was recorded after harvest. The samples were selected from five randomly selected plants from each net plot were cleaned and mean Straw weight was recorded in grams. Harvested plants from net plot were threshed and mean weight was recorded and then converted on hectare basis (kg).

3.4.4.6 Harvest index (%)

Harvest index is defined as the ratio of grain yield to the total biological yield (seed and straw) and is expressed in percentage. It is given by Donald (1962)

$$\textbf{Harvest index (HI)} = \frac{\text{Economical yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.4.5 Quality studies

3.4.5.1 Protein content (%)

Nitrogen content (%) in grain of rice were multiplied by 6.25 to obtain crude protein content in grains. On the basis of crude protein content, the estimated yield of protein per hectare were calculated by following formula.

$$\textbf{Protein yield (kg ha}^{-1}\textbf{)} = \frac{\text{Grain yield} \times \text{Protein content in grain (\%)}}{100}$$

3.4.6 Economic studies

3.4.6.1 Gross monetary return (Rs ha^{-1})

The total value of produce i.e., grain and straw yield was calculated treatment wise as per the prevailing market rate and then average gross monetary return was calculated.

3.4.6.2 Net monetary return (Rs ha^{-1})

The treatment wise net monetary returns were worked out by subtracting treatment wise cost of cultivation from the treatment wise gross monetary returns then average net monetary return calculated.

3.4.6.3 Benefit cost ratio (B:C)

The treatment wise benefit cost ratio was worked out by dividing the gross monetary returns with the cost of cultivation of respective treatment to check economically profitable treatment.

$$\textbf{Benefit cost (B:C) ratio} = \frac{\text{Gross monetary return (Rs ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs ha}^{-1}\text{)}}$$

3.4.7 Chemical studies

3.4.7.1 Initial soil status

Initial soil sample from 20 cm depth were drawn from randomly selected spots across the field. The soil sample was mixed thoroughly and 500 gm sample was taken from the soil. This soil sample was then air dried and grinded in mechanical grinder, soil sample sieved through 2 mm sieve, labeled and stored in cloth bag for chemical analysis of initial available Nitrogen, Phosphorus, Potassium (kg ha^{-1}) by alkaline permanganate method, Olsen's method, flame photometer respectively. PH of soil determined by glass electrode PH and electrical conductivity (dSm^{-1}) by conductivity meter method.

3.4.7.2 Residual fertility status of soil

The representative soil sample was drawn from 20 or 30 cm depth from each net plot after harvest of the crop. This sample were air dried and grinded in mechanical grinder, soil sample sieved through 2 mm sieve, labeled and stored in cloth bag. Chemical analysis was done of initial and after harvest for available Nitrogen, Phosphorus, Potassium (kg ha^{-1}) by alkaline permanganate method, Olsen's method and flame photometer method respectively.

3.4.8 Statistical analysis

The statistical method of analysis of variance was used for analyzing the data. The data was statistically analyzed by “Analysis of variance” method (Panse and Sukhatme, 1967) and the ‘F’ test of significance was used for testing the null hypothesis in order to determine whether the observed treatment effects were real and discernible from chance effects. Whenever the results were found to be significant, critical difference (CD) was calculated for comparison of treatment mean. Suitable graphical representations and figures of relevant data were given at appropriate places.

Chapter IV

RESULTS AND DISCUSSION

The present investigation entitled “Studies on integrated nutrient management in direct seeded rice (*Oryza sativa*L.)” was carried out during *kharif* season of 2021 on the field of Agronomy Section, College of Agriculture, Nagpur. The observations were recorded on various aspects such as growth attributes, yield attributes,soil fertility, and economics. The results so obtained are presented and discussed in this chapter.

4.1 Soil, season and growth.

The experimental site was fairly uniform and levelled. The soil was vertisol, clayey in texture. It was low in available nitrogen and phosphorus, very high in available potassium and medium in organic carbon.soil reaction was slightly alkaline.

The crop was sown on 4^{th}July, 2021 and harvested on 7^{th} November, 2021. The meteorological data presented in Table 2 indicated that the mean weekly maximum and minimum temperature rangedbetween 30.5 to 35.5°Cand 17.5 to 24.7°C, respectively.The mean relative humidity during morning and evening hours ranged between 48 to 95 % and 33 to 79 %, respectively. Total 1194.2 mm rainfall was received in 49 rainy days during crop growthperiodmainlyconcentratedinJune,July,August, SeptemberandOctober. The average evaporation during crop growth period was between 1.6 to 5.6 mm.There was no accountable incidence of any diseases and insect pests during the crop period. Over all, season was quite favorable throughout the growing period which resulted in good crop growth and yield.

4.2 Pre-harvest studies

4.2.1 Initial and final plant stand.

Data regarding to mean initial and final plant stand plot^{-1}and ha^{-1}recorded at 15 DAS and at harvest, respectively ispresented in Table 8. The average initial and final plant stand plot^{-1} was 306 and 292 respectively and plant stand ha^{-1}was 417550 and 405200 respectively.

Table 8. Mean initial and final plant stand of direct seeded riceas influenced by various treatments

Treatment		Plant stand plot^{-1}		Plant stand ha^{-1}	
		Initial	Final	Initial	Final
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	304	290	422200	402700
T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})	305	292	423600	405550
T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})	305	290	423650	402645
T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	306	291	425050	404160
T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	307	291	426300	404105
T_6	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	306	294	405000	408300
T_7	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+ PSB+ Azotobacter	307	295	406310	409700
T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+ PSB + Azotobacter	303	290	420800	402700
T_9	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+ PSB + Azotobacter	306	293	405045	406934
SEm±		-	-	-	-
C.D.(5%)		NS	NS	NS	NS
GM		306	306	417550	405200

The data revealed that various treatments had no significant influence on initial and final plant stand thereby indicating uniform emergence and persistence throughout the crop growth period.

4.2.2 Plant height (cm)

Data in respect of mean plant height as influenced periodically by different treatments are presented in Table 9 and depicted graphically in Fig.3. Data revealed that mean plant height was progressively increased with advancing age up to harvest. Mean plant height during investigation was 23.16, 62.11, 84.22 and 85.74 cm at 30, 60, 90 DAS and at harvest, respectively. The rate of increase in plant height was slow up to 30 DAS, higher between 31- 90 DAS and again elongation was slower particularly between 91 DAS to at harvest.

Effect of Integrated nutrient management

The effect of various treatments onmean plant height was found to be non significant at 30 DAS.

The plant height of direct seeded rice was significantly influenced due to different treatments at 60, 90 DAS and at harvest.

Application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9). recorded significantly higher plant height over the application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1}) (T_2), 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_4), 100% RDF (125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8) and was at par with Application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_6). Application of 75% RDF

(93.75:46.87:46.87 kg NPK ha^{-1}) (T_1) recorded lowest value of plant height.

The increase in plant height might be due to additional supply of nutrients which increased the nutrient uptake and better translocation of nutrients. These results are in accordance with the findings of Singh *et al.* (2018) and Hanamant*et al.(*2019*)*

Table 9.Mean plant height(cm) of direct seeded riceas influenced by various treatments

Treatment		Plant height (cm)			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	23.3	57.3	76.6	77.0
T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})	23.0	60.0	78.3	79.7
T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})	23.0	61.7	81.6	83.0
T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	21.1	59.3	79.7	80.3
T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	23.5	61.0	85.3	86.7
T_6	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	23.7	67.7	90.3	93..3
T_7	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	23.2	58.3	84.0	85.0
T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	24.9	62.7	87.0	89.0
T_1	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	24.0	71.0	95.0	99.7
	SEm±	1.33	1.28	2.36	2.31
	C.D.(5%)	NS	3.58	7.08	6.93
	GM	23.2	62.1	84.2	85.7

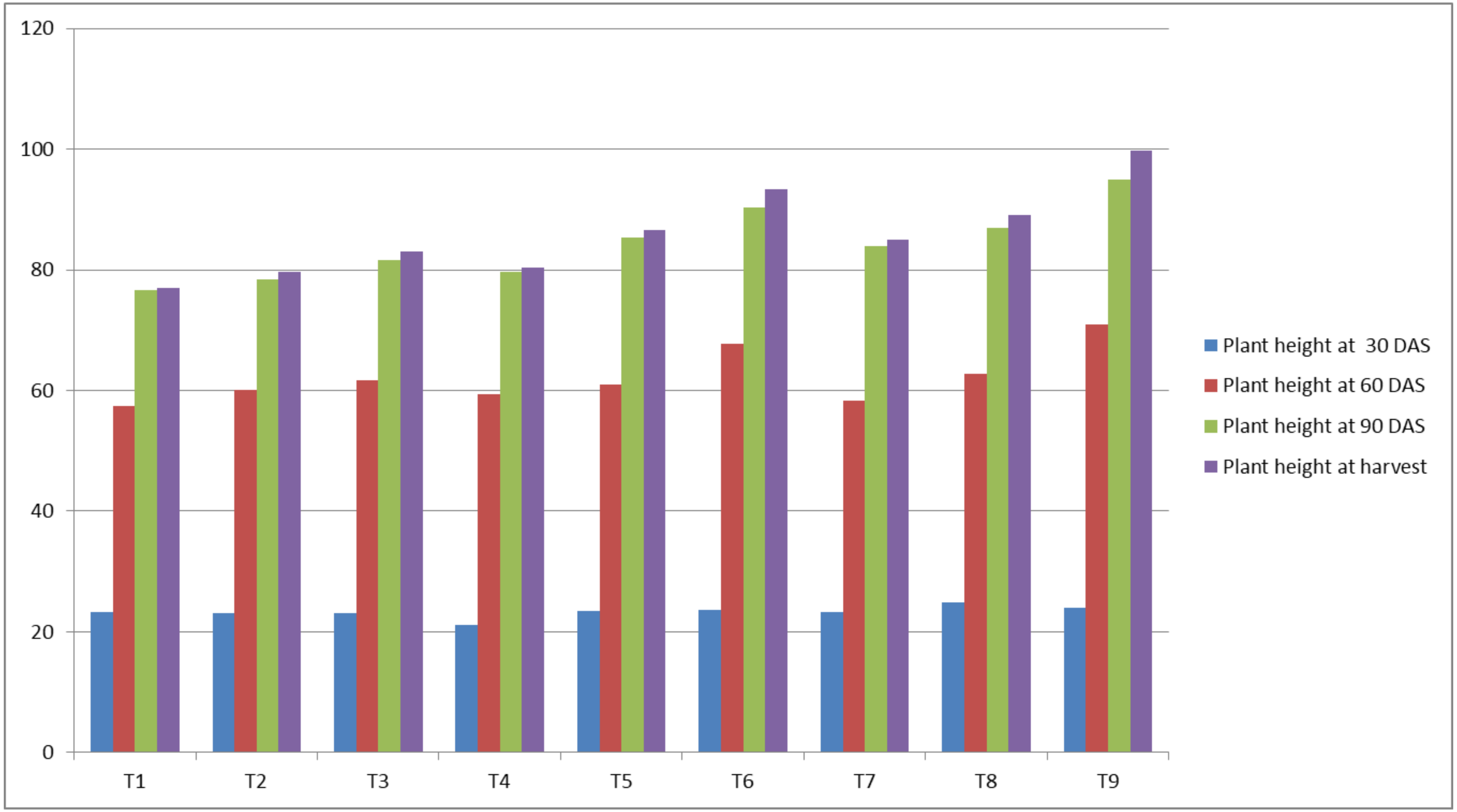


Fig.3.Mean plant height of direct seeded rice at 30,60,90 DAS and at harvest

4.2.3 Number of tillers plant^{-1}

Data on mean number of tillers plant^{-1}as influenced periodically by various treatments are presentedin Table 10 and graphically depicted in Fig. 4 .Mean number of tillers plant^{-1}wereincreased progressively from 30 to 90 DAS. The rate of increase was higher during 30 to 60 DAS and declined towards maturity. The mean number of tillers plant^{-1} at harvest was 12.84.

