INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT ON PERFORMANCE IN DIRECT SEEDED RICE AND SOIL PROPERTIES IN DYSTRUDEPTS OF NAGALAND

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by

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DECLARATION

I, Ms. Avini-e Nakhro, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form the basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis had not been submitted by me for any research degree in any other university/institute.

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This is to certify that the thesis entitled "**Influence of Integrated Nutrient Management on performance in Direct Seeded Rice and Soil Properties in Dystrudepts of Nagaland"** submitted to Nagaland University in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy in Soil Science is the record of research work carried out by Ms. Avini-e Nakhro Registration No. Ph.D./ACSC/00213 under my personal supervision and guidance.

The results of the investigation reported in the thesis have not been submitted for any other degree or diploma. The assistance of all kinds received by the student has been duly acknowledged.

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
@	At the rate
B:C ratio	Benefit:Cost ratio
C	Carbon
^{0}C	Degree centigrade
Ca^{2+}	Calcium
CD	Critical Difference
CEC	Cation exchange capacity
cm	Centimetre
cmol	Centimmol
cm^3	Centimetre cube
DAS	Days after sowing
DF	Degree of freedom
DHA	Dehrdrogenase activity
Dsm^{-1}	Decisiemens per meter
E	East
EC	Electrical conductivity
et al.	*et allia* (and others)
Exch. Ca	Exchangeable Calcium
Exch. Mg	Exchangeable Magenesium
Fig	Figure
FYM	Farm yard manure
g	Gram
ha	Hectare
HI	Harvest index
Hr	Hour
ICAR	Indian Council of Agricultural Research
i.e.	Id est (that is)
K	Potassium
kg ha^{-1}	Kilogram per hectare
m	Metre
m^2	Metre square
M	Molarity
Mg	Magnesium
mg	Milligram
m ha	Million hectares

mt	Million tonnes
MT	Metric tonne
Max.	Maximum
Min.	Minimum
MSS	Mean sum of square
N_2	Dinitrogen
N	Normality
No.	Number
N	North
N	Nitrogen
No.	Number
NS	Non significant
NU	Nagaland University
OC	Organic carbon
OM	Organic matter
%	Percent
P	Phosphorus
ppm	Parts per million
PSB	Phosphate solubilising bacteria
q ha^{-1}	Quintal per hectare
RDF	Recommended dose fertilizer
S	South
S	Sulphur
SAS	School of Agricultural Sciences
SEm ±	Standard error of mean
Sl. No.	Serial number
SMBC	Soil microbial biomass carbon
spp.	Species
SS	Sum of square
t	tonne
TPA	Total potential acidicty
TPF	Triphenyl formazon
TTC	Triphenyl tetrazolium chloride
viz.	Namely
W	West
µg	Microgram

ABSTRACT

Sustaining rice productivity at high level is a great challenge with alarming climate change, scarcity of water or insufficient rainfall and low resource use efficiency of conventional fertilizer management practices. Therefore the integrated use of inorganic fertilizer with organic manure and bio-fertilizers may play an important role in sustaining rice productivity. Considering the above facts, experiment was conducted to evaluate the "Influence of Integrated Nutrient Management on performance in direct seeded rice and soil properties in dystrudepts of Nagaland" under rainfed conditions in two consecutive years (2019-2020) at the research farm of Nagaland University, School of Agricultural Sciences, Medziphema Campus. The experiment was laid out in Randomized Block Design with three replications and 12 treatments. The treatments details are: T_1: Control, T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5+ 30 kg ha^{-1} K_2O), T_3: 100% RDF +PSB, T_4: 100% RDF + FYM @ 2 t ha^{-1}, T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB, T_6: 75% RDF + PSB, T_7: 75% RDF + FYM @ 2 t ha^{-1}, T_8: 75 % RDF + FYM @ 2 t ha^{-1} + PSB, T_9: 50% RDF + PSB, T_{10}: 50% RDF + FYM @ 2 t ha^{-1}, T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB, T_{12}: 109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O (SSNM). Data were collected on growth, yield and yield components. Crop growth rate, relative growth rate and harvest index were computed. The texture and fertility status of the soil was ascertained by collecting soil samples randomly from a depth of 0-15 cm using quadrant methods after harvest of the crop. Economic analysis was also performed by estimating costs of FYM, PSB and inorganic fertilizers as well as grain and straw prices.

Result disclosed that all the growth and yield attributing parameters like plant height of (cm), number of leaves plant^{-1}, number of tillers plant^{-1}, dry matter accumulation (g), crop growth rate (g m^{-2} day^{-1}), panicle length (cm), number of panicle plant^{-1} and number of grains panicle^{-1} were recorded significantly highest in treatment T_5 followed by T_4. Significantly highest grain yield of 38.85 q ha^{-1} in 2019 and 39.45 q ha^{-1} in 2020 was registered with the application of 100% RDF + FYM @ 2 tonnes ha^{-1} + PSB (T_5) which increases the grain yield (q ha^{-1}) and straw yield (q ha^{-1}) to the extent of 73.82 % and 47.13 % respectively over control. Significant increase in nutrient content (%) and uptake (kg ha^{-1}) in grains and straw was obtained with combined application of 100% RDF + FYM @ 2 t ha^{-1} + PSB (T_5) in both the years.

Integrated application of 100% RDF with FYM @ 2 t ha^{-1} and PSB significantly nutrified the soil fertility status of post harvest soil *viz.* OC (%), CEC {cmol (p^+) kg^{-1}}, N (kg ha^{-1}), P (kg ha^{-1}) and K (kg ha^{-1}) to a great extent. Integrated supply of nutrients also ameliorates the soil microbial biomass content of 214.63 µg g^{-1} and dehydrogenase activity of 31.80 µg TPF g^{-1} h^{-1} during the investigation. Slight increase in soil pH was observed where integrated use of chemical fertilizers and manures was applied. However, in terms of economic analysis, highest benefit:cost ratio of 1.23 in 2019 and 1.27 in 2020 was procured in response to the application of 100% RDF + FYM @ 2 t ha^{-1} + PSB (T_5) followed by 109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5+ 46 kg ha^{-1} K_2O (T_{12}). Overall, direct seeded rice responds well to INM technology with judicious use and optimum supply of inorganic fertilizers with organic manures under rainfed condition.

***Key words*:** Direct seeded rice, INM, FYM, Bio-fertilizer.

CHAPTER I

INTRODUCTION

INTRODUCTION

Rice (*Oryza sativa* L.) is a cereal grain that belongs to the family of Poaceae and genus Oryza with chromosome number 2n=24. It flourishes comfortably in wet and humid climates and is probably a descendant of wild grass that was most likely cultivated in the foothills of the far Eastern Himalayas. Rice is a C_3 plant and a self-pollinated crop with high calorific value having 75 % starch, 6-7 % protein in white rice and 7-9 % in brown rice, 2-2.5 % fat and 0.8 % cellulose. Rice is a rich source of carbohydrates and provides protein to our diet. As traditionally known, the journey of rice around the world has been slow but once it got rooted, it became a major agricultural and economical product for the people.

It doesn't matter how it's cooked – steamed, boiled or fried – rice is included in pretty much every meal of the day in India and it stands as the second largest rice growing country in the world. Rice is recognised as a supreme commodity to mankind because rice is truly life, a culture, a tradition and a means of livelihood to millions.

In worldwide, the total amount of rice production was 756.7 metric tonnes (Anonymous, 2022). India holds a pride place in rice production among the food grains where it ranks first in area and second in production after China. It contributes 43 percent of total food grains production and 46 percent of total cereal production. In India, rice is cultivated over an area of 43.78 million hectares with an annual production of 118.4 million tonnes and average productivity of 2.7 tonnes ha^{-1} (Annual report 2020-21, Department of agriculture, cooperation and farmer's welfare).

In Nagaland, rice is the dominant food crop inhabited by different tribes/ethnic groups. It is grown throughout the entire state, especially in the *kharif* season which covers an area of 2,14,450 hectares with a production of

5,35,040 tonnes out of which upland rain fed occupies an area of 91,040 hectares with a total production of 1,81,080 tonnes (Anonymous, 2019). Till today, the production and productivity of rice in the state is below the national average (about 15 q ha^{-1}) because of the fragile ecosystem and varied physio-graphic conditions pertaining to this region. Irrespective of remunerative or non-remunerative, the rice cultivation is the way of life and culture for the people in the state.

Since Indian agriculture continues to be a gamble in monsoon, the scarcity of water for agriculture production has become a major problem. Rice cultivation in India is predominantly practiced under transplanting method that involves raising, uprooting and transplanting of seedlings. This technique requires continuous ponding of water which makes this traditional method of rice production unsustainable in the long run. Combined with other factors like shortage of labour and decreasing arable land, new ideas and innovations in rice cultivation are critically needed to meet rising demand and ensure food security. Therefore, one of the potential solutions to address these challenges is direct seeded rice (Tomar *et al*., 2018).

Direct seeded rice (DSR) is the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery. Direct seeded rice is the only viable option to reduce the unproductive water flows. It is a resource efficient technology that can overcome constraints and limitations of traditional cultivation technology.

Direct seeding can be done by sowing of pre-germinated seed into a puddle soil (wet seeding) or standing water (water seeding) or prepared seedbed (dry seeding) (Kaur and Singh, 2017). Direct seeding of rice is gaining momentum in India due to high demand of labour during peak season of transplanting and availability of water for short periods thus making paddy cultivation cost effective. It matures earlier (7-10 days) than the transplanted crop due to the absence of transplanting shock (Dhyani *et al*., 2005) and allows timely planting of succeeding crop. It is now fast replacing traditional transplanted rice in areas with good drainage and weed control (Balasubramanian and Hill, 2000). Various constraints of traditional cultivation technology like higher water and labour demand, extra expenses during raising nursery, uprooting and transplanting, uncertain supply of irrigation water and increased frequency of drought has necessitated alternative techniques like direct seeded rice that not only reduces the cost of production but also assure its sustainability.

Soil is rightfully called the “soul of infinite life”. This soul, however, has become dilapidated of-late due to ill-agricultural practises being adapted to feed the ever increasing mouths. Sustainability and climate adaptability of our agriculture depends on what we put into our fields, what leaches from our field and gets added to our water and air. Clearly the needle is pointing at our nutrient management practices. Imbalanced chemical fertilisation has ill-effects on soil health deterioration *vis-a-vis* organic matter depletion, soil structure degradation, disturbance in soil hydro-thermal balance, heavy metal contamination and above all, an imbalanced human diet.

Yes, we need to feed our ever increasing mouth but this has to be done without further deteriorating our soils, climate or for that matter, human health. The path forward can start with balanced integrated nutrient management and slowly pave a way towards adapting organic or bio-fertilizers as an alternative to chemical fertilizers.

A long term experiments have shown that continuous application of chemical fertilizers had disastrous sequel on soil health. Moreover high fertilizer price, soaring agricultural input prices and asymmetric market price information constitute risk factors. Also farmers are reluctant to adopt modern agriculture mainly due to poor economic condition. In the recent years, crop productivity has declined regardless of increased consumption of chemical fertilizers which resulted in chemical nutrient saturation of the agricultural ecosystem which leads to huge nutrient losses. Therefore enhancing the rice productivity through the improvement of yield potential genotypes and proper nutrient management has been the main thrust of Indian rice policy. Considering all of these harmful effects, integrated use of nutrients is in the need of the hour to enhance the nutrient status of soil health (Tomar *et al*., 2018). An experiment performed in local rice of Nagaland by Apon *et al*. (2018) reported that integrated nutrient management enhanced the rice yield. Therefore, integrated use of nutrient source appears to be best option.

Integrated nutrient management through combined application of inorganic fertilizers along with organic sources aimed at improving the physico-chemical and biological properties of soil and the supply of plant nutrients in adequate amount (Sannathimmappa *et al*., 2015). Use of organic manures, apart from improving physical and biological properties of soil, also helps in improving the use of efficiency of chemical fertilizers (Syed *et al*., 2020). In contrast to nutrients in organic fertilisers, this required microbial metabolism to make most of them available to plants. So, inorganic fertilisers can directly affect crop growth and yields. Organic and inorganic fertilizer amendments are used primarily to increase nutrient availability to plants, but they also boost the soil microorganisms. Besides, the presence of these inorganic and organic substances in the soil is related with an increase in nutrient contents of soil and with their subsequent effects on soil properties such as microbial activity, the humus fraction, soil structure and cation exchange capacity (Kirchner *et al*., 1993). Therefore, INM may be a feasible approach to ensure the sustained availability of nitrogen and enhancing its use efficiency as well as microbial activity. The integrated treatments involving both inorganic fertilizers and organic sources had pronounced influence in improving available nitrogen status as well as microbial enzymatic activity

(Patra *et al*., 2018). Application of chemical fertilisers makes the soil fertile and increases productivity of crops, while introducing adverse effects on soil and environment. Therefore, it is needed that fertility and productivity of the soil be restored, using organic fertilisers in combination (Khan *et al*., 2009). Integrated nutrient-management system through judicious use of chemical fertilizers along with organics plays a key role in improving crop productivity and soil fertility in direct-seeded upland rice (Choudhary *et al*., 2020). Organic manures are considered as the promising, renewable, easily available in large quantity, economical and nutrient rich source resulting in improved soil-plant-health in a sustainable agricultural eco-system (Chand, 2006).