Effect of integrated nutrient management

The data on mean number of tillers plant^{-1}recorded at regular interval indicated that the mean number oftillersplant^{-1} increased up to 60 DAS and declined with advancement in age. Number of tillersplant^{-1}significantly influenced due to various treatments at all observations except at 30 DAS.

Application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) recorded significantly higher number of tillersover the application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), but was at par with application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6)at 60, 90 DAS and at harvest.Thelowernumber of tillers plant^{-1}was recorded with Application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

The increase in number of tillers might be due to improved growth of morphological character like plant height resulted in a greater number of tillers plant^{-1}. The results have got close conformity with the findings of Singh *et al*. (2018) and) Poornima *et al*., (2019).

Table10.Mean number of tillers plant^{-1} of direct seeded riceas influenced by various treatments

Treatment		Number of tillers plant^{-1}			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	3.12	6.40	9.75	9.68
T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})	3.05	7.00	10.30	10.20
T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})	3.02	8.13	12.27	12.23
T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	3.03	7.60	11.32	11.23
T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	3.84	9.03	14.17	14.13
T_6	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	3.45	10.42	15.00	14.93
T_7	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	3.07	8.50	13.33	13.27
T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	3.96	9.62	14.53	14.47
T_9	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	3.24	10.83	15.45	15.40
	SEm±	0.29	0.15	0.20	0.18
	C.D.(5%)	NS	0.45	0.60	0.54
	GM	3.31	8.61	12.90	12.84

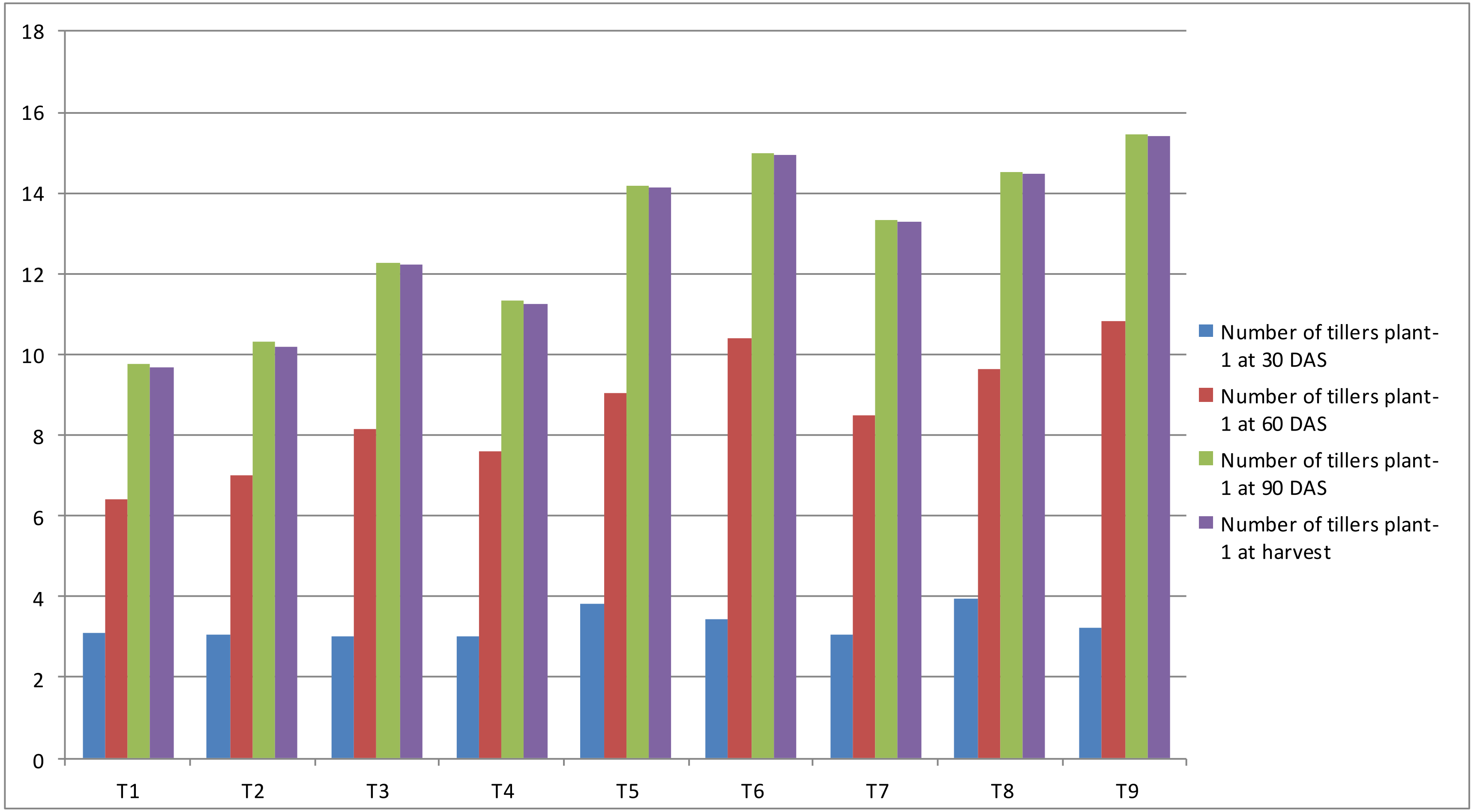


Fig.4 Mean number of tillers plant^{-1} of direct seeded rice at 30,60,90 DAS and at harvest

4.2.4 Dry matter accumulation plant^{-1}(g)

Data regarding mean dry matter accumulation plant^{-1} as influenced periodically by various treatments are presented in Table 11 and graphically depicted in Fig. 5. The mean dry matter accumulation plant^{-1} increased progressively upto harvest and the increase was remarkable from flowering to harvest.The mean dry matter accumulation plant^{-1} at harvest was 15.74 g.

Effect of integrated nutrient management

The data on dry matter accumulation plant^{-1} indicated that the mean dry matter accumulation plant^{-1} (g) significantly influenced by various treatments at 60, 90 DAS and at harvest except 30 DAS.

At 60, 90 DAS and at harvest theapplication of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) recorded significantly maximum dry matter accumulation plant^{-1} over the application of75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), but was at par with 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6).and was at par with treatment application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_3). The lowest dry matter accumulation plant^{-1} was recorded in 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

The increase in dry matter production might be due to beneficial effect of integrated nutrient management. The results are in close confirmationwith the results of Singh*et al.* (2018)

Table 11.Mean dry matter accumulation plant^{-1}(g) direct seeded rice as influenced by various treatments

Treatment		Dry matter accumulation plant^{-1} (g)			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	4.60	5.72	8.09	11.70
T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})	4.72	6.10	8.89	12.95
T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})	4.65	6.72	9.65	14.65
T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	4.55	6.42	9.73	13.40
T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	4.75	7.35	11.07	16.65
T_6	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	4.80	7.90	14.17	18.72
T_7	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	4.60	7.03	10.53	16.07
T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	4.78	7.65	13.05	17.28
T_9	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	4.83	8.13	14.53	19.45
	SEm±	0.21	0.13	0.23	0.31
	C.D.(5%)	NS	0.39	0.69	0.93
	GM	4.70	7.00	11.08	15.65

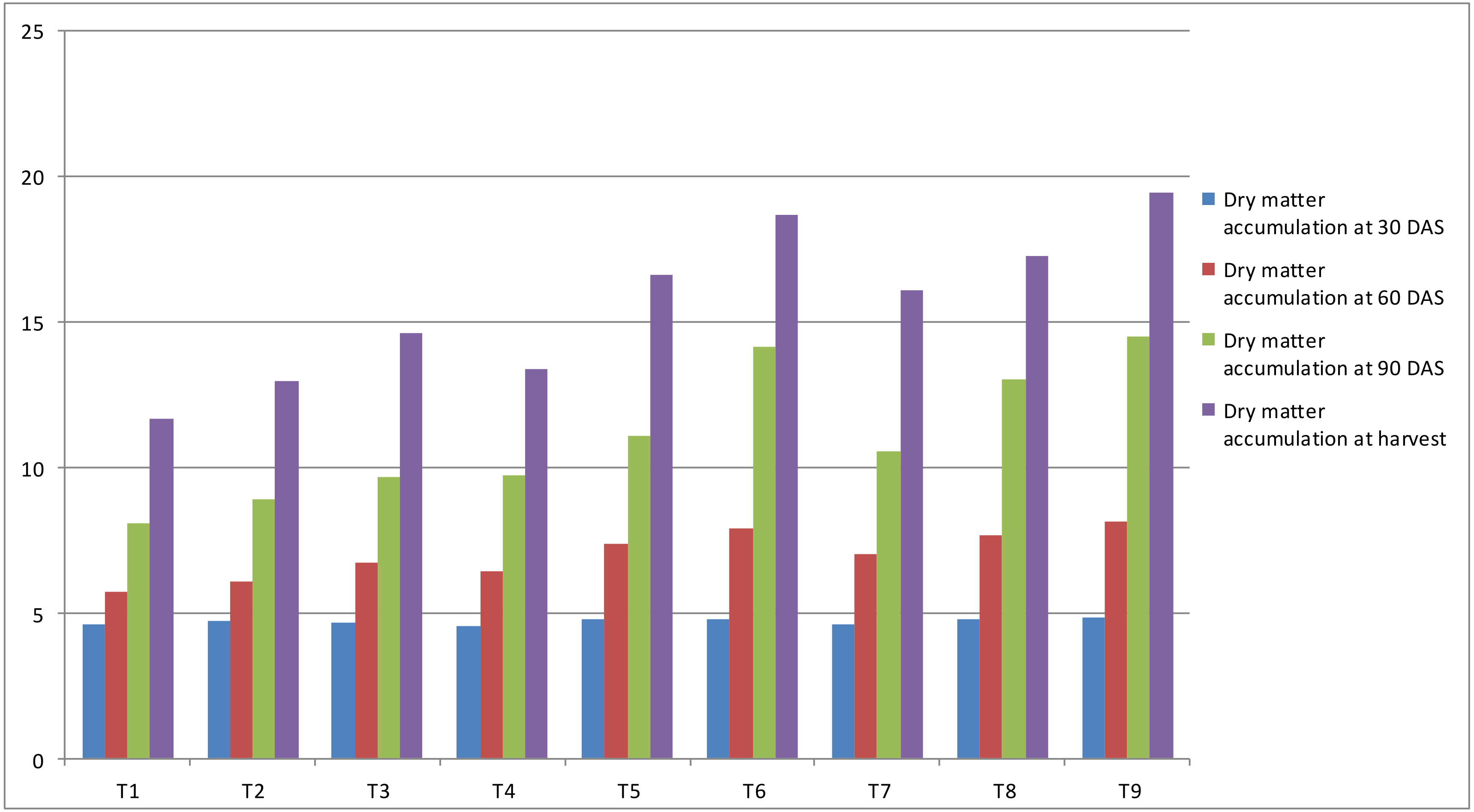


Fig.5 Mean Dry matter plant^{-1} (g)of direct seeded rice at 30,60,90 DAS and at harvest

4.2.5 Number of leaves plant^{-1}

Data on mean number of leaves plant^{-1}as influenced periodically by various treatments are presented in Table 12 and graphically depicted in Fig. 6 . Mean number of leaves plant^{-1}wereincreased progressively from 30 to 90 DAS. The rate of increase was higher during 30 to 60 DAS and declined towards maturity. The mean number of leaves plant^{-1} at harvest was 16.11.

Effect of integrated nutrient management

The data on mean number of leaves plant^{-1}recorded at regular interval indicated that the mean number of leavesplant^{-1} increased up to 90 DAS and declined with advancement in age. Number of leavesplant^{-1}significantly influenced due to various treatments at all observations except at 30 DAS.

Application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) recorded significantly higher number of leavesover the application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with treatment application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6). at 60, 90 DAS and at harvest. The lower number of leaves plant^{-1} was recorded withapplication of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

The increase in number of leaves might be due to improved growth of morphological character like plant height resulted in a greater number of leaves plant^{-1}. The results have got close conformity with the findings of Gawate *et.al*. (2020).

Table 12. Number of leaves plant^{-1}of direct seeded rice asinfluenced by various treatments

Treatment		Number of leaves plant^{-1}			
		30 DAS	60 DAS	90 DAS	At Harvest
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	4.30	10.43	10.82	10.77
T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})	4.83	11.73	11.90	11.85
T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})	4.50	13.07	15.33	15.23
T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	4.23	12.43	12.63	12.60
T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	4.80	14.15	18.07	17.97
T_6	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	4.63	15.50	20.03	19.93
T_7	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+ Azotobacter	4.73	13.77	16.93	16.85
T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+ Azotobacter	4.53	14.93	18.90	18.80
T_9	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+ Azotobacter	4.83	16.33	21.17	21.03
	SEm±	0.34	0.29	0.80	0.64
	C.D.(5%)	NS	0.88	2.39	1.93
	GM	4.60	13.59	16.20	16.11

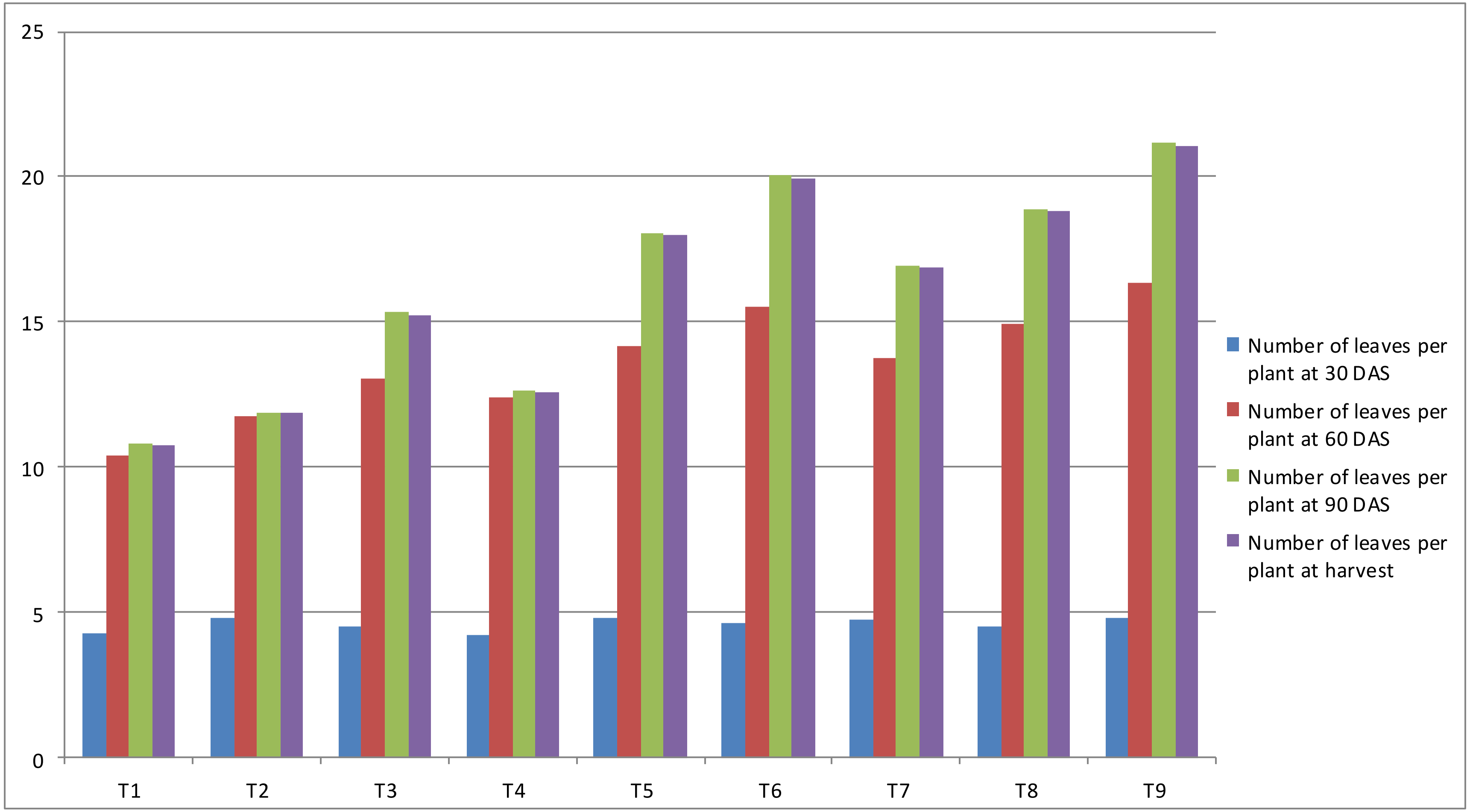


Fig.6 Mean number of Leavesplant^{-1} of direct seeded rice at 30,60,90 DAS and at harvest

4.2.6 Leaf area $(dm)^2$ and Leaf area index

Data pertaining to Leaf area $(dm)^2$and Leaf area index as affected by different treatment recorded at 30 DAS, 60 DAS, 90 DAS and at harvest have been summarized in Table no.13 and 14 and depicted in Fig. 7. It is evident from the data that Leaf area $(dm)^2$and Leaf area indexincreased with the advancement of crop growth up to harvests. The rate of increase was rather slow during initial crop growth period *i.e.* up to 30 DAS and increase up to harvest. It is obvious from the data that at 30 DAS various Integrated nutrient management practices had no significant effect on Leaf area $(dm)^2$and Leaf area index while at rest of the stage Leaf area $(dm)^2$and Leaf area index was affected significantly due to different Integrated nutrient management practices.

Data reveal that theapplication of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) recorded significantly maximum Leaf area $(dm)^2$and Leaf area index over the treatments of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) (T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) (T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6). and at 60, 90 DAS and at harvest. The lower Leaf area $(dm)^2$and Leaf area index was recorded with 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1)

Table 13. Leaf area (dm)^{2}of direct seeded rice asinfluenced by various treatments

Treatment		Leaf area (dm)^2			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	2.64	5.44	5.52	7.40
T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})	2.60	5.58	5.86	8.00
T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})	2.70	5.76	7.12	8.90
T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	2.74	5.92	6.50	8.54
T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	2.72	6.80	8.44	9.76
T_6	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	2.66	7.14	9.44	10.24
T_7	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+ PSB + Azotobacter	2.60	6.38	8.38	9.40
T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} + PSB + Azotobacter	2.76	6.92	8.96	10.20
T_9	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+ PSB + Azotobacter	2.74	7.28	9.94	10.84
	SEm±	0.12	0.12	0.06	0.32
	C.D.(5%)	NS	NS	0.18	0.96
	GM	2.68	2.68	6.36	7.80

Table 14. Leaf area indexof direct seeded rice as influenced by various treatments

Treatment		Leaf area index			
		30 DAS	60 DAS	90 DAS	At Harvest
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	1.34	2.72	2.76	3.70
T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})	1.30	2.79	2.93	4.00
T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})	1.35	2.88	3.56	4.45
T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	1.37	2.96	3.25	4.27
T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	1.36	3.40	4.22	4.88
T_6	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	1.33	3.57	4.72	5.27
T_7	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 tha^{-1}+ PSB + Azotobacter	1.30	3.18	4.19	4.70
T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} + PSB + Azotobacter	1.38	3.46	4.48	5.10
T_9	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+ PSB + Azotobacter	1.37	3.64	4.97	5.43
	SEm±	0.09	0.03	0.16	0.09
	C.D.(5%)	0.27	0.09	0.48	0.27
	GM	4.64	3.18	3.90	4.64