Phosphate solubilizing bacteria (PSB) is a bio-fertiliser which contains a group of beneficial bacteria and has the capacity to hydrolyse the organic and inorganic phosphorus from insoluble compound (Vishwakarma *et al*., 2018). Application of PSB increases the availability of phosphorus in the soil, produces growth substances like indole acetic acid and gibberellins, thus increases the overall phosphate use efficiency. The PSB solubilise the fixed soil phosphorus and efficiency of applied phosphates resulting in higher rice yield (Gull *et al*., 2004).

In light of above scenario, due to major constraints like alarming climate change and low resource use efficiency of conventional fertilizer management, the present investigation entitled, "Influence of Integrated Nutrient Management on Performance in Direct Seeded Rice and Soil Properties in Dystrudepts of Nagaland" was carried out during *kharif* season of 2019 and 2020 at the experimental farm of School of Agricultural Sciences (SAS), Medziphema Campus, Nagaland University with following objectives-

1. To study the influence of Integrated Nutrient Management on growth and yield of direct seeded rice.
2. To study influence of Integrated Nutrient Management on nutrient content and nutrient uptake of direct seeded rice.
3. To study the influence of Integrated Nutrient Management on soil properties and nutrient status.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

2.1 Influence of integrated nutrient management on growth and yield of direct seeded rice

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

Mandal *et al*. (2005) reported that the effective tillers $hill^{-1}$, number of grains $panicle^{-1}$, 1000-grain 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 reported by authors.

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) studied the treatments consisted of FYM, vermi-compost, green manure, Azotobacter, phosphate solubilizing bacteria (PSB), blue-green algae (BGA), rice residue incorporation and NPK fertilizers. Significantly higher yields of 4.3 t ha^{-1} for rice and 4.0 t ha^{-1} for wheat were recorded when rice-wheat were grown after green manuring of dhaincha in-situ or application of FYM (10 t ha^{-1} $year^{-1}$) or vermi-compost (5 t ha^{-1} $year^{-1}$) in *kharif* season.

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.

Virdia and Mehta (2010) disclosed the effect of integrated nutrient management in transplanted rice with treatments comprising various quantity of press mud, FYM and RDF. They found that straw yield was significantly higher with integrated nutrient management (press mud @ 20 t ha^{-1} + RDF), which remained at par with press mud @ 15 t ha^{-1} + RDF or FYM @ 10 t ha^{-1} + RDF.

Mehdi *et al.* (2011) found that different combinations of organic manures with chemical fertilizers increased straw yield significantly over application of organic manures alone. Among different combinations, Sesbania at 20 tonnes ha^{-1} + 75% recommended dose proved to be the best combination followed by Sesbania 20 tonnes ha^{-1} + 50% R.D.

Larijani and Hoseini (2012) also found that more tiller number (28%), more panicle m^{-2} (60%), number of filled grains m^{-2} (20.6%), spikelet $panicle^{-1}$ (19.6%) and more grain yield (30.6%) with combined use of organic and chemical fertilizer compared with chemical fertilizer alone.

Khursheed *et al.* (2013) observed significant increase in grain yield of rice by 10.9, 21.8 and 28.5 % with the conjunctive use of farm yard manure, vermicompost and poultry manure with NPK respectively compared to no manure treatment and NPK alone.

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 and revealed that the dry matter accumulation plant^{-1} at 120 DAT was highest (23.5 g) with the application of FYM @ 20 t ha^{1} and was followed by (22.3 g) with FYM application @ 10 t ha^{-1} and lowest (18.5 g) was observed when no FYM was applied.

Saba *et al*. (2013) noticed that combination of bio-fertilizer, nitrogen and phosphorous (500: 120: 90 kg ha^{-1}) exceeded all other treatments including P and N alone in number of tillers m^{-2}, number of panicles m^{-2}, number of spikelets panicles^{-1}, percent normal kernels, 1000-grain weight (g) and paddy yield (t ha^{-1}).

Sharma (2013) indicated that the growth, development, yield attributes of rice was found to be best when 50% N through farm yard manure and 50% NPK was applied in rice-wheat cropping system.

Tilahun *et al*. (2013) revealed that applying FYM at 15 t ha^{-1} combined with 120 kg N ha^{-1} and 100 kg P_2O_5 ha^{-1} increased grain yield by 123% and 38% compared to the negative (0- 0-0 kg ha^{-1} FYM-N-P_2O_5) and positive (0-120-100 kg ha^{-1} FYM-N- P_2O_5) controls, respectively. Similarly; LAI, CGR, NAR, the number of filled spikelets per panicle, biomass yield and grain protein content as well as agro-physiological efficiency of N and P were significantly enhanced in response to increasing the rates of FYM and inorganic N and P fertilizers. It was observed that 15 t ha^{-1} FYM combined with 120 kg N ha^{-1} and 100 kg P_2O_5 ha^{-1} resulted in the maximum grain yield, grain protein content, and terminal moisture stress escape.

Kumar *et al*. (2014) uncovered that application of 125% RDF + 5 t ha^{-1} vermicompost increased the number of panicles (20.50%), panicle length (23.12%), panicle weight (13.02%), 1000 grain weight (12.90%), grain yield

(31.15%) and straw yield (37.12%) over the control and the individual nutrient sources.

Tzudir and Ghosh (2014) conducted an experiment and showed that the best result was obtained in rice crop with application of 75% N (Enrich Adhar) + 25% N (Urea) + P, K and consequently an increase in grain yield by 27.63%, 28.98% and 20.94% was observed over full NPK (60:30:30), 75% N (urea) + P, K and farmers' practice treated plots respectively. The corresponding increases in straw yields were 23.38, 24.4 and 17.73% respectively. Organic sources of plant nutrient also showed positive effect on other yield attributes such as panicle length (26.31 cm m^{-2}) tiller number (499.24) and filled grains per panicle (101.60).

Jeyajothi and Durairaj (2015) reported that application of green leaf manuring (GLM) @ 6.25 t ha^{-1} + Azophosmet + 100 % NPK registered significantly the highest yield attributes in rice. The number of productive tillers m^{-2} was ranged from as low as 180 m^{-2} under Azophosmet application alone to as high as 416 m^{-2} with integrated application of GLM + Azophosmet + 100 % NPK. 150:50:50 kg ha^{-1}. The grain yield was increased, when GLM was integrated with 100 % NPK application (6030 kg ha^{-1}). The grain yield of rice was further increased, when Azophosmet was applied through seed and soil application along with GLM and 100 % NPK (6617 kg ha^{-1}). However, it was at par with application of FYM + Azophosmet + 100 % NPK. The same trend was noticed in straw yield also.

Mondal *et al*. (2015) tried to evaluate the suitable proportion of organic manures and inorganic fertilizers along with biofertilizer to maximize growth and productivity of hybrid rice on sandy-loam lateritic soils. The crop having 50% recommended dose of fertilizer (RDF) + 50% recommended dose of nitrogen through mustard oil cake and 75% RDF + 25% RDN through MOC + biofertilizer significantly increased plant height, number of tillers m^{-2}, leaf area index, dry matter accumulation and crop growth rate at initial and vital period of grain growth over those of 25% RDF + 75% RDN through MOC and 100% RDN through MOC.

Nagendra (2015) reported that among different nutrient management practices, at maximum tillering stage, the highest plant height was found under TPR (51.2 cm) which was significantly more than AR (45.5 cm) and DSR (43.9 cm).highest number of tillers m^{-2} was recorded in 100% RDF (369) but it was on par with 100% RDF + 50% VC (353) and 75% RDF + 25% VC (319). The lowest number tillers m^{-2} was recorded in control (265) and the highest number of panicle m^{-2} was found in transplanted rice (327) and DSR (326) and lowest in aerobic rice (236).The highest number of grains per panicle was observed in treatment 100% RDF + 50% VC (165) in case of nutrient management practices. The highest number tillers m^{-2} was found in transplanted rice (346) and DSR (341) and both were significantly higher than that in aerobic rice (252).

Sahu *et al*. (2015) confirmed from the findings that the treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) was found to be significantly superior not only over control (T_1) but also over rest of the treatments in increasing the plant height, dry matter, total and effective tillers of rice except 100% GRD + 5 t FYM ha^{-1} (T_5) which was statistically similar to T_{10} in case of dry matter, total and effective tillers of rice. STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) registered significantly higher values of panicle length and total filled grains panicle-1 over control. As regards to grain and straw yield of rice, significantly higher value was noted in treatment STCR dose with 5 t FYM for YT 50 q ha^{-1} (T_{10}) as compared to rest of the treatments, however it was statistically similar to treatments 100% GRD (100:60:40) (T_4), 100% GRD+ 5 t FYM ha^{-1} (T_5) and 100% GRD + 10 kg BGA ha^{-1} (T_7).

Mahmud *et al*. (2016) showed from the study that application of medium level of chemical fertilizer with 4 t ha^{-1} vermi-compost gave the maximum yield. Results also revealed that the highest plant height, effective tillers hill^{-1}, flag leaf length, panicle length, filled grains panicle^{-1}, 1000 grain weight, grain yield, straw yield and biological yield were obtained from the combination of 4 t ha^{-1} vermi-compost with 100 kg ha^{-1} N, 16 kg ha^{-1} P, 66 kg ha^{-1} K, 12 kg ha^{-1} S.

Kumar *et al*. (2017) revealed from the experiment that 100% RDF has significantly improved growth parameters, yield attributes, yield, NPK removal and net returns over other fertility levels tested. Combined application of FYM + BGA produced significantly higher growth parameters, yield attributes, yield, NPK removal and net returns over FYM and control. Hence, aromatic rice can be grown with 100% RDF and FYM along with BGA for higher growth, productivity and net returns under eastern U. P condition.

Kumar *et al*. (2017) opined that application 75% RDF as inorganic fertlizers along with green manuring of dhaincha insitu incorporated in alternate year recorded significantly higher values of growth and yield attributes over rest of the treatments except 100% RDF as inorganic fertilizers. This treatment also recorded significantly highest grain and straw yield (45.04 and 72.0 q ha^{-1} respectively) followed by 75% RDF as inorganic fertilizers along with green manuring of sunhemp insitu incorporated in alternate years and 100% RDF.

Moe *et al*. (2017) reported that the poultry manure @ 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, total dry matter, and yield parameters to 100% NPK.

Shalini *et al*. (2017) conducted a field experiment to study the effect of iron (FS 1% and SA 30 kg ha^{-1}), zinc (FS 0.5% and SA 25 kg ha^{-1}) and organic manures application (FYM 2.5, 5.0 t ha^{-1} and vermin-compost 1.5, 3.0 t ha^{-1} and brown manure) on direct seeded dry rice. Thus reported that vermin-compost applied in conjunction with brown manure (RDF +BM + 1.5 t VC) resulted in production of more dry matter, more number of effective tillers and higher grain yield and higher gross return, this treatment was found at par with combined foliar application of zinc and iron. Combined foliar application of iron and zinc (RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$) yielded more than their combined soil application than their sole application.

Kipgen *et al*. (2018) concluded that varying the nitrogen levels influenced the growth characteristics of rice application of 140 kg N ha^{-1} produced significantly higher number of tillers m^{-2} which was statistically at par with 120 kg N ha^{-1}.

Maruthupandi and Jayanthi (2018) conducted a field trial to study the effect of integrated nutrient management in rice-gingelly-maize cropping system. Thus, reported that application of 100% RDF + vermin-compost at 5 t ha^{-1} (T_1) recorded higher system yield of 15,102 kg ha^{-1} and 15,551 kg ha^{-1}. This was followed by application of 100% RDF + goat manure as pond silt at 5 t ha^{-1} (T_4), 100% RDF + FYM 12.5 t ha^{-1} (T_{13}) and 100% RDF + turkey manure as pond silt at 5 t ha^{-1} (T_2). Application 100% RDF + goat manure at 5 t ha^{-1} recorded higher gross return and net return and 75% RDF + vermicompost at 5 t ha^{-1} recorded higher B:C ratio of 2.69 and 2.78.

Saajan *et al*. (2018) conducted a field experiment to check the effect of different nitrogen sources on the yield of direct seeded rice and also to find out the best combination of nitrogen sources for integrated nutrient management and revealed that treatment T_7 (azotobacter + 25% vermicompost +50% RDN) gave the significant result in growth and yield attributes with respect to control treatment (inorganic sources only).

Saha *et al.* (2018) analysed data from a long term rice-wheat cropping sequence to evaluate the effects of integrated nutrient management on yield trends and sustainability, nutrient balance and soil fertility of the system and thus revealed that the yield of rice and wheat were highest when 50% N was supplied through green manure and FYM respectively.

Thind and Singh (2018) conducted an experiment to evaluate the interaction effect of four N rates (0, 120, 150 and 180 kg ha^{-1}) as urea and 4 schedules of N application on yield and N use efficiency in DSR. Thus, reported that higher yield and NUE in DSR was achieved through these interaction applications.

Tomar *et al.* (2018) found that integrated use of nutrients boosted the growth characters like plant height (cm), number of tillers m^{-2}, dry matter accumulation (g), LAI, yield attributes, number of panicle m^{-2}, length of panicle, grain weight $panicle^{-1}$, test weight (g), grain and straw yield (q ha^{-1}) of rice were maximum under F_2 (75% NPK+25% FYM) which was at par with F_1 (100% NPK) during course of investigation.

Hanamant *et al.* (2019) revealed that application of 100% recommended NPK + FYM + plant growth promoting rhizobacteria (PGPR) + 20:20:20 water soluble fertilizers (T_5) 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) and number of tillers (22.56) which contributed to the yield. The lowest yield was recorded with the control plot (16.47q ha^{-1}).