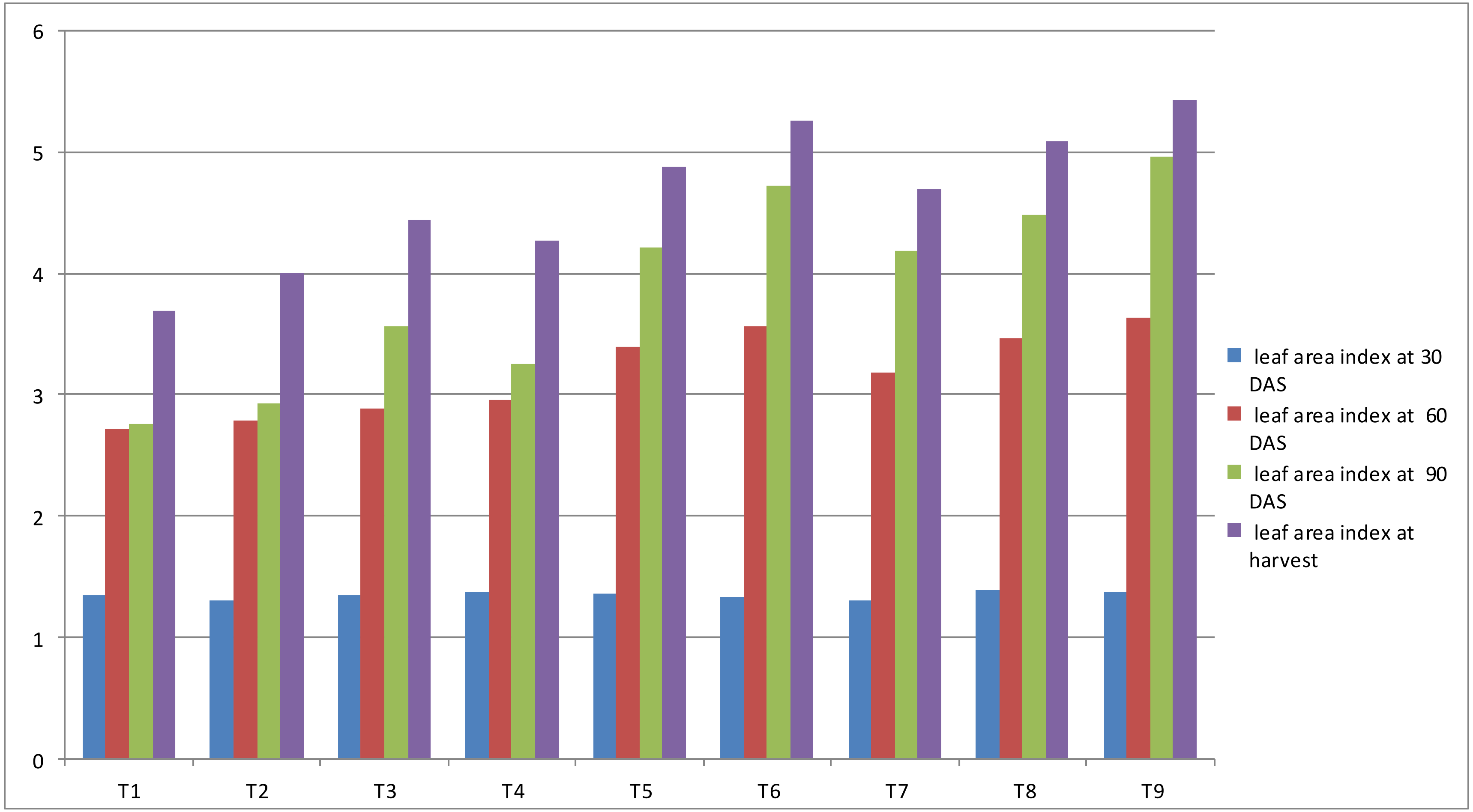


Fig.7 Mean leaf area index of direct seeded rice at 30,60,90 DAS and at harvest

4.3 Post harvest studies

4.3.1 Yield attributes

In the present investigation data on yield attributes *viz.,*length of panicles plant^{-1},grain yield plant^{-1} (g), straw yield plant^{-1} (g) and test weight (g) as influenced by various treatments are presented in Table 15.

4.3.2 Length of panicle plant^{-1} (cm)

Data pertaining to mean length of panicle plant^{-1}(cm) at harvest as influenced by different treatments are presented in Table 15 and graphically depicted in Fig. 8. Mean length of panicles at harvest was 24.42 cm.

Effect of integrated nutrient management

Data presented in Table 15 indicate that significantly maximum length of panicles plant^{-1}(27.67 cm) observed under application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-}1+PSB+Azotobacter (T_9) over the application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6) at harvest. The minimum length of panicle(20.37 cm) was recorded with 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

Application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter resulted in increased length of panicles.The results are in consonance with Poornima malviya *et al.*(2018).

4.3.3 Number of grains panicle^{-1}

Data pertaining to mean number grainspanicle^{-1} at harvest as influenced by different treatments are presented in Table 15 and graphically depicted in Fig. 8 Mean number of grains panicle^{-1}at harvest was 156.

Effect of integrated nutrient management

Data pertaining to number of grains panicle^{-1} are presented in Table 15 and illustrated in Fig. 8. reveals that the application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) recorded significantly maximum number of grains panicle^{-1} (190) over the application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) (T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) (T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with the application of125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6). at harvest. The lower number of grains panicle^{-1}(122) was recorded with 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

Application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter resulted in increased number of grains panicle^{-1}. The results are in consonance with Hanamant *et al*. (2019).

4.3.4 Grain yield plant^{-1} (g)

Data related to grain yield plant^{-1} (g) at harvest as influenced by various treatments are presented in Table 15 and graphically depicted in Fig.8. Mean grain yield plant^{-1} was 6.71 g.

Effect of integrated nutrient management

Data presented in Table 15 revealed that grain yield plant^{-1} (g) was significantly influenced due to application of Integrated nutrient management theapplication of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) recorded significantly maximum grain yield plant^{-1} overthe treatments of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6).

Application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter resulted in increased ingrain yield (8.98 g) plant^{-1}. The results are in consonance with Hanamant *et al*. (2018) and Gawate *et al*.(2020).

4.3.5 Straw yield plant^{-1} (g)

Data related to straw yield plant^{-1} (g) at harvest as influenced by various treatments are presented in Table 15 and graphically depicted in Fig. 8. Mean straw yield plant^{-1} was 8.93 g.

Effect of integrated nutrient management

Data presented in Table 15 revealed that straw yield plant^{-1} (g) was significantly influenced due to application of Integrated nutrient management. The application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) recorded significantly maximum straw yield (10.50 g) plant^{-1} over application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8) and was at par with treatment application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6) at harvest. The lower straw yield (7.20 g) plant^{-1} (g) was recorded with 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1)

The results so obtained are in confirmative with the findings of Singh *et al*.(2018) and Gawate *et al*.(2020).

Table 15. Length of panicles plant-^{1} (cm), Number of grains panicle-^{1}, grain yield plant-^{1} (g) and straw yield plant-^{1}(g)

Treatment		Length of panicle (cm)	Number of grains panicle^{-1}	Grain yield plant^{-1} (g)	Straw yield plant^{-1} (g)
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	20.37	122	4.68	7.20
T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})	21.90	130	5.20	7.70
T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})	24.10	149	6.15	8.58
T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	22.88	141	5.35	8.05
T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	25.38	163	7.22	9.38
T_6	125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	26.93	186	8.42	10.20
T_7	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} + PSB + Azotobacter	24.43	155	6.70	7.35
T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} + PSB + Azotobacter	26.10	171	7.68	9.50
T_9	125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} + PSB + Azotobacter	27.67	190	8.98	10.50
	SEm±	0.33	2.96	0.39	0.32
	C.D.(5%)	1.00	8.88	1.17	0.96
	GM	24.42	156	6.71	8.93

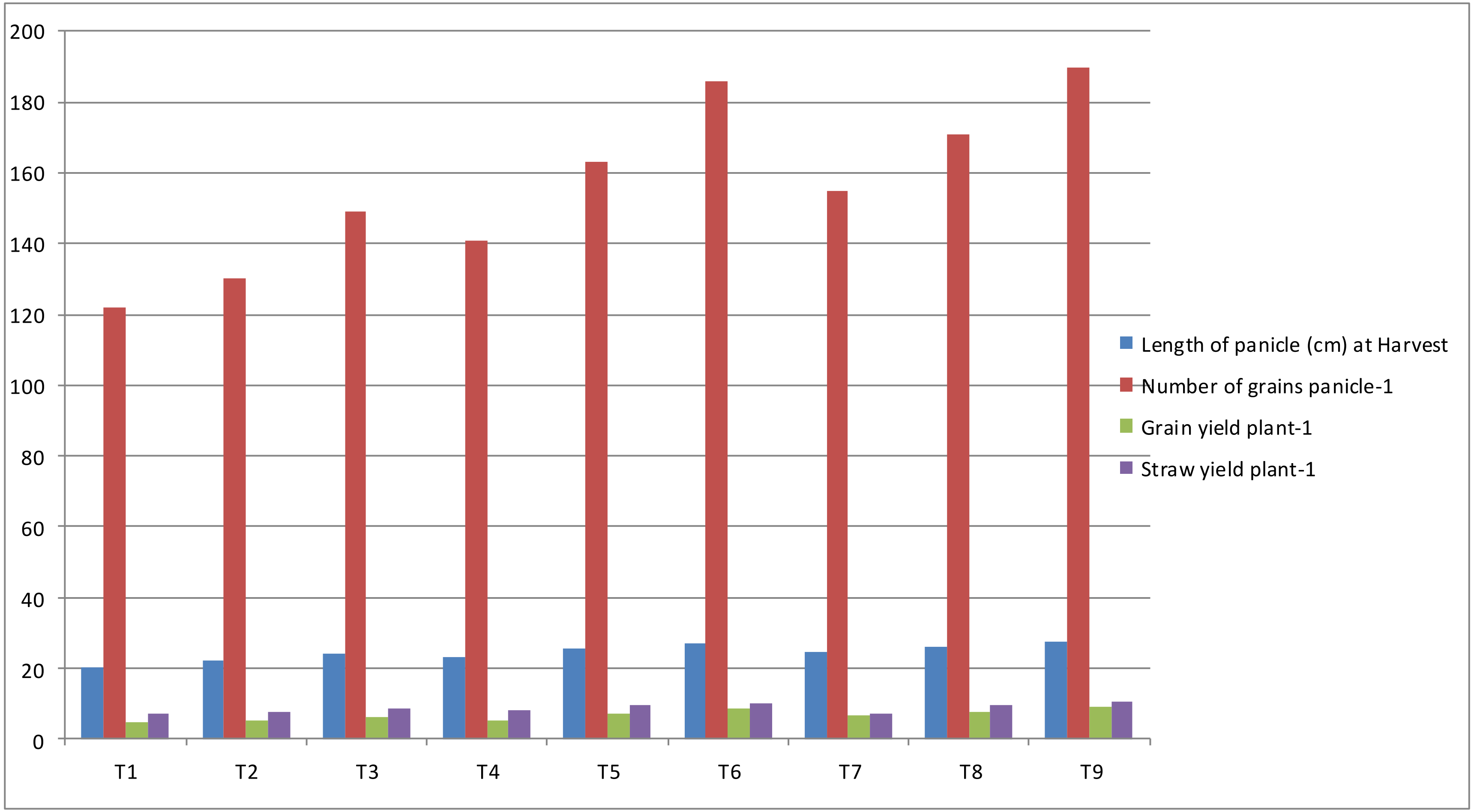


Fig.8 Length of panicles plant-[1] (cm), Number of grains panicle-[1], grain yield plant-[1] (g) and straw yield plant-[1](g)

4.3.6 Number of effective tillers $plant^{-1}$

Data pertaining to mean Number of effective tillers $plant^{-1}$ at harvest as influenced by different treatments are presented in Table 16. Mean Number of effective tillers $plant^{-1}$ was 12.84.