Jat *et al.* (2019) investigated a field trials to devise the influence of different nutrient management practices on productivity in basmati rice (*Oryza* *sativa*) – wheat (*Triticum aestivum*) cropping systems and found that application of N in 75% organic + 25% inorganic form (T_4) recorded the highest grain yield of basmati rice (4.73 t ha^{-1}) and wheat (4.44 t ha^{-1}) and found statistically at par with T_3, T_2 and T_1. Similar trends were observed in biological yield of both the crops. The lowest grain yield (3.16 and 3.07 t ha^{-1}) and biological yield (8.50 and 8.20 t ha^{-1}) of both basmati rice and wheat, respectively were recorded in T_6 (100% inorganic treatment).

Kumari *et al*. (2019) from two years experimentation unveiled that the application of various integrated nutrient management practices significantly increased dry matter accumulation on 30 DAS, 60 DAS, and 90 DAS and at maturity but days taken to maximum tillering, 50% flowering and maturity of rice had not been significantly influenced. Among all treatments, application of 100% RDF + 25% N through VC resulted in higher dry matter accumulation on 30 DAT (159.5 g m^{-2}), 60 DAT (394.1 g m^{-2}), 90 DAT (916.4 g m^{-2}) and at maturity (1200.5 g m^{-2}) which was superior to rest of the treatments. Two year study indicates that the application of 100% RDF + 25% N through VC was the best for higher dry matter accumulation and yield from rice.

Chakraborty *et al*. (2020) showed that, yield and yield components of boro rice were significantly influenced by variety, nutrient management and interaction of variety and nutrient management. The highest yield and yield component were obtained from poultry manure @ 2.5 t ha^{-1} + 50% prilled urea and full dose of inorganic fertilizers and produced the maximum grain yield (5.70 t ha^{-1}). In the interaction of variety and integrated nutrient management, the highest grain yield (6.83 t ha^{-1}) and straw yield (7.61 t ha^{-1}) was obtained from poultry manure @ 2.5 t ha^{-1} + 50% prilled urea and full dose of inorganic fertilizers with BRRI dhan29 variety. So, BRRI dhan29 with 2.5 t ha^{-1} poultry manure + 50% prilled urea and full dose of the recommended inorganic fertilizers might be a promising practice for boro rice cultivation.

Chaudhary *et al*. (2020) observed that yield attributing characters like panicles plant^{-1}, panicle length (cm), panicle weight plant^{-1} (g), number of grains panicle^{-1} and test weight (g) were found higher in T_6 (1.45, 21.27, 19.81, 119.73 and 24.49, respectively) and increase to the tune of 17.88, 26.23, 29.73, 47 and 17.68% respectively over control. Similarly, seed and straw yield found maximum in T_6 with application of 157:125:70 kg N, P_2O_5 and K_2O with 5 t FYM ha^{-1} (5725 and 7623 kg ha^{-1} respectively).

Geetha *et al*. (2020) unveiled that among the IPNS imposed treatments, the treatment T_9 (125% RDF + FYM @ 6 t ha^{-1} + biofertilizers @ 12.5 kg ha^{-1} + foliar spray of 19:19:19 (1%) at 45, 60 and 75 DAS) exerted significant higher grain and straw yield (7,461 and 8,808 kg ha^{-1} respectively) as compared to other treatments.

Kumar *et al*. (2020) investigated the impact of FYM, green manures, poultry manures and wool based manures with 75, 50, 25 per cent nitrogen from fertilizers and 100 per cent above organic sources on growth, yield and yield attributes of rice (*Oryza sativa* L.) - wheat (*Triticum aestivum* L.) cropping system. Thus, confirmed that growth, yield and yield attributes showed better performance in treatment combination with T14 (25% N, from wool based 75% fertilizers). The residuals effects of these fertilizers treatment combination (T_{14} – T_{17}) showed better results. While lowest growth, yield and yield attributes was showed under (T_1) control.

Meena *et al*. (2020) investigated the influence of varying seed rates and integrated nutrient management on performance of direct-seeded hybrid rice and confirmed that amongst integrated nutrient management treatments, application of 50% RDN by urea + 50% N by FYM recorded better performance with respect to tillers m^{-2}, dry matter accumulation, LAI, SPAD value, grain and straw yields and nutrient uptake while 100% RDF through inorganic fertilizer recorded lowest growth and yield. Seed rate of 20 kg ha^{-1}

recorded superior performance with respect to number of tillers m^{-2}, dry matter accumulation, LAI, SPAD value, grain and straw yields and nutrient uptake as compared to seed rate of 16 and 24 kg ha^{-1}.

Pandit *et al*. (2020) found that 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}) have been observed where direct seed rice crop received 75% of the recommended dose of fertilizers, FYM @ 5ton ha^{-1} and brown manuring with dhaincha. Highest number of effective tillers $plant^{-1}$ (18.86), panicle length (28.89 cm) and number of filled grains $panicle^{-1}$ (260.54) and seed yield (3079.92 kg ha^{-1}) have also been observed with spraying of vermiwash and N-P-K 19:19:19 at 35 DAS and 55 DAS respectively to the direct seeded rice crop.

Sahu *et al*. (2020) carried out a field experiment to study the effect of organic and inorganic sources of nutrients on soil chemical properties and nutrient availabilities under direct seeded rice. The grain (46 q ha^{-1}) and straw (51.3 q ha^{-1}) yield of rice was registered higher in T_8 treatment followed by T_7 treatment (44.8 and 50.2 q ha^{-1}) and lowest in control treatment (24.5 and 37.5 q ha^{-1}). Further the results suggest that inorganic fertilizer with organic manure (FYM) enhanced the rice yield, soil fertility and soil physical and chemical environment.

Shankar *et al*. (2020) reported that rice variety IR-36 showed positive influence on integrated nutrient management and resulted in significantly greater values of growth and yield attributes and yield of summer rice. The recommended dose of nutrients was 120 : 60 : 60 kg ha^{-1} of N : P_2O_5 : K_2O of summer rice, respectively. The treatments with 75% RDN+25% poultry manure (T_4) and 75% RDN+25% FYM (T_8) recorded better performance compared to other treatments.

Shrestha *et al*. (2020) carried out an investigation to assess the effects of different fertilizers on the growth, development and production of rice. Hence, observed that the integrating organic and inorganic fertilizers enhanced the growth parameters and yields of rice. The balanced use of fertilizers improves crop productivity and soil fertility in a sustainable manner without any environmental damage.

Behera and Pany (2021) revealed that highest and significant values were recorded with respect to growth parameters i.e., plant height, number of tillers hill^{-1}, effective tillers hill^{-1} and yield attributes i.e., number of panicles hill^{-1}, panicle length, number of filled grains 1000 seed weight (test weight) in the treatment that received 100% RDF + FYM @ 5 t ha^{-1}. Combination of FYM (5 t ha^{-1}) with lower levels of RDF (50 and 75% RDF) also registered higher increase in the above parameters as compared to the application of inorganic fertilizers alone with the corresponding levels. Grain and straw yields followed the same trend as that of growth parameters and at higher levels of nitrogen in the inorganic form(150 % RDF) the values of the various parameters including grain and straw yield were significantly lower than the treatment where 100% RDF +FYM @ 5 t ha^{-1} was applied.

Bhosale *et al*. (2021) noticed that application of 50 % RDF along with 50 % RDN through FYM (T_6) produced maximum and significantly higher grain (57.52, 57.87 q ha^{-1}) and (68.36, 67.94 q ha^{-1}) straw yield as compared to rest of the treatments except the treatments T_{10} (application of 50 % RDF through fertilizers and 50 % RDN substitution through GGLM) and T_5 where 100 % RDF (NPK) was applied through fertilizers. During both season, minimum grain yield (25.07, 22.87 q ha^{-1}) and straw yield (30.65, 28.14 q ha^{-1}) were recorded respectively under control.

Midya *et al*. (2021) from the findings concluded that integration of 75% RDN through chemical fertilizer and substitution of 25% RDN through vermicompost followed by 50% RDN through chemicals, 25% RDN through vermi-compost and brown manuring coupled with the application of bio-fertilizer *Azospirillium brassilense* recorded the best-integrated plant nutrition package for yield enhancement of rice under both aerobic, system of rice intensification (SRI) and conventional flooded culture for better growth and yield attributes, crop and water productivity and economic profitability.

Singh *et al*. (2021) revealed that INM through farmyard manure resulted in increased growth such as plant height, total leaf area, more of leaves and tillers plant^{-1} in lesser accumulated thermal time (21.2 °C days leaf^{-1}) required for leaf emergence @ 0.646 leaf day^{-1}. Therefore, it is evident that combining inorganic fertilizers with organic manures could enhance the growth and facilitate steady nutrition to the rice crop in addition to improved soil health over conventional method of cultivation.

Bajpai *et al*. (2022) reported from the investigation that the application of T_4: 150% RDF produced the highest growth yield and yield attributing parameters which was statistically similar to the treatments of T_3: 100% RDF, T_5: 100% RDF + $ZnSO_4$, T_6: 100% N and P_2O_5 and T_8: 100% RDF + FYM at all stages of crop growth. The lowest growth and yield attributing parameters were observed under control where no nutrient was applied during both the years and on mean basis.

Laila *et al*. (2022) studied the combined effect of vermi-compost with inorganic fertilizers on the growth attributes of aromatic fine rice varieties. Thus, revealed that the tallest plant, the highest number of total tillers hill^{-1}, total dry matter production, leaf area index and chlrophyll content were obtained from % 55 less than recommended dose of inorganic fertilizer + vermi-compost @ 3 t ha^{-1} at all sampling dates. But the shortest plant, the lowest number of total tillers hill^{-1}, leaf area index, total dry matter production, crop growth rate and chlorophyll content were found in control at all sampling dates.

Mangaraj *et al*. (2022) revealed that the treatment comprised of 50% recommended dose of fertiliser (RDF) through chemicals + 50% recommended dose of nitrogen (RDN) through farmyard manure (FYM) increased the plant height, tillers, dry matter accumulation, leaf area and leaf area duration, and yield parameters in short grain aromatic rice. It was concluded that the treatment consisting of 50% RDF (chemical fertiliser) + 50% RDN (FYM) to rice and 75% RDF + Rhizobium + PSB to greengram increased the productivity of the rice–green gram cropping system.

Rautela *et al*. (2022) concluded that from the two years field experiment which was carried out to investigate the impact of various organic, inorganic and integrated nutrient amendments on growth parameters of basmati rice where the best results of growth parameters *viz*. plant height, LAI, leaf weight, shoot weight and total dry matter were found in 50% NPK through organic sources (incorporation of GM) + 50% chemical fertilizer which are comparable with 100% RDF.

2.2 Influence of integrated nutrient management on nutrient content and uptake of direct seeded rice

Virdia and Mehta (2009) studied that the pooled result of nutrient uptake and they found that the application of organic fertilizer along with recommended dose of fertilizer (RDF) gave numerically higher uptake value of N, P, K. than only RDF treatment in grain, straw and total uptake.

Siddaram *et al.* (2010) revealed that significantly higher nitrogen, phosphorus and potassium uptake (124.2, 30.6 and 93.9 kg ha^{-1}, respectively) registered with recommended dose of fertilizer (100:50:50 kg N:P:K ha^{-1}) + 10 tonnes of FYM ha^{-1}.

Mehdi *et al.* (2011) uncovered that maximum contents of N, P and K both in paddy and straw of rice were recorded maximum in the treatment receiving combination of Sesbania at 20 ton ha^{-1} + 75% recommended dose (RD) and least in FYM alone at 20 ton ha^{-1} in rice-wheat cropping system.

Weijabhandara *et al.* (2011) reported that application of 75% RDF + biofertilizers resulted in significantly higher grain yield, uptake of N, P, K and Zn by grains and residual available N, P, Zn compared to other treatments.

Acharya *et al.* (2012) revealed that nutrient uptake of rice was highest due to integrated nutrient application than that of inorganic nutrients alone, whereas lowest value was observed with control plot where no nutrient was applied.

Rani and Sukumari (2013) from the conducted investigation confirmed that higher total N, P, K, Fe, Mn and Zn uptake by medicinal rice (Njavara) was recorded under integrated nutrient source when compared with the individual organic and inorganic sources.

Ranjitha and Reddy (2013) reported that higher nitrogen uptake by grain and straw (56.0 and 26.7 kg ha^{-1} respectively) was observed with the application of FYM @ 10 t ha^{-1} + 100 percent RDF but was comparable with the treatment of 100 percent RDF alone. Similarly, highest P and K uptake (16.6 kg ha^{-1} and 10.3 kg ha^{-1} P; 18.9 and 127.1 kg ha^{-1} K) by grain and straw was obtained by FYM @10 t ha^{-1} + 100 percent RDF followed by 100 percent RDF and lowest was with FYM @ 10 t ha^{-1}.

Zayed *et al*. (2013) proved that application of two-thirds of the RDN plus some organic fertilizer, either FYM or rice straw compost at a rate of 7 t ha^{-1} and 5 t ha^{-1} respectively resulted in higher plant nitrogen and phosphorus content even under saline soil conditions of rice field.

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 and nutrient uptake.

Kumar *et al*. (2014) proved that application of organic and inorganic sources of nutrient in combination remarkably increased N uptake in grain (36.81%) and straw (42.81%), P uptake in grain (32.62%) and straw (31.56%) and K uptake in grain (35.46%) and straw (25.39%) over control.

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.