Effect of integrated nutrient management

Data presented in Table 16 indicated that significantly maximum number of effective tillers $plant^{-1}$ observed under application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter(T_9) over the application of75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8) and was at par with application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6) at harvest. The lower Number of effective tillers $plant^{-1}$ was recorded with application 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

Application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter resulted in increased number of effective tillers $plant^{-1}$.The results are in consonance with Poornima *et al.*(2019).

4.3.7 Test weight (g)

Data regarding mean test weight influenced by integrated nutrient managementare presented in Table 16 . Mean test weight was 24.31 g.

Effect of integrated nutrient management

The data revealed that test weight of rice was not significantly influenced due to integrated nutrient management. However, the application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+ Azotobacter(T_7) recorded numerically higher testweight (24.67g) as compare to rest of the treatments. The lower test weight (24.03) was recorded in 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4).

Table 16. Number of effective tillers $plant^{-1}$ and test weight (g) of direct seeded rice as influenced by various treatments

Treatment		Number of effective tillers $plant^{-1}$	Test weight (g)
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	9.68	24.03
T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})	10.20	24.17
T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})	12.23	24.33
T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	11.23	24.00
T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	14.14	24.13
T_6	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	14.93	24.47
T_7	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	13.27	24.73
T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	14.47	24.27
T_9	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	15.40	24.67
	SEm±	0.18	0.47
	C.D.(5%)	0.54	NS
	GM	12.84	24.31

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

Data pertaining to grain yield (kg ha^{-1}) of direct seeded rice as influenced by various treatments are presented in Table 17 and graphically depicted in Fig. 9. Mean grain yield of direct seeded rice was 2715 kg ha^{-1}.

Effect of integrated nutrient management

The data presented in Table 16 revealed that the grain yield (kg ha^{-1}) was significantly influenced due to Integrated nutrient management.Amongst, the treatment application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} + PSB + Azotobacter (T_9) recorded significantly highest grain yield (3634 kg ha^{-1}) over the treatments of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1), 100% RDF (125:62.5:62.5 kg NPK ha^{-1}) (T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) (T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} + PSB + Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} + PSB + Azotobacter (T_8), and was at par with application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6) at harvest. The lower grain yield (1855 kg ha^{-1}) was recorded with 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

Increase in direct seeded rice grain yield due to integrated nutrient management mighthave increased due to growth parameters like plant height, number of tillers plant^{-1} and dry matter accumulation plant^{-1} which ultimately increased yield parameters like length ofpanicles and grain yield plant^{-1}. The results are in agreements with Gawate *et al.* (2020) and Hanamant *et al*. (2019).

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

Data pertaining to straw yield (kg ha^{-1}) of direct seededrice as influenced by various treatments are presented in Table 17 and graphically depicted in Fig. 9. Mean straw yield of direct seeded rice was 3628 kg ha^{-1}.

Effect of integrated nutrient management

The data presented in Table 17 revealed thatthe straw yield of direct seeded rice significantly influenced by integrated nutrient management.Amongst,theapplication of125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter(T_9) recorded significantly highest straw yield (4258kg ha^{-1}) over the application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1), 100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with T_6(4197 kg ha^{-1}) i.e application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}. The lower straw yield (2875 kg ha^{-1}) was recorded with 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

Results are in accordance with the results recorded Poornima *et al.*(2019).

4.3.10 Biological yield (kg ha^{-1})

Data pertaining to Biological yield(kg ha^{-1}) of direct seededrice as influenced by various treatments are presented in Table 17 and graphically depicted in Fig. 9. Mean Biological yield of direct seeded rice was 6343 kg ha^{-1}.

Effect of integrated nutrient management

The data presented in Table 17 revealed thatthe biological yieldof direct seeded rice significantly influenced by integrated nutrient management. Amongst, the treatments, application of125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter(T_9) recorded significantly highest biological yield (7892kg ha^{-1}) over the application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with T_6 (7666 kg ha^{-1}) i.e application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}. The lowestbiological yield(4730 kg ha^{-1})was recorded with 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

Results are in accordance with the results recorded by Poornima *et al.* (2019).

4.3.11 Harvest index (%)

Data pertaining to harvest index of direct seeded rice as influenced by various treatments are presented in Table 17. The mean harvest index obtained was 42.41%.

Effect of integrated nutrient management

Application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) recorded highest harvest index (46.04%) followed by (T_6) 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(45.22%). Lowest harvest index was recorded with application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})(T_1)(39.21%). Results are in accordance with the reported by Poornima *et al.* (2019).

Table 17. Grain yield (kg ha^{-1}), straw yield (kg ha^{-1}), Biological Yield (kg ha^{-1}) and harvest index (%) of direct seeded rice as influenced by various treatments

Treatment		Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	1855	2875	4730	39.21
T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})	2087	3144	5231	39.89
T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})	2450	3479	5929	41.32
T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	2146	3233	5379	39.89
T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	2890	3817	6707	43.07
T_6	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	3469	4197	7666	45.23
T_7	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	2772	3797	6569	42.19
T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	3136	3851	6987	44.88
T_9	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	3634	4258	7892	46.04
	SEm±	160	122	230	-
	C.D.(5%)	480	366	689	-
	GM	2715	3628	6343	42.41

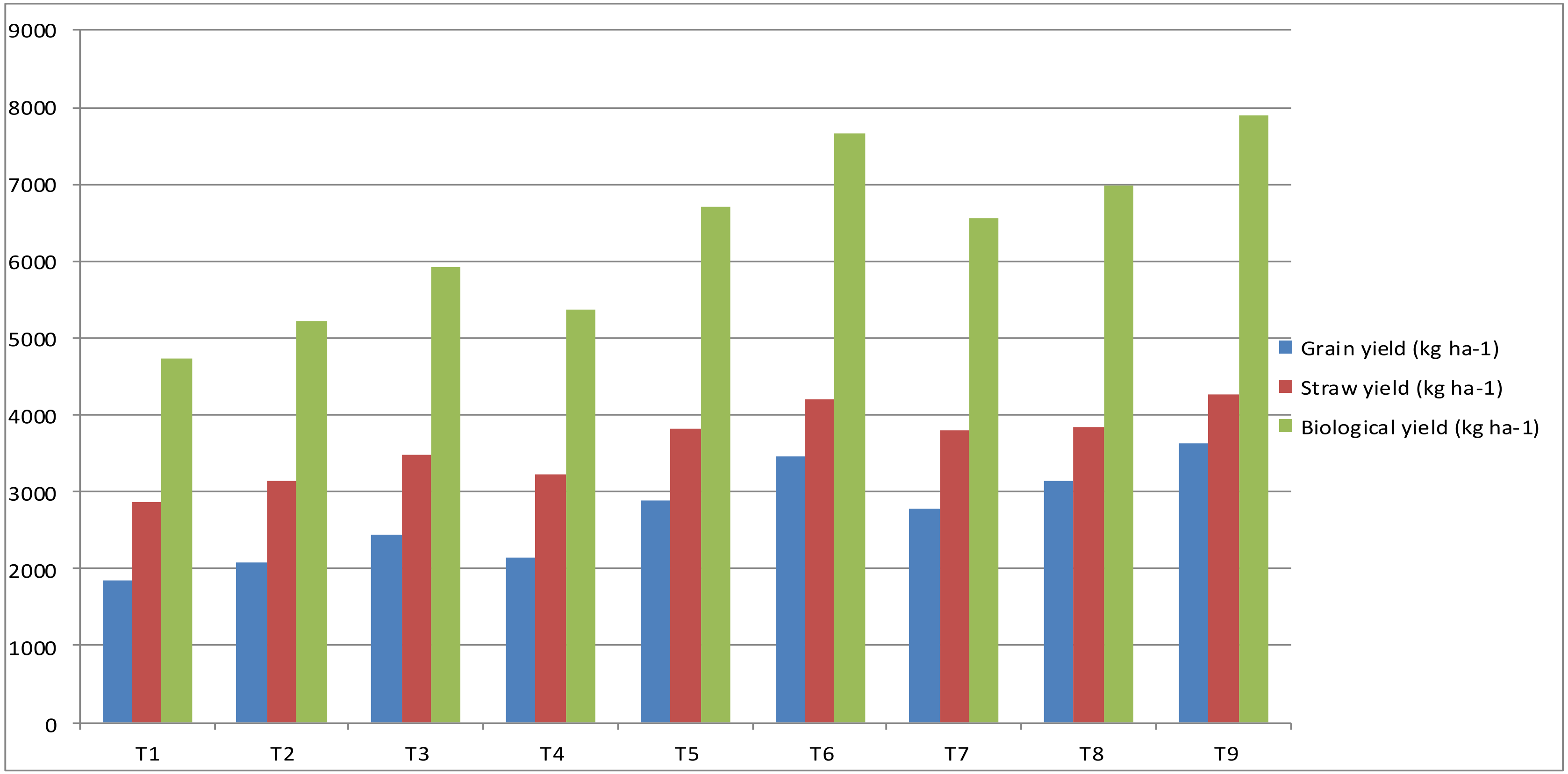


Fig.9 Grain yield (kg ha^{-1}), straw yield (kg ha^{-1}), Biological Yield (kg ha^{-1}) and harvest index (%) of direct seeded rice as influenced by various treatment

4.3.12 Protein content (%)

Data pertaining to protein content of direct seeded rice as influenced by various treatments are presented in Table 18. and graphically depicted in Fig. 10. Mean protein content of rice was 6.95%.

Effect of integrated nutrient management

The data presented in Table 18 revealed that protein content (%) was not influenced significantly due to various treatments. Theapplication of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) recorded significantly highest protein content (7.06%) over the application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) (T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) (T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8). The lower protein content (6.91 %) was recorded with 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

Similar Results are in close confirmation with the findings of Yadav and Singh (2016)

4.3.13 Protein yield (kg ha^{-1})

Data pertaining to protein yield (kg ha^{-1}) of direct seeded rice as influenced by various treatments are presented in Table 18.Mean Protein yield of rice was 189 kg ha^{-1} and graphically depicted in Fig. 10.

Effect of integrated nutrient management

The data presented in Table 18 revealed that protein yieldwere influenced significantly due to various treatments. Theapplication of

125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) recorded significantly highest protein yield (257 kg ha^{-1}) over the treatments of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) (T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) (T_3), 75%RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8) and was at par with treatment application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6).The lower protein yield (128 Kg ha^{-1})was recorded with 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

Similar results are in close confirmation with the findings of Yadav and Singh (2016).