Stephan (2015) examined two indigenous rhizospheric phosphate solubilising isolates PSB 12 identified as *Gluconacetobacter sp*. and PSB 73 *Burkholderia sp*. for their growth enhancement potential of rice under pot culture and thus reported that the treatments *Burkholderia sp.* + RP_{60} and *Gluconacetobacter sp.* + RP_{60} produced comparable amount of P with the highest nutrient uptake and yield.

Wolie and Admassu (2016) disclosed that higher total nutrient uptake by rice crop was recorded under integrated nutrient source. Integrated application of inorganic and organic fertilizers helped in increasing the availability of nutrients and improves major physical and chemical characteristics of the soil. Therefore it was concluded that application of 50 % fertilizers from organic sources and 50 % from inorganic sources is the best combination for rice yield and soil properties improvement.

Goswami *et al.* (2017) conducted a field experiment to compare three different direct seeded upland rice varieties under five different integrated weed and nutrient management practices. Thus, the results revealed that N and P content in grain and straw of all the three varieties was significantly higher in W_2 while Rasi showed significantly higher P content in combination with W_2. The N, P and K uptake was significantly higher in grains of Rasi and W_2 showed highest in grain, straw and total uptake. An increase in yield as evident by higher grain and straw yield for all the three varieties was observed in W_2. The variety Rasi showed significantly higher grain yield when combined with W_2 while Maizubiron showed significantly higher straw yield when combined with W_2.

Kumar and Mukhopadhyay (2017) noted that combined application of Azotobacter and PSB produced more influence on nutrient uptake than their sole application. It has been observed from the pooled data that FYM at 10 t ha^{-1} resulted in removal of (131.65 kg N, 36.61 kg P and 144.48 kg K ha^{-1}) and 100% RDF accounted for (153.31 kg N, 41.47 kg P and 164.04 kg K ha^{-1}). Thus, higher doses of organics and fertilizers influenced the plant growth and developmental characters which ultimately resulted in higher uptake of nutrients.

Kumar *et al*. (2017) noticed that the uptake of N, P and K by rice crop was affected significantly due to various treatments. Combined use of green manuring along with inorganic fertilizers improved the uptake of nutrients (NPK) over control. Rice fertilized with 75% RDF as fertilizers with green manuring of dhaincha incorporated in alternate year had significantly higher uptake of (97.5 kg N ha^{-1}), (22.8 kg P ha^{-1}) and (145.4 kg K ha^{-1}) followed by 75% RDF as inorganic fertilizers along with green manuring of sunhemp added alternate year and 100% RDF as inorganic fertilizers.

Puli *et al*. (2017) conducted a field experiment for two consecutive years and revealed that the NPK uptake by rice at various growth periods was significantly increased with the application of 100% NPK in combination with FYM @ 10 t ha^{-1}. However, it was on par with that of green manuring together with 100% NPK during both the years of the study.

Sharma *et al*. (2017) reported that inorganic fertilizers in conjunction with FYM improved quality parameters of rice. Grain yield of direct seeded rice with brown manuring *Sesbania* was statistically at par with conventional transplanting of rice. Maximum nutrients uptake was recorded with higher level of nitrogen.

Kumar *et al*. (2018) observed significant increased in NPKS uptake with application of 50% NPK Zn + Bio-fertilizer (PSB+BGA) + FYM (10 t ha^{-1}) (T_4). This experiment proved the superiority of integration between chemical fertilizer and biofertilizer over chemical fertilizer alone at all level of fertility.

Tomar *et al*. (2018) studied an experiment which was laid out in split plot design with four replications consisting of four planting methods (S_1-transplanting, S_2-SRI, S_3- drum seeded and S_4- direct seeded) and three integrated nutrient management (F_1- 100% NPK, F_2- 75% NPK+25% FYM and F_3- 50% NPK+ 50% FYM) and reported that various integrated nutrient management affected significantly nutrient uptake by rice. The maximum NPK uptake was recorded by the application of 75% NPK + 25% FYM through inorganic and organic fertilizer which was at par with 100% NPK. Availability of nutrients might be sufficient & it led to higher nutrient uptake. Minimum nutrient uptake was recorded where 50% NPK + 50% FYM) was applied.

Latha *et al*. (2019) conducted a field experiment to study the effect of INM on rice major nutrient content and uptake by rice and reported that nitrogen content in rice was ranged from 1.71 to 2.22% and 1.58 to 2.18%, phosphorus content was ranged from 0.34 to 0.51% and 0.14 to 0.58% and potassium content was ranged from 1.65 to 2.20% from active tillering to grain filling stage. Nitrogen uptake was ranged from 49.48 to 156.23 kg ha^{-1}, 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} from active tillering to grain filling stage.

Raki *et al*. (2019) recorded that among nutrient management, application of 100 per cent RDF (N_4) obtained significantly higher N, P, K uptake by grain, straw and total uptake as compared to other treatments. The lowest N, P, K uptake by grain and straw and total uptake were observed under the application of 75 per cent RDF (N_1).

Biswas *et al*. (2020) evaluated the quality parameter, nutrient content and nutrient uptake in rice and recorded the highest nitrogen and potassium content by rice grain and straw with the application of 75% RDF + 25% N through vermi-compost. The phosphorus content in grain was highest with 100% RDF + S40Zn5B1.5 kg ha^{-1} while in straw, it was maximum with customized fertilizer. The higher K content in grain and straw were noticed in 75% RDF + 25% N through sewage sludge.

Devi *et al.* (2020) carried out an investigation to study the influence of integrated nutrient management on dry matter production, yield and NPK content of transplanted rice. Thus, reported that significantly higher content of N in grain was observed in T_{10} (75% RDN from urea + 25% RDN from FYM + 10 tonnes Azolla ha^{-1}) while treatments T_8 and T_{10} showed the similar effect in straw N content. However, statistically higher P concentration was recorded in T_{11} (50% RDN from urea + 50% RDN from FYM + 10 tonnes Azolla ha^{-1}) throughout the growing period and also in grain and straw at harvest time. T_{12} (25% RDN from urea + 75% RDN from FYM + 10 tonnes Azolla ha^{-1}) noted the highest K concentration in grain followed by T_{11} while K content in straw was highest in both the treatments T_{11} andT_{12}.

Jana *et al.* (2020) undertook an experiment to study the growth, productivity and nutrient uptake of aerobic rice as influenced by different nutrient management practices. Thus, observed that nutrient uptake and residual nutrient status was recorded highest in NPK @ 60:30:30 kg ha^{-1} + VC @ 2.5 t ha^{-1} + $ZnSO_4$ @ 20 kg ha^{-1} + borax @ 2 kg ha^{-1} fertilized plot. Similarly, from the same treatment, significant increase in grain yield was also observed.

Kaisar *et al.* (2020) noticed that the NPKS content and uptake by BRRI dhan48 were influenced significantly due to combined use of manure and fertilizers. The maximum N, P, K and S uptake by grain (35.55, 6.99, 15.20 and 3.38 kg ha^{-1} respectively) were obtained from the treatment where nutrients was applied in an integrated manner. The minimum N, P, K and S uptake by grain (20.08, 3.64, 8.35 and 1.74 kg ha^{-1} respectively) were found from T_5 (Control). Similarly, the maximum N, P, K and S uptake by straw (3.38, 5.43, 99.25 and 7.37 kg ha^{-1} respectively) were found from T_3: INM. The minimum N, P, K and S uptake by straw (1.74, 2.67, 49.70 and 3.87 kg ha^{-1} respectively) were obtained from T_5 (Control). Therefore, considering nutrient content and uptake, the application of chemical fertilizers in combination with manure based on INM could be recommended for BRRI dhan48 production in *aus* season.

Patra *et al*. (2020) unveiled that in rice, the integrated use of enriched compost @ 2 t ha^{-1} with 25% recommended doses of NP + 100% K showed significant increment in N and P content in grain, husk and straw over rest of the treatments. The K content in grain (0.36%), husk (0.37%) and straw (2.03%) was also found to be highest under application of 25% recommended doses of NP + enriched compost @ 2 t ha^{-1} + 100% K as compared to other treatments. There was a highly significant negative correlation was found between exchangeable Al and strongly organically bound and interlayer Al with N, P and K content of rice. Thus, integrated use of enriched compost with reduced dose of recommended nitrogen and phosphorus of rice reduced the toxic Al fractions in an acid soil which led to enhanced N, P and K content in rice grain, husk and straw.

Ram *et al*. (2020) reported that integrated nutrient management has significant impact in nutrient uptake of summer rice. Maximum uptake of nitrogen, phosphorous and potassium by rice was more (85.6, 28.1 and 128.7 kg ha^{-1} respectively) with 75% RDN + 25% N through vermicompost and the treatment also showed maximum value of N (255.0 kg ha^{-1}), P (16.7 kg ha^{-1}) and K (144.0 kg ha^{-1}) in post harvest soil.

Sahu and Chaubey (2020) observed that the application of soil test crop response (STCR) dose (125:50:46) with 5 t FYM for YT 50 q ha^{-1} recorded significantly higher uptake of N, P and K in rice followed by 100% GRD+5 t FYM ha^{-1} over control at 30, 60 DAT and harvesting stage of rice. Whereas, the N, P and K content at different stages of rice was found non-significant. The yield of rice was significantly higher in treatment STCR (125:50:46) with 5 t FYM for YT 50 q ha^{-1} as compare to rest of the treatments, however it was statistically similar to 100% GRD+ 5 t FYM ha^{-1}, 100% GRD + 10 kg BGA ha^{-1} and 100% GRD (100:60:40).

Sahu *et al*. (2020) showed that the highest nitrogen, phosphorus and potassium content and uptake by grain and straw was recorded in the treatment receiving 100% NPK +5 t FYM + $ZnSO_4$ @ 25 kg ha^{-1} + lime 3 q ha^{-1} (T_8) which was significant over all other treatments which was followed by the treatments 100% NPK + 5 t FYM + $ZnSO_4$ @ 25 kg ha^{-1}. The lowest nutrient content and uptake by grain and straw was obtained in control.

Singh *et al*. (2020) reported that optimum combinations of manures and fertilizer in rice crop had great impact. There was significant increase in nutrient content (NPK) in grain and straw of rice in the treatment where nutrient was applied in an integrated manner. On the other hand, lowest nutrient content was recorded in control treatment where no external source of nutrients was applied.

Tiwari *et al*. (2020) revealed that nutrient content and uptake were significantly influenced due to different treatments. The nutrient content and its uptake by rice was observed higher with the application of 100% RDF through (IF) + 25% RDN through Neem Cake as compare to other treatments. The lowest nutrient content and its uptake was found under100% RDF through FYM (Organic source).

Verma *et al*. (2020) investigated the effect of integrated nutrient management and crop diversification through inclusion of legume and vegetable crops in direct seeded basmati rice (*Oryza sativa* L.)–based cropping systems (DSRB) on nutrient availability for crop uptake. Thus, found that diversification of rice–wheat system with legume (greengram) or vegetable (cabbage and onion) crops and integrated nutrient management strategies had positive effect on nutrient uptake and available nutrient status in the soil. Significantly higher uptake of N, P and K in all crops and Zn, Fe, Mn and Cu in rice and wheat were observed with NS_2 and NS_3 as compared to NS_0. Available N, P and K status were significantly higher in NS_2 and NS_3 as against NS_0 and NS_1.

Midya *et al.* (2021) carried out an experiment which aimed at understanding the effects of different rice production systems and INM on nutrient content and uptake. Thus, uncovered that the nutrient content and uptake under integrated plant nutrition, irrespective of crop culture was higher compared to sole application of chemical fertilizer, owing to better availability of nitrogen due to application of organic sources and biofertilizer that ultimately triggered better nitrogen content both in grains and straw. However, phosphorus content and uptake that was relatively lower under INM treatments compared to sole application of chemical fertilizer.

Senthamizhkumaran *et al.* (2021) obtained from the research that nitrogen removal by rice grain and straw were highest of in RDF 75 % + Vermicompost @ 5 t ha^{-1} + Seed treatment with Azospirillum and Phosphobacteria + soil application of AM fungi which was on par with RDF 75 % + FYM @ 12.5 t ha^{-1} + Seed treatment with Azospirillum and Phosphobacteria + soil application of AM fungi and RDF 75 % + Vermicompost @ 5 t ha^{-1} respectively. There was an increased concentration of N in grain and straw due to graded levels of N application. This could be as a result of increase in N absorption by plant.

2.3 Influence of integrated nutrient management on soil properties and nutrient status

Hoque *et al.* (2007) observed that the application of various organic manures treatments under study influenced pH, organic matter content, total N, available P, exchangeable K and available S content of post-harvest soil. As regard to the contribution of various organic manures on soil properties and availability of nutrients, the performance of poultry manure, cow dung, rain tree leaf litter and different manure combinations were good.

Nyalemegbe *et al.* (2009) showed that cow dung and poultry manure applied at half their recommended rates, i.e. 10 t ha^{-1} CD plus 45 kg N ha^{-1} urea and 10 t ha^{-1} PM plus 60 kg N ha-1 urea enhanced soil physical properties (particularly under upland condition) and soil fertility as well as bring about low soil pH/redox potential as compared with the recommended inorganic nitrogen fertilizer level of 90 kg N ha^{-1}. Therefore, it is evident from the study that application of vermicompost and biofertilizer in integration with NPK helped in increasing organic carbon, available N, available P, available K and available micronutrient status in soil than RD of NPK alone.