Table 18. Protein content and protein yield of direct seeded rice as influenced by various treatments

Treatment		Protein Content (%)	Protein yield (kg ha^{-1})
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	6.91	128
T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})	6.91	144
T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})	6.92	170
T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	6.94	149
T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	6.93	200
T_6	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	7.00	243
T_7	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	6.94	192
T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	6.94	218
T_9	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	7.06	257
	SEm±	-	11.12
	C.D.(5%)	NS	33.35
	GM	6.95	189

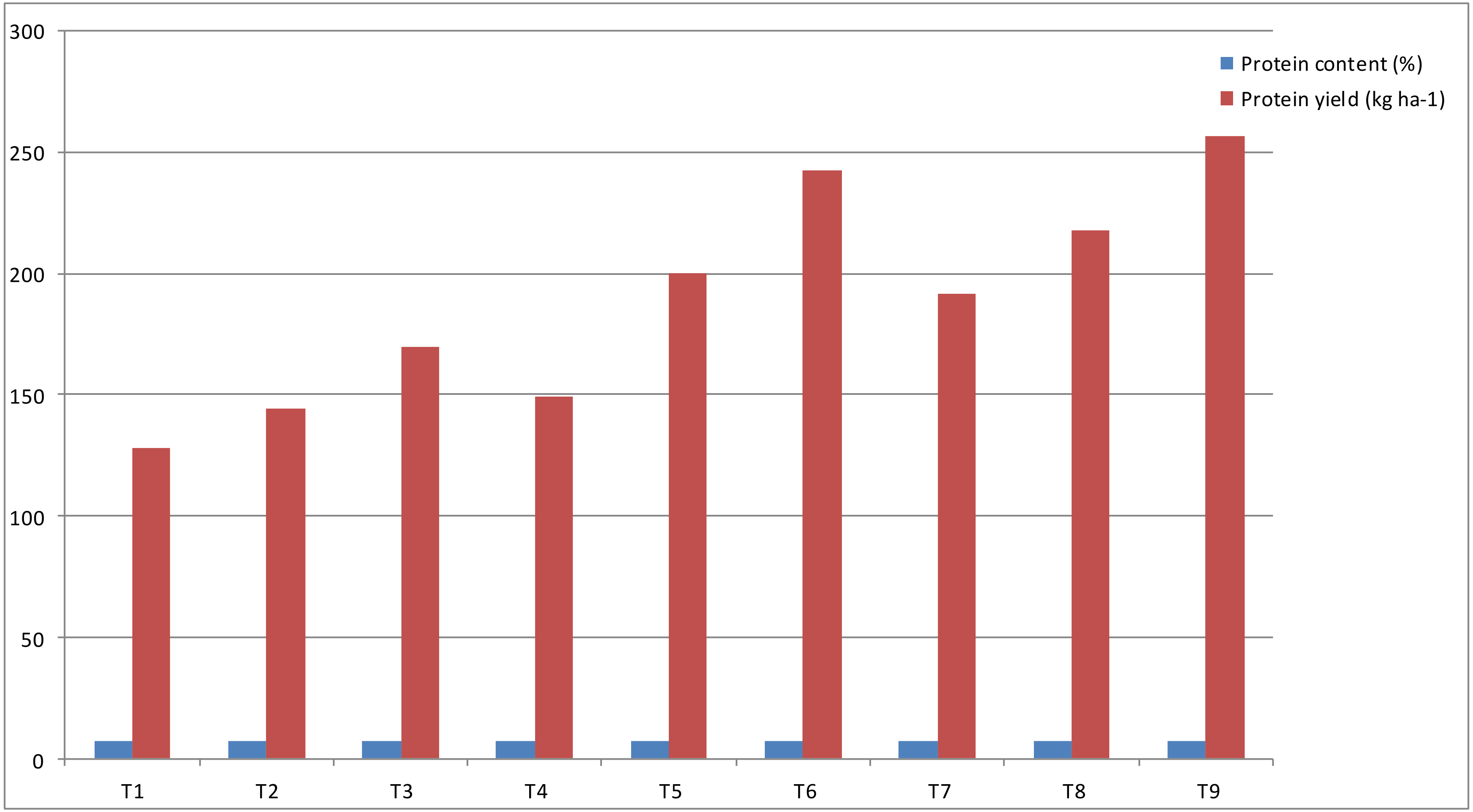


Fig.10 Protein content and protein yieldof direct seeded rice as influenced by various treatments

4.4 Economics

4.4.1 Cost of cultivation (Rs. ha^{-1})

The cost of cultivation of direct seeded rice recorded lowest in application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1) was (Rs. 27666ha^{-1}) and the maximum in (T_9) 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacterwas (Rs 38869 ha^{-1}).

4.4.2 Gross monetary returns (Rs. ha^{-1})

Data pertaining to gross monetary returns as influenced by various treatments are presented in Table 19. Mean gross monetary returns received was Rs. 69525 ha^{-1}.

Effect of integrated nutrient management

The data presented in Table 18 revealed that gross monetary returns were influenced significantly due to various treatments.The application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter(T_9) registered significantly highest gross monetary returns of Rs. 91166ha^{-1}over the application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6). The lowestGross monetary returns (Rs 49342 ha^{-1}) was recorded with 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

This might be due to higher yield obtained as a result of integrated nutrient management. The results are in confirmation with the findings of Gawate *et al.* (2020).

4.4.3 Net monetary returns (Rs. ha^{-1})

Data regarding net monetary returns as influenced by various treatments are presented in Table 19. Mean net monetary returns obtained was Rs. 36102 ha^{-1}.

Effect of integrated nutrient management

Net monetary returns were influenced significantly due to various treatments. The data revealed that significantly highest net monetary returns were recorded with application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter(Rs. 52297 ha^{-1}) over the application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with treatment of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}.The lowestnet monetary returns (Rs 21676 ha^{-1})was recorded with 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1).

The results are in confirmation with the findings of Gawate *et al.* (2020).

4.4.4 B: C ratio

Data pertaining to benefit cost ratio is presented in Table 19. Mean benefit cost ratio was found to be 2.05.

Effect of integrated nutrient management

Data presented in Table 19 indicates that the higher benefit cost ratio 2.34 was registered highest inapplication of125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}+ Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter(T_9)(2.35) and application of 125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}(T_6)(2.35) over the application of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+ Azotobacter (T_8). and the lowestbenefit cost ratio was obtained with 75% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}(T_4)(1.68).

Similar results were also reported by Gawate *et al* (2020).

Table 19. Gross monetary returns (Rs. ha^{-1}), net monetary returns (Rs. ha^{-1})and B: C ratio of direct seeded rice asinfluenced by various treatments

	Treatments	Cost of cultivation (Rs. ha^{-1})	GMR (Rs. ha^{-1})	NMR (Rs. ha^{-1})	B:C ratio
T_1	75%RDF (93.75:46.87:46.87 kg NPK ha^{-1})	27666	49342	21676	1.78
T_2	100% RDF through chemical fertilizers (125:62.5:62.5 kg NPK ha^{-1})	29479	55151	25672	1.87
T_3	125 % RDF through chemical fertilizers (156.25:78.12:78.12 kg NPK ha^{-1})	31287	63896	32609	2.04
T_4	75% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}	33666	56710	23044	1.68
T_5	100% RDF through chemical fertilizers+ Vermicompost @ 2 t ha^{-1}	35479	74360	38881	2.09
T_6	125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}	37287	87556	50269	2.34
T_7	75% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	34416	71737	37321	2.08
T_8	100% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	36229	79378	43149	2.19
T_9	125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	38869	91166	52297	2.34
	S.E. (m)±		3398	3398	-
	C.D.at 5%		10191	10191	-
	GM		69525	36102	2.04

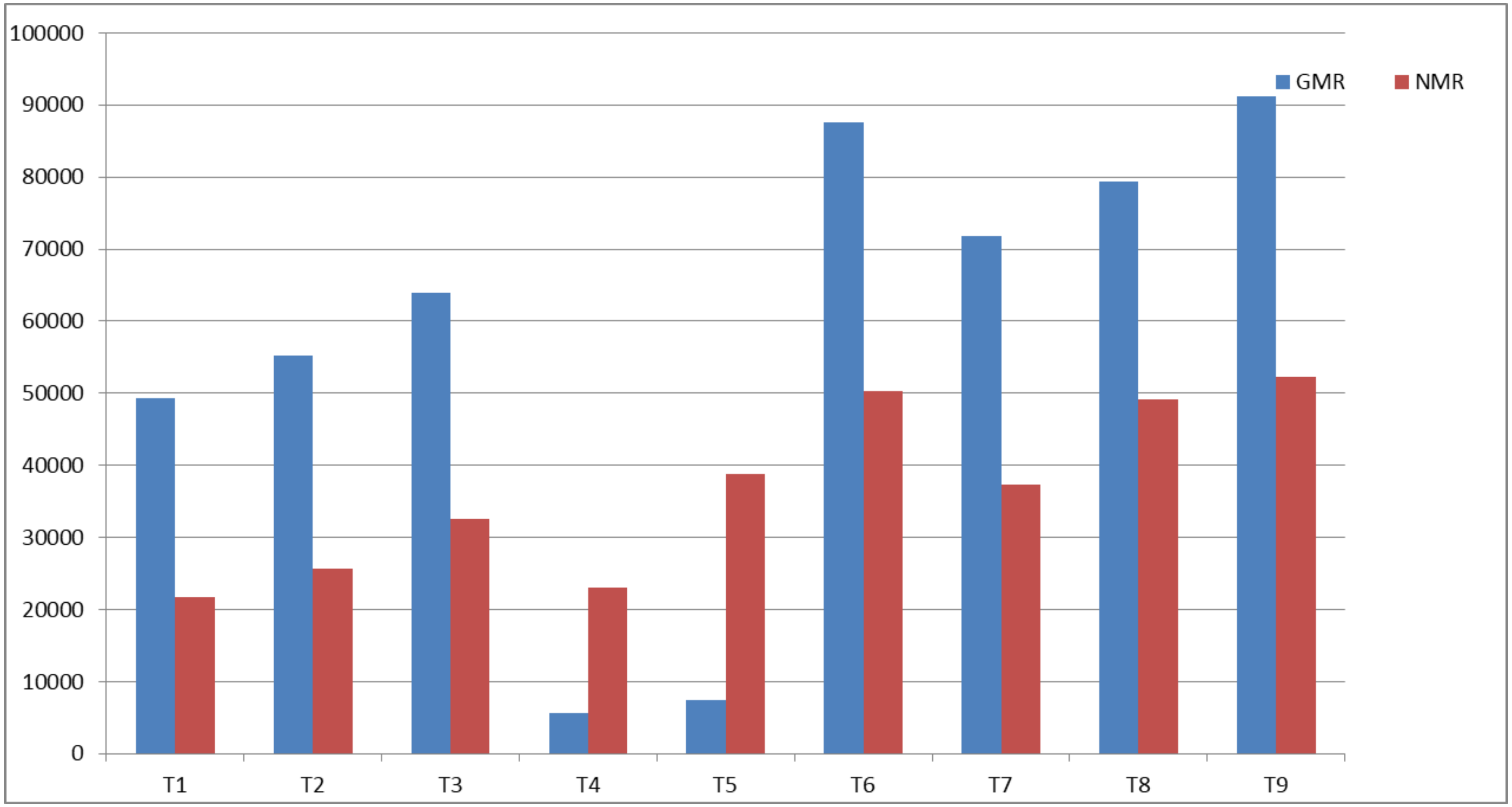


Fig.11 Gross monetary returns (Rs. ha^{-1}) and net monetary returns (Rs. ha^{-1}) of direct seeded rice asinfluenced by various treatments

4.5 Effect of integrated nutrient management on nutrient content and uptake of nutrients by direct seeded rice.

4.5.1 Content and uptake of nitrogen

The data in relation to content and uptake of nitrogen by direct seeded rice as influenced by various treatments are presented in Table 20.