Rather and Sharma (2009) reported that significant improvement in soil properties and fertility status was found under treatment (T_{20}) comprising of 100% recommended NPK + Vermi-compost + Zinc + PSB. Organic carbon content of soil improved from 3.0 to 4.6 g kg^{-1} soil, bulk density reduced from 1.50 to 1.32 Mg m^{-3}, water holding capacity increased from 20.32 to 23.72 %, available N from 197.0 to 219.0 kg ha^{-1}, available P from 13.0 to 19.1 kg ha^{-1}, available K from 113.0 to 130.4 kg ha^{-1} and available Zn from 1.50 to 1.87 mg kg^{-1} soil by the integration of organics with inorganics.

Virdia and Mehta (2009) noticed the increment of organic carbon, available P_2O_5 and K_2O content in soil in the treatments receiving integrated nutrient sources when compared with the initial values except in treatment receiving only RDF.

Walia *et al*. (2010) confirmed that the combination of compost, green manure, wheat cut straw and farm yard manure along with chemical fertilizers improved the physical properties of soil like water holding capacity, infiltration rate, available soil moisture, liable C and microbial count, penetration resistance and reduces bulk density, soil strength in rice-wheat cropping system.

Singhl *et al*. (2011) disclosed from the investigation that integrated application of inorganic fertilizers and organic manures with micronutrients helped in increasing the availability of nutrients and in sustaining and restoring soil fertility in its available nutrients and major physical and chemical characteristics of the soil.

Ghosh *et al*. (2012) reported significant increase in soil nutrient availability with the application of farm yard manure (FYM @ 7.5t ha^{-1}), paddy straw (PS @ 10 t ha^{-1}) and green manure (GM @ 8 t ha^{-1}) along with inorganic fertilizer. Both microbial biomass C and mineralizable C as well as yield of kharif rice were increased with the addition of the organic inputs.

Islam *et al*. (2012) noticed that bulk density and pH gradually decreased in organic fertilizer management compared to inorganic fertilizer management. However, percent organic carbon (0.68 to 0.80%) and organic matter (1.19 to 1.37%) of soil increased in organic management compared to inorganic management (0.53 to 0.66% and 0.91 to 1.14%, respectively).

Kumar *et al*. (2012) assessed that the possibility of improving productivity of rice under two levels of fertilizer N and P applications. The use of organic manure decreased soil pH and its combined use with fertilizers were significantly reflected in the build-up of available N, P, K, organic carbon and DTPA-extractable Fe and Mn content of the soil.

Babar and Dongale (2013) studied the different soil fertility parameters *viz*., bulk density, porosity, organic carbon and available nutrients (NPK) content in soil and thus concluded that there was significant improvement with the application of organic, inorganic and organic + inorganic sources of nutrients compared to the control treatment. The available nutrients content in soil was also slightly higher under T_7 [50% NPK (IF) + 50% N (M)] treatment compared to only chemical fertilizers (T_3).

Krishnakumar and Haefele (2013) found that the application of N at 90 kg level as 50% through rice straw cut + 50% N as poultry manure registered higher available N, P and K contents of soil during different growth stages as compared to the other treatment combinations including recommended NPK fertilizers.

Tilahun *et al*. (2013) assessed the effects of combined application of farm yard manure (FYM) and inorganic NP fertilizers on soil physico-chemical properties. Therefore, results showed that application of 15 t ha^{-1} FYM significantly increased soil organic matter and available water holding capacity on the other hand decreased the soil bulk density, creating a good soil condition for enhanced growth of the rice crop. Application of 15 t ha^{-1} FYM increased the level of soil total nitrogen from 0.203% to 0.349%. Combined application of 15 t ha^{-1} FYM and 100 kg P_2O_5 ha^{-1} increased the available phosphorous from 11.9 ppm to 38.1 ppm. Positive balances of soil N and P resulted from combined application of FYM and inorganic N and P sources. Application of 15 t ha^{-1} FYM and 120 kg ha^{-1} N resulted in 214.8 kg ha^{-1} N positive balance while application of 15 t ha^{-1} FYM and 100 kg ha^{-1} P_2O_5 resulted in a positive balance of 69.3 kg ha^{-1} P_2O_5 available P.

Choudhary and Suri (2014) conducted a field experiment to study on INM technology in rain fed upland rice to harness the potential of DSR technology and thus found that NPK at 90:45:45 kg ha^{-1} + FYM at 5 t ha^{-1} significantly resulted in the greatest magnitude of growth and development and yield-contributing characters followed by sole use of NPK at 90:45:45 kg ha^{-1} and NPK at 60:30:30 kg ha^{-1} + FYM at 5 t ha^{-1} in rain fed upland rice. Application of NPK at 90:45:45 kg ha^{-1} +FYM at 5 t ha^{-1} also resulted in improvement of soil organic carbon and available NPK status over other treatments. Overall, it is inferred that INM technology with judicious use of NPK at 90:45:45 kg ha^{-1} + FYM at 5 t ha^{-1} in rain fed upland rice under DSR technology can enhance the rice productivity and resource-use efficiency in NW Himalayas.

Chaudhary and Suri (2014) stated from the investigation that soil organic carbon (SOC), available N, P_2O_5, and K_2O content were significantly greatest in plots supplied with N–P_2O_5–K_2O at 90:45:45 kg ha^{-1} + FYM at 5 t ha^{-1} followed by sole use of NPK at 90:45:45 kg ha^{-1} and NPK at 60:30:30 kg ha^{-1} + FYM at 5 t ha^{-1}, respectively, while other treatments showed intermediate trends. The effect of INM treatments on soil pH was nonsignificant, however, increase in fertility levels resulted in increase in soil pH.

Dubey *et al*. (2014) proved that the bulk density of soil and available P and K contents almost maintained their parental status after completion of fourth crop cycle under 100% organics and integrated nutrient management, while 100% inorganic exhibited declining trend in P and K as well as rising trend in bulk density.

Parewa *et al*. (2014) revealed that application of different treatments decreased bulk density and improved the water holding capacity, organic carbon and CEC significantly after harvest of wheat. The dehydrogenase, phosphatase enzyme activity and soil microbial biomass carbon (SMBC) and available N, P and K and microbial population of soil after the harvest of wheat were improved significantly due to the integration of inorganic fertilizers with FYM and bioinoculants. Positive impact of biological and organic manure application have been recorded with an additional advantage of reduction of chemical fertilizer use.

Sharma and Subehia (2014) observed that organic carbon content increased from its initial value of 6.0 to 8.66 g kg^{-1} and available phosphorus from 21.9 to 75.2 kg ha^{-1} through integrated use of organic and fertilizers for the last twenty years while the status of available N and K declined over the years in all the treatments. No addition of fertilizer or manure (control) also led to the significant reduction in available sulphur in comparison to fertilizer treated plots.

Goutami *et al*. (2015) analysed that the soil properties *viz*., bulk density, porosity, pH and EC were not markedly influenced by the imposed treatments. On the other hand, significantly high organic carbon was recorded in FYM treated plots. There was a significant influence of the treatments on available nitrogen and phosphorus, but not on potassium. Among micronutrients (Cu, Zn, Mn and Fe), the treatment influence was significantly related to Fe only. Addition of inorganics in combination with organics and bio-fertilizers proved to be more efficient in improving the microbial population and enzyme activities (urease and dehydrogenase) significantly.

Nath *et al*. (2015) reported that application of enriched compost (EC) (2 t ha^{-1}) demonstrated clear increase in dehydrogenase (DH) (220.0 µg TPF g^{-1} d^{-1}) and phosphomonoesterase (PME) (388.8 µg p-nitrophenol g^{-1} h^{-1}) activities with only 25% of recommended nitrogenous (N) and phosphatic (P) fertilizer. The integration of biofertilizers or EC with reduction of 75 to 50% NP fertilizers resulted higher MBC in between 270.6 and 323.3 µg g^{-1} compared to chemical fertilizer alone. Similarly, the application of biofertilizers with 50% NP showed highest value (234.3 kg ha^{-1}) of available N, whereas highest available P (25.8 kg ha^{-1}) was obtained in the INM treatment that contained EC (2 t ha^{-1}).

Mondal *et al*. (2016) analysed the impact of integrated nutrient management (INM) on crop productivity, nutrient use efficiency of applied nutrients and soil fertility in restoring sustainability with hybrid rice cultivation and disclosed that INM with 50% or more RDN through MOC + remaining N through chemical fertilizers significantly increased organic carbon and available N, P and K contents in soil over their initial values. The organic carbon and available N, P and K contents in soil increased steadily due to increasing the level of MOC application and the highest organic carbon and available N, P and K contents in soil were recorded from the plots having 100% RDN through MOC under the study.

Babu *et al*. (2017) noticed that the soil microbial biomass carbon, nitrogen and phosphorous improved significantly with the different treatments. Highest soil biomass carbons, nitrogen, phosphorous were recorded with the combined application of inorganic nutrients and farm yard manure (T_7) over the remaining other treatments. The highest soil biomass were recorded in treatment T_7 and lowest in T_1. As a consequence application of NPK and FYM combination was more effective on increasing rice productivity targeted to 40 q ha^{-1} and 50 q ha^{-1} and soil nutrient status than single application of FYM or chemical fertilizer.

Bhatt *et al*. (2017) found that combined application of inorganic fertilizer and FYM resulted in a positive influx of nutrients by increasing soil pH, electrical conductivity, cation exchange capacity, organic carbon content, available nitrogen, available phosphorus, available potassium and yield of wheat in both the surface and sub-surface layer of soil. Lowest physico-chemical properties were recorded in control in both the surface and sub-surface layer while, the highest were recorded due to combined application of inorganic fertilizer along with organic manure.

Gawde *et al*. (2017) found from the trials that combined application of inorganic fertilizer and organic manure during *kharif* and *rabi* improve chemical properties of soil like organic carbon, available N, P and K status in soil. The highest available nitrogen (288.6 kg ha^{-1}) and available phosphorus (28.5 kg ha^{-1}) content was recorded in T_{10} - 50% RDF + 50% GM - 100% RDF. The higher available calcium and sulphur was recorded in T_6 - 50% RDF + 50% FYM -100% RDF. The available micronutrient was observed in T_6 - 50% RDF + 50% FYM - 100% RDF.

Harikesh *et al*. (2017) studied an experiment with objective to know the various integrated nutrient management and rice varieties on soil chemical properties which comprised of six integrated nutrient modules *viz*., F_0 (control), F_1 [RDF (120:60:60)], F_2 (50% RDF + 50% N through vermi-compost), F_3 (75% RDF + 25% N through vermi-compost), F_4 (50% RDF + 50% N through FYM) and F_5 (75% RDF + 25% N through FYM), two varieties (NDR-359 and Sarju-52) and plant geometry S_1 (20cm × 20cm) and S_2 (30cm × 30cm). Thus revealed that maximum availability of N, P and K after crop harvest were estimated under the treatment having F_2 (50% RDF + 50% N through vermin-compost), which was closely followed by F_4 and F_3. Therefore, the maximum availability N, P and K were found in variety NDR-359 under plant geometry S_2 (30 cm × 30 cm) followed by Sarju-52and S_1 (20 cm × 20 cm), respectively.

Mallikarjun and Maity (2018) studied the effect of integrated nutrient management practices on soil biological properties in rice. Thus, revealed that treatment T_8 (50% N as chemical fertilizer with 25% FYM along with Azolla dual cropping) recorded the maximum load of total bacteria, actinomycetes, fungi and enhanced the activity of urease and dehydrogenase along with soil microbial biomass carbon. Hence replacement of either 25% RDN or 50% RDN of chemical fertilizers through organics is desirable to improve soil health by increasing microbial load and enzymatic activity in the lateritic belt of west Bengal.

Jat *et al*. (2019) observed the build up of available N, P, K and SOC in soil under both organic and integrated nutrient management practices (T_1–T_4). However, the available N, P, K and SOC content were decreased in soil under inorganic nutrient management (T_6) during study period. Results further revealed that T_2 with application of 75% of nutrients through organic sources along with bio-fertilizer strains was observed statistically at par with 100% organic nutrient management (T_1) in terms of available N, P, K and SOC status of soil.

Sangeeta *et al.* (2019) conducted a field experiment to know the effect of soil microbial count and dehydrogenase activity as influenced by integrated nutrient management in direct seeded rice and revealed that higher microbial count (25.90 cfu ×106 g^{-1} of bacteria, 8.79 cfu ×103 g^{-1} of fungi and 10.31 cfu ×104 g^{-1}) of actinomycetes at harvest and dehydrogenase activity of 101.96 of μg TPF formed g^{-1} of soil hr^{-1} at 45 and 109.70 of μg TPF formed g^{-1} of soil hr^{-1} at 60 DAS with the treatment T_2 (100% of NPK + FYM @ 10 tonnes ha^{-1}) when compared to other treatments.

Mondal *et al.* (2020) experimented the effect of different nutrient management practices on growth, grain yield, production economics and soil nutrient availability in transplanted rice (*Oryza sativa* L.) and revealed from the result that significantly higher available nitrogen, phosphorus and potassium of 261.01, 36.03 and 224.28 kg ha^{-1} respectively were recorded from the fertilised plot that higher dose of NPK @ 80:40:40 kg ha^{-1} respectively were applied.

Nagabhushanam and Bhatt (2020) observed the effect of sowing dates and nutrient management practices on yield attributes, yield and economics of rice and confirmed that among the nutrient management practices, cost of cultivation was higher in S_4- 150% RDF (RDF+Zn) (N_3: splits @1/2+1/4+1/4) (Rs.55, 000) and S_3- 150% RDF (RDF+Zn) (N_3: splits @1/3+1/3+1/3) (Rs. 55,000). The net returns (Rs. 42,550) as well as return per rupee invested (1: 0.77) is maximum in S_2- 150% RDF (RDF+Zn) (N_3: splits @1/2+1/4+1/4) (Rs. 37,815) (0.75) respectively. The higher yields of grain and straw recorded in these treatments were the main reason for higher benefit cost ratio.

Nayak *et al*. (2020) carried out a trial to find out the suitable organic nutrient management practice for higher productivity, and maintenance of soil fertility in scented rice-rice sequence. Therefore, they confirmed that maximum organic carbon (0.63%), available N (296.87kg ha^{1}), available P (62.94kg ha^{-1}), available K (189.23kg ha^{-1}) was recorded with the same treatment which ultimately induced the content and uptake of nutrients. Comparatively lesser gain in soil NPK after completion of the two-year sequence was noticed in fully inorganic treatment as compared to the organic treatments.

Patra *et al*. (2020) revealed that application of biofertilizers and enriched compost had positive impact on plant accessible nitrogen, phosphorus and potassium in soil as compared to inorganic fertilizers. Also, soil organic matter content increased considerably by these treatment. Integrated nutrient management practice in rice had also significantly enhanced the dehydrogenase, fluorescein diacetate and phospho-monoesterase activity in soil.

Sahu *et al*. (2020) studied on the effect of organic and inorganic sources of nutrients on soil chemical properties and nutrient availabilities under direct seeded rice. Therefore, they recorded the highest pH in 50% NPK +5 t FYM +

ZnSO4 @ 25 kg ha^{-1} + lime 3 q ha^{-1} (T_{12}) whereas the lowest pH was recorded in 100% NPK. The continuous application of organic materials along with fertilizers significantly increased the soil organic carbon as compared to the application of fertilizers alone. The use of organic manure like FYM with chemical fertilizers increased the availability of macro (N, P, K, S, Ca, and Mg) and micro (Zn) nutrients in soil over chemical fertilizer alone.

Sandhu *et al*. (2020) conducted a 31 years field experiment on integrated nutrient management to evaluate their effect on soil physic-chemical properties under rice-wheat system. Thus, reported that there was significant reduction in bulk density and soil strength and significant increase in infiltration rate and water retention. A positive and significant correlation was also observed between organic carbon and soil physic-chemical properties. Therefore, integrated use of balanced chemical fertilizer in combination with organic manure on long term basis enhanced soil sustainability.

Yadav *et al*. (2020) revealed that the maximum available nitrogen, phosphorus and potash was recorded in the treatment T_9 (100% NPK + 25% N through vermin-compost) which was significantly superior over rest of the treatments and minimum available nitrogen, phosphorus and potassium was recorded in treatment T_5 (50% NPK + 50% N through FYM). The maximum organic carbon content (0.45%) was noted in T_5 (50% NPK + 50% N through FYM) and PH, EC was fined non significant.

Arunkumar and Kumari (2021) reviewed from the study that integrated nutrient management is best practice when compared with chemical fertilizers. Complete shift of organic cultivation improve productivity and also maintain soil health in a long run. Application of organic sources of nutrients can be made from local availability to decrease the cost of cultivation over inorganic fertilizers.

Midya *et al*. (2021) opined that available nitrogen, phosphorus and potassium status was observed as higher under INM treatments F_7 and F_8 due to conjunctive use of chemical fertilizer, FYM/vermicompost, brown manuring, and biofertilizer. Furthermore, higher dehydrogenase activities was observed under INM treatment due to brown manuring and application of organic matter and biofertilizer as activity of dehydrogenase depends on the metabolic activity of soil biota and significantly correlates with soil biomass carbon in organically amended soil

Paul *et al*. (2021) reviewed nutrient management in fragrant rice and opined that among different agronomic performances, proper nutrient management can improve the yield of fragrant rice not only by giving the required amount of nutrients but also by maintaining the health of the soil and the quality of the produce. Therefore, a suitable approach of nutrient management is required to keep the production of fragrant rice to a notable amount and increase the nutrient use efficiency of soil. Application of manures and fertilizers in an appropriate dose which is the main object of nutrient management is required for its utmost importance in the growth and development of the crop that finally results in better yield and grain quality.

Randhawa *et al*. (2021) disclosed that integrated application of manures and fertilizers reported maximum organic carbon (0.39%) in the treatment receiving 100% of the recommended dose of fertilizers (RDF) + farmyard manure and lowering the pH to 6.39. The maximum available N (360.8 kg ha^{-1}) was found in 100% RDF + press mud treatment; available P (66.30 kg ha^{-1}) was found in 75% RDF + poultry manure; and available K, Zn, Cu, and Fe (226.3 kg ha^{-1} and 2.220, 0.732, and 36.87 mg kg^{-1}, respectively) in 100% RDF + farmyard manure treatments. Similarly, total macro and micronutrient content in soil increased with the addition of organic manures alone or in combination with chemical fertilizers.

Krishna *et al*. (2022) disclosed that integrated use of organics, inorganics and their combination did not show any marked difference in physical (water holding capacity, bulk density, porosity, aggregate stability) and physico-chemical (pH, EC) properties of soil at harvest stage of rice and sorghum but they improve soil properties (physical and physico-chemical) over initial but the effect was not statistically significant during both the years of experimentation.

Urmi *et al*. (2022) revealed that the addition of organic fertilizer significantly influenced the organic carbon, total carbon, total nitrogen, ammonium nitrogen, nitrate nitrogen, soil pH, phosphorus, potassium, sulfur, calcium, and magnesium contents in post-harvest soil, which indicated enhancement of soil fertility. The maximum value of the organic carbon stock (18.70 t ha^{-1}), total carbon stock (20.81 t ha^{-1}), and organic carbon sequestration (1.75 t ha^{-1}) was observed in poultry manure at the rate of 5 t ha^{-1} with 50% RD. The soil bulk density decreased slightly more than that of the control, which indicated the improvement of the physical properties of soil using organic manures. Therefore, regular nourishment of soil with organic and inorganic fertilizers might help rejuvenate the soils and ensure agricultural sustainability.

2.4 Influence of integrated nutrient management on economics of direct seeded rice

Khan *et al*. (2009) observed that among the INM treatments, the application of 60:50:80 kg NPK ha^{-1} proved superior over rest of the nutrient management treatments for all the variety. Application of FYM 10 t ha^{-1} + 30:25:40 kg NPK ha^{-1} was also equally important and realized higher gross and net monetary return and the higher B: C along with high quality produce.

Hasanuzzaman *et al*. (2010) reported that the application of Poultry manure @ 4 t ha^{-1} + 50% of recommended dose of NPK maximized the profit and benefit-cost ratio (BCR) was the highest (1.75) among all the other treatments which was almost similar to 100% RDF of NPKS *i.e.*- 80:12:72:10 kg ha^{-1}. The lowest benefit-cost ratio (1.07) was obtained from control treatment.

Singh *et al*. (2012) reported that the application of 100% RDF through inorganic fertilizers gave the maximum net profit (Rs. 12583 ha^{-1}) and benefit-cost ratio (2.01) followed by 50% RDF as inorganic fertilizers + 50% RDN through FYM.

Pankaj *et al*. (2013) reported that among the different nutrient management practises, the conjunctive use of organic and inorganic source of fertilizer significantly induced to release higher concentration of N, P, K and S in the soil available pool thereby increased uptake by lentil plant. A significantly higher yield and economic return (B: C=0.72) was noted when the crop was grown under 100% N through FYM.

Borah *et al*. (2015) reported that integrated nutrient management with 75% RDN through VC + 25% RDF and 75% RDN through FYM + 25% RDF produced the highest grain and straw yields and paid maximum gross and net returns from rain fed upland rice among all other treatments though the crop with 75% RDN through FYM + 25% RDF faced greater weed infestation than other treatments except 100% RDN through FYM.

Mondal *et al*. (2015) noticed very striking effect of nutrient management practices on economics of hybrid rice cultivation. The cost of cultivation increased steadily due to increase in the rate of MOC application, and the maximum cost involved with the use of 100% RDN through MOC ($1,304) was significantly greater than that of all other fertility treatments. Application of 75% RDN through MOC + 25% RDF through chemical fertilizers also recorded markedly higher cost of cultivation over the remaining fertility treatments.

Kumar *et al*. (2017) concluded from the investigation that rice crop should be fertilized with 75% RDF as fertilizers along with green manuring of dhaincha in-situ incorporated in alternate year to obtain higher yield, net income, benefit: cost ratio and sustainability of soil fertility.

Shalini *et al*. (2017) observed that the total cost of cultivation was higher in case of vermicompost fertilization and transplanted method of rice establishment *i.e*. in RDF + 3.0 t VC and in RDF + $ZnSO_4$ @ 25 kg ha^{-1} (TPR) (44057 and 40802 Rs. ha^{-1}). Maximum gross return (84551 Rs. ha^{-1}), net return (34126 Rs. ha^{-1}) and B:C ratio (1.74) was recorded with RDF + BM + 1.5 t VC and was found significantly superior to all the treatments being at par with RDF + 1 FS of 0.5% $ZnSO_4$ + 3 FS of 1% $FeSO_4$, RDF + 3.0 t VC and RDF + BM + 2.5 t FYM. The lowest gross return was observed in treatment of sole RDF.

Shinde *et al*. (2017) reported that the performance of two different varieties of rice in the terms of their yield attributes, grain yield productivity, quality traits and economics (gross returns, net returns, benefit-cost ratio) were highest under the application of 50 % recommended dose of N through chemical fertilizers, 25 % through application of FYM and remaining 25 % through poultry manure application.

Tiwari *et al*. (2017) conducted an investigation in kharif season to access the impact of INM on soil properties and economics of the rice yield amd obtained maximum gross return (Rs. 92,093), maximum net return (Rs. 66,420) & maximum Benefit cost ratio B:C (2.59) in the treatment where integrated nutrients was applied.

Dongarwar *et al*. (2018) determined the effect of different fertilizer doses on yield and economics of direct seeded rice uncovered that the highest gross monetary return, net monetary return and B: C ratio, recorded in T_5 - 150:75:75 kg NKP ha^{-1} (76,717 INR ha^{-1}, 39,917 INR ha^{-1} and 2.03

respectively) followed by T_4 (70,785 INR ha^{-1}, 35,360 INR ha^{-1} and 2.0) and T_7 (69,221 INR ha^{-1}, 34,136 INR ha^{-1} and 1.97).

Mandal *et al*. (2018) found that the highest cost of cultivation was recorded in treatment T_8 where 25% RDN from chemical fertilizer + 75% RDN from mustard oil cake was applied (68,637 ha^{-1}) followed by application of 50% RDN from chemical fertilizer + 50% RDN from mustard oil cake (59550 ha^{-1}). In the treatment of only chemical nitrogen application it was the lowest (41,378 ha^{-1}) cost of cultivation of rice. The result indicated that, combination of organic and inorganic nutrients became costlier than that of RDN from sole chemical fertilizer. The highest return per rupee invested (2.25) was found in 100% RDN from chemical fertiliser. However, this was at par with 75% RDN from chemical fertiliser + 25% RDN from dhaincha green manure (2.23).

Tomar *et al*. (2018) analysed the economics factors like cost of cultivation, gross return, net return, and B:C ratio to evaluate the effect of the treatment from practical point of view to the farming community as well as to the planner. Maximum Gross return and net return was recorded in (S_2F_2) SRI method + 75% NPK + 25% FYM which was followed by (S_2F_1) SRI and 100% NPK.

Jat *et al*. (2019) showed from the findings that in terms of net returns, organic farming (T_1 and T_2) led to higher economic gains as compared to inorganic and integrated nutrient management (T_3–T_6). The highest net returns of basmati rice (` 99.3 × 103 $ha^{-1}$) were recorded in $T_1$ followed by $T_2$ while, the highest net returns of wheat (` 44.9 × 103 ha^{-1}) and BRWCS (` 141.4 × 103 $ha^{-1}$) were recorded in $T_2$. Due to higher yields and inclusion of premium price, additional returns under organic nutrient management practices like $T_1$ and $T_2$ were higher to the tune of ` 53.2 × 103 ha^{-1} and ` 59.7 × 103 ha^{-1}, respectively as compared to T_6. These findings pointed towards the scope for financial security under organic nutrient management system in long term.

Singh *et al.* (2019) investigated the productivity, sustainability and profitability of rice wheat system with eight treatments *viz.*, N, NP, PK, NPK, NPK + FYM and Control. Result revealed that application of NPK + FYM gave the highest and sustainable yields, enhance soil organic carbon content and highest net return was recorded.

Khanda *et al.* (2020) studied the effect of integrated nutrient management in scented rice and its residual effect on pea under paira cropping system and reported that application of STBFR (75 : 30 : 20 kg N : P_2O_5 : K_2O ha^{-1}) + FYM @ 5 t ha^{-1} + Azospirillum @ 5 kg ha^{-1} + PSM @ 5 kg ha^{-1}+ Zn @ 5 kg ha^{-1} + S @ 20 kg ha^{-1} (T10) recorded maximum gross return (Rs. 1,26,991 ha^{-1}) , net return (Rs. 80,146 ha^{-1}) and B : C ratio of 2.71. The increase in rice equivalent yield (REY) in this treatment was 51.4% higher than the farmer practice *i.e.* application of chemical fertilizers alone (40 : 20 : 20 kg N : P_2O_5 : K_2O ha^{-1}).