Non-significant result were found the content of nitrogen in grain and straw varies from 1.105 to 1.13 % in grain and 0.38 to 0.56 % in straw. Higher content of nitrogen in grain (1.13 %) and straw by rice (0.56 %) was recorded with the application of 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment (T_9). The lowest nitrogen content in grain (1.105%) and straw (0.38 %) was recorded in control treatment (T_1). It was also noticed that the content of nitrogen is higher in grain than straw.

The data in relation to uptake of nitrogen was found to vary from 20.50 to 41.07 kg ha^{-1} in grain and 10.93 to 23.85 kg ha^{-1} in straw. Significantly higher uptake of nitrogen by grain (41.07 kg ha^{-1}) was recorded with the application of 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment (T_9) and was on par with T_6 (38.85 kg ha^{-1}) received 125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}. Significantly higher uptake of nitrogen by straw (23.85 kg ha^{-1}) was recorded with the application of 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment (T_9) and was on par with T_6 (23.08 q ha^{-1}) received 125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}. The lowest uptake of nitrogen by grain (20.50 kg ha^{-1}) and straw (10.93 kg ha^{-1}) was recorded in Treatment (T_1).

The nutrient management practices also significantly influenced the total N uptake by grain and straw and maximum total N uptake was observed in 125% RDF through chemical fertilizers + Vermicompost @

2 t ha^{-1} + Azotobacter + PSB seed treatment (T_9)(64.92 Kg ha^{-1}) and was on par with T_6 (61.93 kg ha^{-1}) received 125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}. Minimum total N uptake 31.43 Kg $ha^{-1}$was observed under (T_1). This may be due to higher biomass of rice in respective treatments.

A critical observation of the data reveals that the performance of treatment 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment (T_9) in general, was better over other treatments in increasing the uptake of N in direct seeded rice. The highest N uptake was associated with treatment of soil test based N application and vermicompost (Singh *et al* . 2006). This might be due to added fertilizers, vermicompost and biofrtilizers as a result better availability of N in soil to the rice crop. The lowest N uptake in treatment (T_1) plot by the crops is due to the lower yield obtained in these plots. The application of organics and chemical fertilizers increased crop yields that resulted in increased uptake. The increase in nutrient uptake was directly related to the crop yields. It can be explained on the basis that application of fertilizers along with manures improved initial process of plant growth such as cell division, number of root hairs etc. The healthy root system might have helped the plant in better absorption of nutrients and moisture from soil (Subehia and Sepehya, 2012). Similar trend was reported by Kumar *et al*., (2014).

Table 20: Nitrogen Content(%) and nitrogen (kg ha^{-1}) uptake influenced byvarious treatment indirect seeded rice

Treatments		Nitrogen Content (%)		Nitrogen uptake (kg ha^{-1})		
		Grain	Straw	Grain	Straw	Total
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	1.105	0.38	20.50	10.93	31.4
T_2	100% RDF through chemical fertilizers (125:62.5:62.5 kg NPK ha^{-1})	1.105	0.45	27.03	14.14	37.2
T_3	125 % RDF through chemical fertilizers (156.25:78.12:78.12 kg NPK ha^{-1})	1.107	0.45	27.13	15.65	42.8
T_4	75% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}	1.110	0.47	23.82	15.19	39.0
T_5	100% RDF through chemical fertilizers+ Vermicompost @ 2 t ha^{-1}	1.108	0.51	32.02	19.47	51.2
T_6	125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}	1.12	0.55	38.85	23.08	61.9
T_7	75% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	1.11	0.53	30.76	20.12	50.9
T_8	100% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	1.11	0.54	34.80	20.79	55.6
T_9	125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	1.13	0.56	41.07	23.85	64.9
	S.E. (m)±	-	-	1.10	0.54	1.86
	C.D. at 5%	-	-	3.30	1.62	5.59
	GM	1.11	0.49	29.27	15.69	44.9

4.5.2 Phosphorus content and uptake of phosphorus

The data in relation to content and uptake of phosphorus by rice as influenced by various treatments are presented in Table 21.

The non-significant difference was noticed in phosphorus content in the plants supplied with inorganic fertilizers and integrated nutrient management. Higher content of phosphorus in grain (0.24 %) of rice was recorded in treatment T_9 i.e., application of 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment with non-significant higherdifferences content of phosphorus in straw (0.1%)was recorded in treatment T_9 i.e., application of 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment. Lowest content of phosphorus in grain (0.22 %) and straw (0.06 %) was recorded in (T_1).

Significantly higher uptake of phosphorus by rice grain (8.72 kg ha^{-1}) and straw (4.25 kg ha^{-1}) was recorded with the application of 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment (T_9) and it was on par with the treatmentsof apllication of 125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}(T_2)in grain. The lowest uptake of phosphorus by grain (4.08 kg ha^{-1}) and straw (1.72 kg ha^{-1}) was recorded in (T_1).

The nutrient management practices had also significantly influenced the total P uptake with maximum uptake in 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment (T_9) and minimum under (T_1). This may due to higher biomass production of rice in different treatments. Through P content in grain was influenced by the treatments, the increase in grain and straw yields had reflected in higher P uptake.

A critical observation of the data reveals that the performance of treatments 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment (T_9), in general, was better over other treatments in increasing the uptake of P in direct seeded rice. This might be due to the soil containing higher phosphorus level by the addition of P through fertilizers and vermicompost which are larger sources of P and application of PSB. These treatments might have ensured steady supply throughout the growth period of crop due to increased P availability. Kumar *et al* ., (2014) found that 125% RDF + 5 t ha^{-1} vermicompost recorded significantly higher N, P and K uptake in comparison to other treatments and this was followed by 100% RDF + 5 t ha^{-1} vermicompost in rice crop. Similar findings related with Nagendra (2015).

Table 21. PhosphorusContent (%) and uptake of phosphorus (kg ha^{-1}) influenced by various treatment indirect seeded rice

	Treatments	Phosphorus Content (%)		Phosphorus uptake(kg ha^{-1})		
		Grain	Straw	Grain	Straw	Total
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	0.22	0.06	4.08	1.72	5.8
T_2	100% RDF through chemical fertilizers (125:62.5:62.5kg NPK ha^{-1})	0.23	0.06	4.80	1.88	6.68
T_3	125 % RDF through chemical fertilizers (156.25:78.12:78.12 kg NPK ha^{-1})	0.23	0.06	5.63	2.08	7.71
T_4	75% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}	0.24	0.07	5.15	2.26	7.41
T_5	100% RDF through chemical fertilizers+ Vermicompost @ 2 t ha^{-1}	0.22	0.06	6.35	2.29	8.64
T_6	125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}	0.23	0.08	7.97	3.35	11.32
T_7	75% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	0.24	0.07	6.65	1.95	8.6
T_8	100% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	0.24	0.07	6.65	2.65	9.3
T_9	125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	0.24	0.1	8.72	4.25	12.97
	S.E.(m)±	-	-	0.53	0.35	0.93
	C.D. at 5%	-	-	1.60	1.05	2.80

4.5.3 Potassium Content and potassium uptakeinfluenced by varioustreatment indirect seeded rice

The data in relation to content and uptake of potassium by rice asinfluenced by various treatments are presented in Table 22.

Table 22. PotassiumContent (%) and uptake of phosphorus Potassium (kg ha^{-1}) influenced by various treatment indirect seeded rice

Treatments		Potassium content (%)		Potassium uptake(kg ha^{-1})		
		Grain	Straw	Grain	Straw	Total
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	0.72	0.91	13.6	26.2	39.7
T_2	100% RDF through chemical fertilizers (125:62.5:62.5 kg NPK ha^{-1})	0.73	1.20	15.2	37.7	52.9
T_3	125 % RDF through chemical fertilizers (156.25:78.12:78.12 kg NPK ha^{-1})	0.74	1.22	18.1	42.4	60.6
T_4	75% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}	0.73	1.24	15.7	40.1	55.7
T_5	100% RDF through chemical fertilizers+ Vermicompost @ 2 t ha^{-1}	0.76	1.33	28.0	50.8	72.7
T_6	125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}	0.76	1.32	26.4	55.3	81.7
T_7	75% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	0.75	1.31	20.8	49.7	70.5
T_8	100% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	0.78	1.36	24.5	52.4	76.8
T_9	125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	0.80	1.37	29.1	58.3	88.6
	S.E. (m)±	-	-	1.22	1.2	2.73
	C.D. at 5%	-	-	3.66	3.60	8.2
	GM	49.44	1.22	13.1	40.1	53.2

Data recorded on K contents in grain and straw at harvest ranged from 0.72 to 0.80 % and 0.91 to 1.37 %, respectively (Table 22) Different nutrient management practices failed to show significant influence on potassium contents at any stage of observation.

the data are presented in Table 22. initiated that the uptake of K, as influenced by different treatments, by grain, straw and total uptake ranged from 13.55 to 29.07 and 26.16 to 58.33, 39.71 to 88.15 kg ha^{-1}, respectively.

The nutrient management practices had significantly influenced the K uptake in grain with maximum K uptake in treatment 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment (T_9) and was on par with T_6. T_9 treatments were found significantly superior to (T_1). The minimum K uptake in grain was observed in (T_1). This may be due to lower grain yield of rice in that nutrient management practices treatment.

Similarly, nutrient management practices significantly influenced the K uptake in straw with maximum K uptake in treatment 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment (T_9) and was on par with T_6 (55.18 q ha^{-1}) received 125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}. Treatment$T_9$was found significantly superiorover the treatments of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1),100% RDF(125:62.5:62.5 kg NPK ha^{-1})(T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})(T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}(T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8). The significantly lower uptake K in straw was observed by (T_1).

The nutrient management practices had significantly influenced the total K uptake with maximum uptake in 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment (T_9) and was on par with T_6 (72.52 q ha^{-1}) received 125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}. All treatments were significantly superior to T_1 and significantly lower total uptake K was recorded under (T_1). This may be attributed higher biomass production in various treatments. Kumar *et al.,* (2014) found that 125% RDF + 5 t ha^{-1} vermicompost recorded significantly higher N, P and K uptake in comparison to other treatments and this was followed by 100% RDF + 5 t ha^{-1} vermicompost.

4.6 Effect of integrated nutrient management on available nutrient status of soil after harvest of rice

The nutrient status of available nitrogen, phosphorus and potassium in the soil after harvest of rice was analyzed and results significantly influenced by various treatments are presented in table 23.

4.6.1 Available nitrogen

Effect of integrated nutrient management on soil available nitrogen is presented in the table 23 which indicated that there was a significant difference between integrated nutrient management treatments. The available N in soil after harvest of rice was highest in T_9 (224.90 kg ha^{-1}) with the application of 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment and was on par with T_6 (223.82 kg ha^{-1}) received 125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} and lowest corresponding values T_1 were 214 kg ha^{-1}.

Table 23. Available NPK(kg ha^{-1}) in soil as influenced by various treatments in direct seeded rice

	Treatments	Available nutrient (kg ha^{-1})		
		N	P	K
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	214	14.41	370
T_2	100% RDF through chemical fertilizers (125:62.5:62.5 kg NPK ha^{-1})	219	15.90	391
T_3	125 % RDF through chemical fertilizers (156.25:78.12:78.12 kg NPK ha^{-1})	222	17.31	400
T_4	75% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}	218	15.20	381
T_5	100% RDF through chemical fertilizers+ Vermicompost @ 2 t ha^{-1}	219	17.02	395
T_6	125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1}	223	19.30	407
T_7	75% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	218	15.60	385
T_8	100% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	220	17.05	399
T_9	125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment	225	19.83	410
	S.E. (m)±	0.52	0.68	0.55
	C.D. at 5%	1.56	2.06	NS
	GM	220	16.84	393

4.6.2 Available phosphorus

The available phosphorus in soil was found significantly higher by various treatments and it ranged from 14.41 to 19.83 kg ha^{-1} indicating that the soil was low in available phosphorus. Highest available phosphorus (19.83 kg ha^{-1}) in soil was recorded with the application of 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment (T_9) and was on par with T_6 (19.30 kg ha^{-1}) received 125 % RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} and the lower available phosphorus (14.41 kg ha^{-1}) was recorded in (T_1).

Available P in soil may increase due to organic matter and biofertilizer PSB which makes unavailable form of P into available form. Similar result were found by Rai *et al.* (2014) and Tripathi *et al.* (2009).

4.6.3 Available potassium

Results pertaining to available K in soil after harvest of rice embodied in table 23. Available K in soil after harvest of rice crop non-significantly increased in various treatments and ranged from 370 to 409 kg ha^{-1}. Maximum and higher value of available K was observed in treatment 125% RDF through chemical fertilizers + Vermicompost @ 2 t ha^{-1} + Azotobacter + PSB seed treatment(T_9) and lowest value of available potassium is in (T_1). Increase in available potassium due to addition of organic manures may be ascribed to the reduction of potassium fixation and release of potassium due to interaction of organic matter with clay, besides the direct potassium addition to the pool of soil (Urkurkar*et al.* 2010). Such increase in the content of available potassium with the use of organics with chemical fertilizers has also been reported by Gupta *et al.* (2006) and Singh *et al.* (2009).

CHAPTER V

SUMMARY AND CONCLUSION

5.1 Summary

An agronomic investigation entitled "Studies on integrated nutrient management in direct seeded rice (*Oryza sativa* L.)" was carried out during *Kharif* season of 2021 at Agronomy Farm, College of Agriculture, Nagpur. The experiment was laid out in randomized block design with nine treatments and replicated thrice. The treatments consisted of T_1 - 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}),T_2-100% RDF(125:62.5:62.5 kg NPK ha^{-1}), T_3-125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}),T_4 - 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}, T_5 - 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}, T_6 - 125% RDF(156.25:78.12:78.12 kg NPK ha^{1}) +Vermicompost @ 2 t ha^{1}, T_7-75% RDF (93.75:46.87:46.87 kg NPK ha^{1})+Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter, T_8 - 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} +PSB+Azotobacter, T_9 - 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter.

The soil was clayey in texture with slightly alkaline reaction. It was low in available nitrogen and available phosphorous and very high in available potassium. Rainfall 1194.2 mm was received in 49 rainy days during the crop period. The observations on growth parameters, yield contributing characters and quality parameters were recorded at periodic intervals to evaluate the treatment effects.

5.1.1 Effect of integrated nutrient management on direct seeded rice.

The initial and final plant stand were not influenced due to integrated nutrient management.

5.1.2 Growth attributes

The treatment application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) recorded significantly superior growth attributes viz., plant height, number of tillers plant^{-1}, leaf area index, number of leaves plant^{-1} and dry matter accumulation plant^{-1} over the treatments of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) (T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) (T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with treatment application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6).

5.1.3 Yield attributes

Yield attributing characters *viz.,* number of panicles plant^{-1}, grain yield plant^{-1}(g), straw yield plant^{-1}(g), test weight (g), grain yield kg ha^{-1}, straw yield kg ha^{-1} and harvest index were recorded significantly highest with application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9)over the treatments of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) (T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) (T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with treatment application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6).

Protein content (%) and Protein yield (Kg ha^{-1}) was recorded significantly highest with application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) over the treatments of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) (T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) (T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with treatment application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6).

5.1.4 Economics

The treatment application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_9) recorded significantly maximum gross and net monetary returns and B: C ratio over the treatments of 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) (T_1), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) (T_2),125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) (T_3), 75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_4), 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_5), 75 % RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_7) 100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter (T_8), and was at par with treatment application of 125% RDF (156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1} (T_6).

5.2 Conclusion

On the basis of the results obtained from present investigation, following conclusions were emerged.

1) Application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacterrecorded highest growth attributes viz., plant height, number of tillers $plant^{-1}$, leaf area index, number of leaves $plant^{-1}$ and dry matter accumulation $plant^{-1}$ of direct seeded rice.

2) Application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacterrecorded highest yield and yield attributes of direct seeded rice*viz.*, number of panicles $plant^{-1}$, grain yield $plant^{-1}$, straw yield $plant^{-1}$, test weight, grain yield kg ha^{-1} and straw yield kg ha^{-1}.

3) Economic returns is profitable in terms of gross monetary returns, net monetary returns and B: C ratio with the application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter.

From the study, it can be concluded that The application of 125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacterrecorded higher growth, yield and economics in direct seeded rice. These conclusions are based on the result of one-year investigation and therefore further detail experimentation is needed to arrive at valid conclusion.

Chapter VI

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APPENDIX-I

Prevalent rates of various operational inputs and material (Rs.)

Sr. No.	Particulars	Rates (Rs.)
(A)	**Input charges**	
1	Tractor (Ploughing)	2468 ha^{-1}
2	Tractor (Harrowing)	1585 ha^{-1}
3	Rice seed (PDKV-Sadhana)	40 kg^{-1}
4	Bullock pair	1000 day^{-1}
1	**Fertilizer cost**	
1	Urea	6 kg^{-1}
2	SSP	8 kg^{-1}
3	MOP	15 kg^{-1}
(B)	**Labour charges**	
1	Male	282 day^{-1}
2	Female	282 day^{-1}

APPENDIX-II

Common cost of cultivation (Rs.ha^{-1}) of direct seededrice (2021)

Sr. No.	Particulars	Frequency	M	F	B.P.	Input cost	Total (Rs.ha^{-1})
I	**Preparatory Tillage**						
1	Ploughing (Tractor)	1	1	-	-	-	2750
2	Harrowing Tractor	1	1	-	-	-	1857
3	Levelling	1	1	-	-	-	1507
II	**Seed and Sowing**						
1	Cost of seed	1	-	-	-	3000	3000
2	Seed treatment with Thirum			-	-	60.75	60.75
3	Sowing	1	1	3	-	-	1628
4	Fertilizer application cost	1	2	7	-	-	1974
IV	**Intercultural Operation**						
1	Gap filling	1	-	7	-	-	846
2	Weeding	1	-	7	-	-	1420
3	Hoeing						1128
4	Spraying	2	-	15	-	-	1000
V	**Harvesting Operation**						
1	Harvesting	1	2	8	-	-	2592
2	Threshing	1	2	-	-	1961	1064
3	Market and transport	1	2	-	-	1000	1400
	Total						**22227**

APPENDIX-III

Treatment wise cost of Fertilizers and Vermicompost (Rs. ha^{-1}) of direct seeded rice

	Fertilizer	Kg ha^{-1}	Rs. kg^{-1}	Total cost (Rs ha^{-1})
T1	Urea	204	6	1224
	SSP	292.5	8	2340
	MOP	125	15	1875
			Total (T1)	5439
T2	Urea	272	6	1632
	SSP	390	8	3120
	MOP	166.67	15	2500
			Total (T2)	7252
T3	Urea	340	6	2040
	SSP	487.5	8	3900
	MOP	208	15	3120
			Total (T3)	9060
T4	Urea	204	6	1224
	SSP	292.5	8	2340
	MOP	125	15	1875
	Vermicompost	2000	3	6000
			Total (T4)	11439
T5	Urea	272	6	1632
	SSP	390	8	3120
	MOP	166.67	15	2500
	Vermicompost	2000	3	6000
			Total (T5)	13252
T6	Urea	340	6	2040
	SSP	487.5	8	3900
	MOP	208	15	3121
	Vermicompost	2000	3	6000
			Total (T6)	15060

T7	**Urea**	**204**	**6**	**1224**
	SSP	**292.5**	**8**	**2340**
	MOP	**125**	**15**	**1875**
	Vermicompost	**2000**	**3**	**6000**
			Total (T7)	**11439**
T8	**Urea**	**272**	**6**	**1632**
	SSP	**390**	**8**	**3120**
	MOP	**166.67**	**15**	**2500**
	Vermicompost	**2000**	**3**	**6000**
			Total (T8)	**13252**
T9	**Urea**	**340**	**6**	**2040**
	SSP	**487.5**	**8**	**3900**
	MOP	**208**	**15**	**3121**
	Vermicompost	**2000**	**3**	**6000**
			Total (T9)	**15060**

APPENDIX-IV

Total cost of production (Rs. ha^{-1}) as influenced by various treatment combinations

Sr.No.	Treatments	Common cost	Fertilizer cost	Total cost
T_1	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1})	22227	5439	27666
T_2	100% RDF(125:62.5:62.5 kg NPK ha^{-1})	22227	7252	29479
T_3	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1})	22227	9060	31287
T_4	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	22227	11439	33666
T_5	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	22227	13252	35479
T_6	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}	22227	15060	37287
T_7	75% RDF (93.75:46.87:46.87 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	22227	12189	34416
T_8	100% RDF(125:62.5:62.5 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	22227	14002	36229
T_9	125% RDF(156.25:78.12:78.12 kg NPK ha^{-1}) + Vermicompost @ 2 t ha^{-1}+PSB+Azotobacter	22227	16642	38869

Market selling price of rice qt^{-1}

Grain: Rs. 2040/-

Straw: Rs. 400/-