Ram *et al.* (2020) unveiled that the highest gross return was recorded when crop was supplied nutrients with75% RDN+25% N through vermicompost (T_2) and it was statistically at par with 75% RDN+25% RDN through FYM (T_3), 100% RDN (T_1), 50% RDN+50% N through vermin-compost (T_4), 50% RDN+50% N through FYM (T_5) and 50% RDN+25% N through vermicompost+25% N through FYM (T_6). The net returns was found highest in T_3 and it was closely followed by T_2 and T_1. Further, these three treatments were statistically at par with each other. As expected, the control treatment (T_8) resulted in the least gross and net return from summer rice. The benefit cost ratio was found higher in 100% RDN (T_1) and it was followed by 75% RDN+25% RDN through FYM (T_3).

Subramanyam and Singh (2021) reported that the maximum gross return , net return and B:C ratio were recorded superior with application of Azotobacter (12.5 g kg^{-1}) + Azospirillum (12.5 g kg^{-1}) + FYM (12 t ha^{-1}). According to research results, the stated treatment had the most positive effect on the measured characteristics. Also the use of Azotobacter, Azospirillum and FYM was increased the yield and yield components of organic rice.

Neti *et al.* (2022) carried out an investigation on effect of integrated nutrient management on rice (Oryza sativa L.) yield under Surguja district. Hence, observed noticed that application of 50% RDF + 50% N through green leaf manure followed by 100% NPK fetched maximum NMR (56201 Rs. Ha^{-1}) with the B:C ratio (2.32), which was at par to 50% + 50% N GLM (57353.8 Rs. Ha^{-1}) with B:C ratio (2.33). The interaction of FYM in place of green leaf manure was equally good with regards to NMR and B:C ratio.

CHAPTER III

METERIALS AND METHODS

MATERIALS AND METHODS

The present investigation entitled, ”Influence of integrated nutrient management on performance in direct seeded rice and soil properties in dystrudepts of Nagaland” was conducted at the experimental farm of School of Agricultural Sciences (SAS), Medziphema Campus, Nagaland University during *kharif* season of 2019 and 2020. The details of climatic, geographical and edaphic conditions under which the experiment was carried out and the materials used, experiment procedures followed and various methods employed during the experimentation to meet the objectives are described in this chapter.

3.1 Experimental site and geographical situation

The field experiment was carried out at the experimental farm of School of Agricultural Sciences (SAS), Medziphema Campus, Nagaland University during *kharif* season of 2019 and 2020.

Geographically, the site of the experiment is situated at $20^0$45’43” N latitude and $93^0$53’04” E longitude at an elevation of 310 m above mean sea level. The field experiment was well levelled with good drainage facilities.

3.2 Climate and weather condition during the period of the experiment

The experimental farm lies in the humid sub-tropical climate zone with hot and humid summer and mild winter. The South-West monsoon is the main source of rain which sets normally in the first week of May and extends till October while the North-East monsoon normally sets in the month of November and extends up to December.

Table 3.1: Monthly meteorological data during the period of investigation (2019)

Months	Temperature (^{0}C)		Relative Humidity (%)		Rainfall (mm)	Sunshine Hours	Rainy Days
	Max	Min	Max	Min			
June	33.5	24.0	91	69	195.0	4.5	15
July	33.0	24.8	93	72	271.3	3.1	14
August	34.1	24.9	93	73	274.5	4.9	16
September	32.7	23.9	94	72	173.4	4.1	11
October	30.3	21.7	95	73	244.8	5.9	11
November	28.8	16.3	97	64	52.9	7.0	4
December	23.7	10.4	97	62	0.9	6.1	0

Table 3.2: Monthly meteorological data during the period of investigation (2020)

Months	Temperature (^{0}C)		Relative Humidity (%)		Rainfall	Sunshine Hours	Rainy Days
	Max	Min	Max	Min			
June	32.5	23.8	92	72	266.2	3.9	17
July	32.4	24.5	94	74	199.9	2.6	17
August	33.7	25.0	93	70	80.3	4.4	9
September	32.8	24.3	95	73	157.6	4.8	9
October	31.3	23.0	95	74	175.7	5.2	8
November	27.9	15.6	97	59	35.2	6.7	2
December	24.5	9.8	97	52	0	7.0	0

*Source: ICAR Regional Research Centre, Jharnapani, Nagaland.

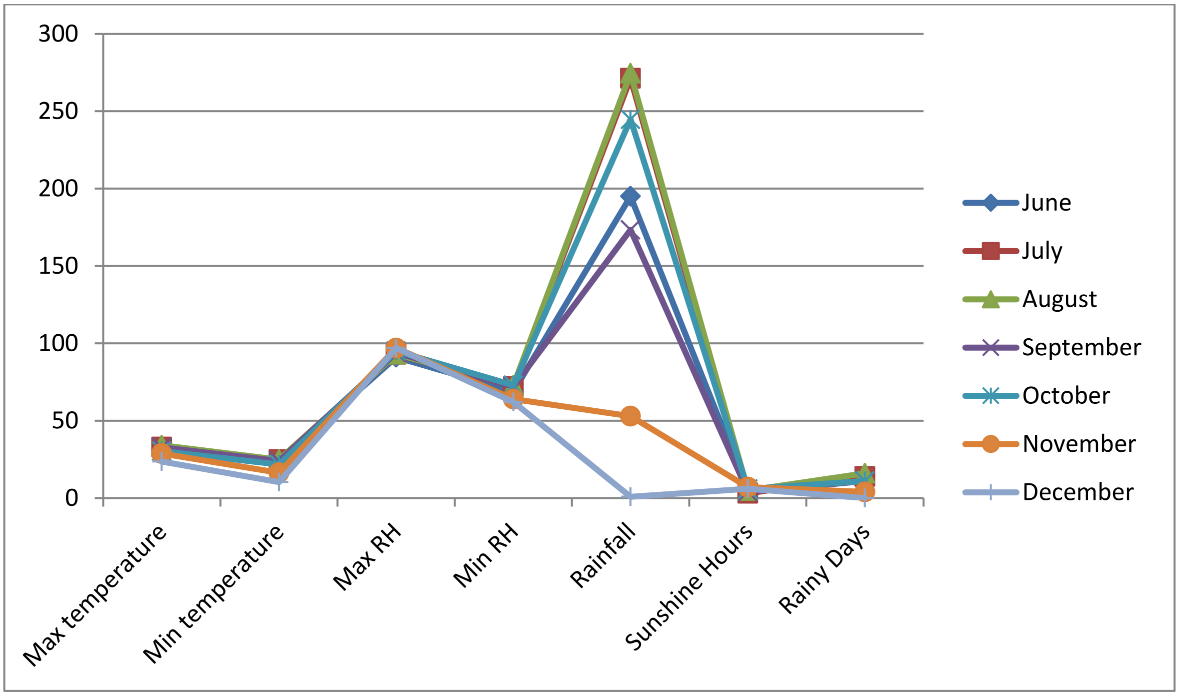

Fig 3.1 Monthly meteorological data during the period of investigation (2019)

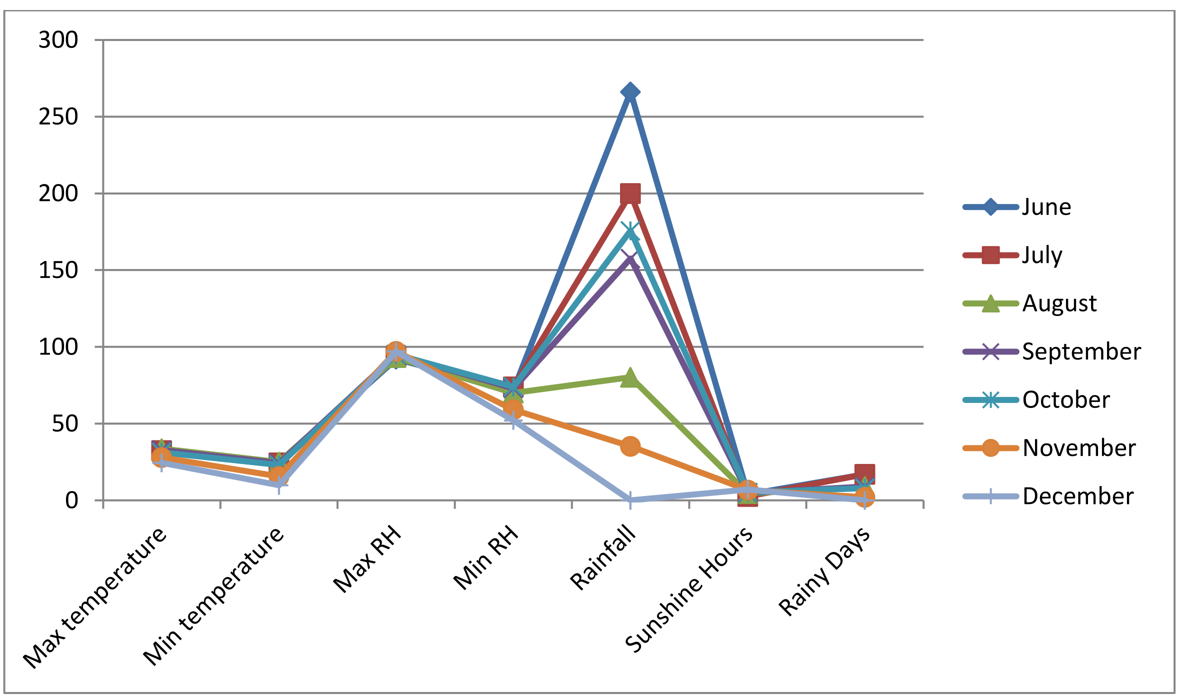

Fig 3.1 Monthly meteorological data during the period of investigation (2020)

The annual precipitation ranges from 1500-2500 mm, with high humidity and moderate temperature. Due to high atmospheric humidity, the mean temperature varies from 21^0C to 32^0C during summer and rarely goes below 8^0C in winter. Maximum and minimum temperature, maximum and minimum relative humidity, rainfall, sunshine hours and rainy days are the monthly meteorological data recorded during crop growth period in both the years of the investigation which is presented in Table 3.1 and 3.2 and graphically illustrated in Fig 3.1 and 3.2.

3.3 Soil Condition

The soils of the experimental site is dominated by the soil order of Inceptisol with low base saturation with an “Udic” soil moisture regime, therefore it is laid down in “Dystrudepts” great groups.

The soil of the experimental plot was characterized by well drained and sandy clay loam texture. The texture and fertility status of the soil was ascertained by collecting soil samples randomly from a depth of 0-15 cm using quadrant methods by means of auger before and after harvest of the crop. Proper precautions as prescribed were followed very carefully during soil sampling.

The collected samples were air dried, crushed and sieved to pass through 2 mm sieve. The processed samples were procured for analysis of mechanical, physico-chemical and biological parameters following standard analytical procedures. The results of the initial soil status obtained are presented in Table 3.3.

Table 3.3: Initial soil status of the experiment plot

SL. No.	SOIL PRAMETERS	METHODS	VALUES	
			2019	2020
1.	Soil pH	Glass electrode pH meter (Richards, 1954)	4.70	4.85
2.	Organic Carbon (%)	Rapid titration method outlined by Walkley and Black (1934) and expressed in percentage as described by Jackson (1973).	1.26	1.40
3.	EC (dS m^{-1})	Conductivity bridge (Richards, 1954)	0.171	0.185
4.	Cation Exchange Capacity {cmol (p^+) kg^{-1}}	1 *N* NH_4OAc at pH 7.0 (Chapman, 1965)	16.75	19.20
5.	N (kg ha^{-1})	Alkaline potassium permanganate method as described by Subbiah and Asija (1956)	260.54	276.80
6.	P (kg ha^{-1})	Brays and Kurtz method (1945)	16.93	20.85
7.	K (kg ha^{-1})	Flame photometric method using neutral normal ammonium acetate (pH 7.0) (Jackson, 1973).	133.45	142.64
8.	S (kg ha^{-1})	Turbidimetric method (Chesnin and Yien, 1950)	5.20	6.98
9.	Total Potential Acidity (meq/100g)	$BaCl_2$ – triethanolamine extract buffer at pH 8.0-8.2 (Baruah and Barthakur, 1977).	20.85	18.35
10.	Exchangeable Ca {cmol (p^+) kg^{-1}}	1 *N* ammonium acetate extracts of soil by titration against EDTA (Black, 1965)	2.24	3.09
11.	Exchangeable Mg {cmol (p^+) kg^{-1}}	1 *N* ammonium acetate extracts of soil by titration against EDTA (Black, 1965)	0.38	0.43
12.	Microbial biomass carbon (µg g^{-1})	Fumigation-extraction method (Macfayden, 1970)	177.35	120.88
13.	Dehydrogenase	2-3-5- triphenyltetrazolium chloride	17.50	21.65

	activity (µg TPF g^{-1} h^{-1})	reduction technique (Casida *et al*., 1964)		
14.	Mechanical analysis Sand (%) Silt (%) Clay (%)	International Pipette Method using 1 *N* NaOH (Piper, 1966)	51.20 19.00 29.80	49.90 22.90 27.20
15.	Soil Texture	International Pipette Method using 1 *N* NaOH (Piper, 1966)	Sandy clay loam	
16.	Nutrient content of FYM	N: 1.32 % P: 0.43 % K: 1.28 %		

3.4 Experimental details

3.4.1 Experimental layout

The field experiment was laid out in Randomized Block Design with twelve treatments which were replicated thrice. The experiment was conducted for two consecutive years (2019 and 2020) on the same site. The whole experimental field was equally divided into three blocks and each block was again divided into equal sized plots measuring 3 m x 2 m to accommodate the treatments. Altogether there were 36 plots. The treatments were allotted randomly within the plots of each experimental block.

The details of the experimental field:

1. Crop: Rice (*Oryza sativa* L.)
2. Variety: Local
3. Experimental Design: Randomized Block Design
4. Number of replications: 3
5. Number of treatment: 12

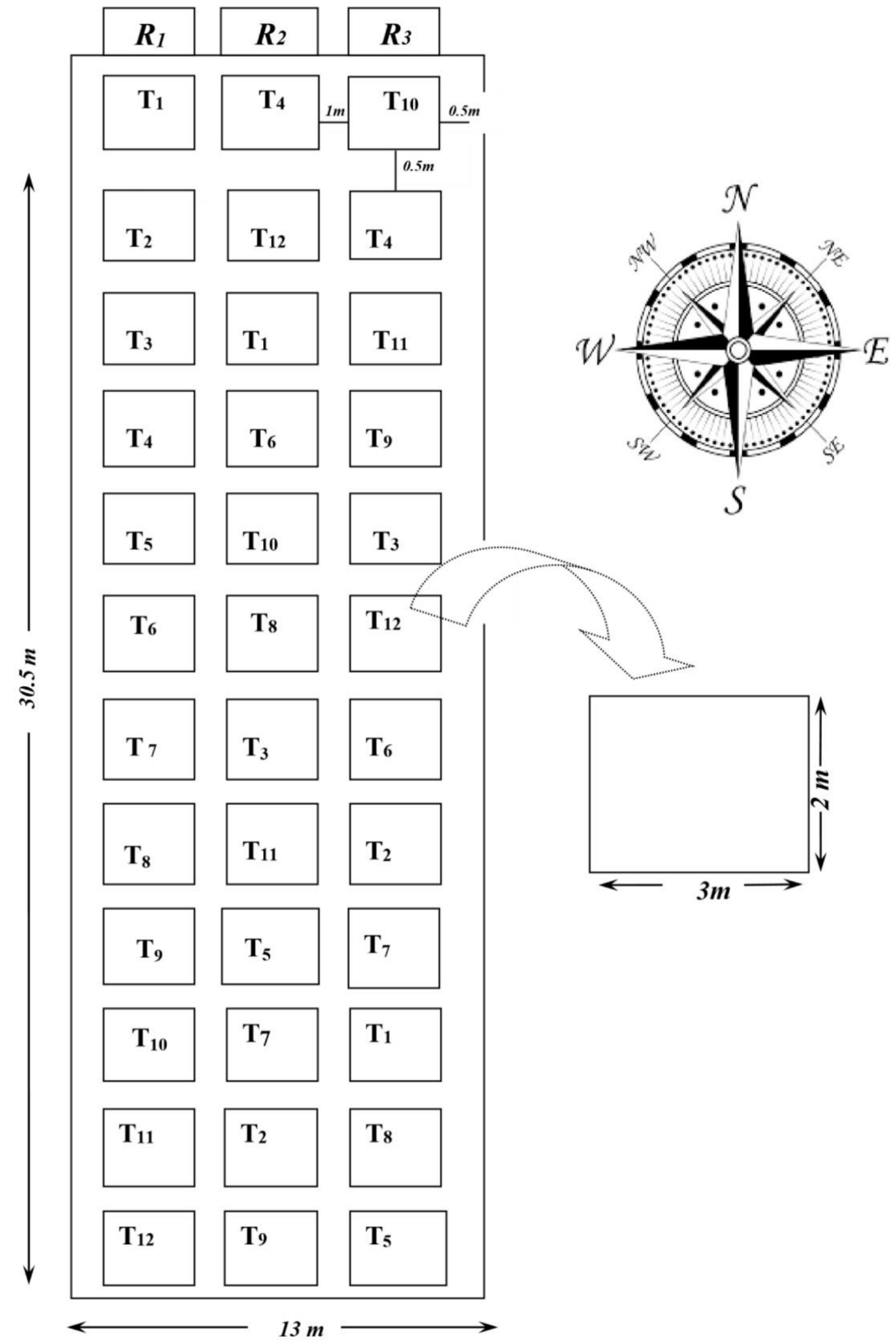

Fig 3.3 Layout of the experimental field in randomized block design

6. Plot size : 3 m x 2 m
7. Spacing :

   Row to row: 20 cm

   Plant to plant: 10 cm

3.4.2 Treatment details

1. T_1: Control
2. T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)
3. T_3: 100% RDF +PSB
4. T_4: 100% RDF + FYM @ 2 t ha^{-1}
5. T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB
6. T_6: 75% RDF + PSB
7. T_7: 75% RDF + FYM @ 2 t ha^{-1}
8. T_8: 75 % RDF + FYM @ 2 t ha^{-1} + PSB
9. T_9: 50% RDF + PSB
10. T_{10}: 50% RDF + FYM @ 2 t ha^{-1}
11. T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB
12. T_{12}: 109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O (SSNM)

3.5 Cultivation details

3.5.1 Selection and preparation of field

A rectangular plot having uniform soil fertility and even topography was selected for field experiment. Land preparation was carried out one month before sowing by ploughing with a tractor drawn plough followed by a rotavator to break the hard pans and clods to make it into fine seedbed. All the weeds and stubbles were removed and then the field was leveled and laid according to the layout plan.

3.5.2 Manures and Fertilizer application

Well decomposed FYM was uniformly broadcasted in the required plots @ 2 tonnes ha^{-1} prior to 30 days of sowing.

Calculated amount of pre-planned fertilizer doses was applied to each plot. Recommended doses of N, P_2O_5 and K_2O i.e. @ 120, 40 and 30 kg ha^{-1} respectively were applied. 90 N kg ha^{-1}, 30 P_2O_5 kg ha^{-1} and 22.5 K_2O kg ha^{-1} was considered as 75% of recommended dose of fertilizer; 60 N kg ha^{-1}, 20 P_2O_5 kg ha^{-1} and 15 K_2O kg ha^{-1} was considered as 50% of the recommended dose of fertilizers. Nitrogen was applied through urea. Basal application of phosphorus and potassium was made through SSP and muriate of potash, respectively as per treatment.

3.5.3 Seed rate and sowing

Healthy and bold seeds of rice were sown directly to their respective plots by maintaining a spacing of 20 cm row to row and 10 cm plant to plant with a seed rate of 80 kg ha^{-1}. The sowing was done in the forth-night of June.

Seed treatment of phosphorus solubilizing bio-fertilizer (PSB) at the rate of 200 g per 10 kg seeds as per the treatments was done prior to sowing.

3.5.4 Thinning and gap filling

The thinning operation was carried out after about one month of sowing to maintain a uniform plant to plant spacing and at the same time gap filling was done in the required plots for rice crop.

3.5.5 Weed control

The first hand weeding was carried out at 20 DAS with the help of *khurpi* and local hoe and later at 15 days interval. This cultural practice was carried out because during the seedling stage the crop-weed competition was very high especially for direct-seeded rice.

3.5.6 Harvesting

Experimental crop was harvested after it attained physiological maturity of grain in respective plots. The crop was harvested in the initial week of October when 85% panicles had about 85 % ripened spikelets and upper portion of spikelets look straw coloured. The grains were hard enough having less than 20 % moisture. The straws were cut from the ground level with the help of sickle, after which the harvested crop from their respective plots was carefully bundled, tagged and brought to the threshing floor for threshing.

3.5.7 Threshing

Threshing was done manually plot wise and the grain yield was recorded after winnowing and cleaning. Grain yield, thus, obtained from each plot were recorded as q ha^{-1}. The straws were sun dried for dry weight basis.

3.6 Observations to be recorded

3.6.1 Growth parameters

3.6.1.1 Plant height (cm)

Five plants from each plot were randomly selected and tagged for recording the plant height at different growth intervals. The plant height was measured in centimeter (cm) from the ground level to the top of the plants at 30, 60 and 90 DAS. The average height of the plant for each treatment was calculated.

3.6.1.2 Number of leaves plant^{-1}

The number of leaves plant^{-1} was recorded from the tagged plants from each plot at 30 DAS, 60 DAS and 90 DAS. The average number of leaves plant^{-1} for each treatment was calculated and recorded.

3.6.1.3 Number of tillers plant^{-1}

The number of tillers plant^{-1} was recorded from the tagged plants from each plot at 30 DAS, 60 DAS and 90 Das. The average number of tillers plant^{-1} for each treatment was calculated and recorded.

3.6.1.4 Dry matter accumulation plant^{-1}

Dry matter accumulation at 30 DAS, 60 DAS and 90 DAS was recorded by selecting five plants randomly from each plot. The samples were collected in the paper bags and sun dried for about 2 days. After sun drying, the samples were dried in hot air oven 65-70^{0}C till the constant weight attained. The average dry weight was then recorded for each treatment and the values of dry weight of plant were computed in gram plant^{-1}.

3.6.1.5 Crop growth rate (g m^{-2} day^{-1})

It represents dry weight gained by a unit area of crop in a given time. It is expressed in g m^{-2} day^{-1}. The crop growth rate (CGR) at 30, 60 and 90 DAS was calculated by using the dry matter accumulation (g) of plants for each plot at successive growth with the following formula.

$$CGR = \frac{w_2 - w_1}{(t_2 - t_1)s}$$

Where,

W_1 and W_2 are the dry weight of the plants at time t_1 and t_2 respectively.

S is land area (m^2) over which dry matter was recorded.

3.6.1.6 Relative growth rate (g g^{-1} day^{-1})

The relative growth rate of crops at time instant (t) is defined as the increase of plant material per unit weight per unit time. It is expressed in g^{-1} g^{-1} day^{-1}. Relative growth rate (RGR) at 30, 60 and 90 DAS was calculated using the same recorded data of the dry matter accumulation of plants with the help of the following formula.

$$RGR = \frac{\text{In } w_2 - \text{In } w_1}{(t_2 - t_1)}$$

Where,

W_1 and W_2 are the dry matter produced by a gram (g) of existing dry matter in a day at time t_1 and t_2 respectively.

3.6.2 Yield attributes

3.6.2.1 Panicle length (cm)

The panicle length per plant was recorded from the tagged plants of each plot at the time of harvest. The length was measured from the neck nodes to the tip of the upper most spikelet in centimeter. The average panicle length per plant for each treatment was calculated and recorded.

3.6.2.2 Number of panicles per plant

The number of panicles per plant was counted from the tagged plants from each plot and the average number of panicles per plant was recorded for each treatment.

3.6.2.3 Number of grains per panicle

The number of grains per panicle was counted from the tagged plants from each plot at the time of maturity and the average number of grains per panicle was recorded for each treatment.

3.6.2.4 Test weight (g)

1000 bold grains were counted from the threshed and cleaned grains and their weight was precisely recorded by an electronic weighing balance for each treatment. The weight of these 1000 grains was taken in gram.

3.6.3 Yield

3.6.3.1 Grain yield (q ha^{-1})

The grain yield obtained from their respective plots after threshing and cleaning were sun dried and then weighed to determine the grain yield. The grain yield obtained from each plot was recorded in kg which was converted into q ha^{-1} using the following formula:

$$\text{Grain yield (q ha}^{-1}\text{)} = \frac{\text{Weight of the grains per plot (kg)}}{\text{Size of the plot (m}^2\text{) x 100}} \times 10000$$

3.6.3.2 Straw yield (q ha^{-1})

The straw bundles collected from the plots after threshing were sun dried for some days after which the weight was recorded to determine the straw yield. The straw yield obtained from each plot was recorded in kg and further converted in to q ha^{-1} using the following formula:

$$\text{Straw yield (q ha}^{-1}\text{)} = \frac{\text{Weight of the stover per plot (kg)}}{\text{Size of the plot (m}^2\text{) x 100}} \times 10000$$

3.6.3.3 Harvest index (%)

Harvest index is the ratio of economic yield to biological yield. The harvest index for each treatment was calculated using the formula:

$$\text{Harvest Index (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \text{ x } 100$$

$$\text{Harvest Index (\%)} = \frac{\text{Grain yield}}{\text{Grain yield+Straw yield}} \text{ x } 100$$

3.7 Plant analysis

The collected grains and straw from the designated plots were sun dried separately and put to oven for drying at 60-70^{0}C to attain a constant weight. The dried samples such as grains and straw were then grinded to powder from a willy-mill and stored in polythene bags labelled for various chemical analysis.

3.7.1 Estimation of nitrogen in seed and straw (%)

Half a gram powdered sample was digested with concentrated H_2SO_4 in the presence of digestion mixture ($CuSO_4$ + K_2SO_4) till the digest gave clear bluish green colour. The digested sample was further diluted carefully with distilled water to known volume. Then a known volume of aliquot was transferred to distillation unit (Micro kjeldahl – apparatus) and liberated ammonia was trapped in boric acid containing mixed indicator. Later it was titrated against standard H_2SO_4 and the amount of ammonia liberated was estimated in the form of nitrogen as per the procedure given by Black (1965).

3.7.2 Digestion of plant samples for other nutrients

Half a gram powdered sample was pre-digested with concentrated HNO_3 overnight. Further pre-digested sample was treated with di-acid (HNO_3:$HCIO_4$ in the ratio 10:4) mixture and kept on hot plate for digestion till colourless thread like structures was obtained. After complete digestion precipitate was dissolved in 6 *N* HCl and transferred to the 100 ml volumetric flask through Whatman No. 42 filter paper and finally the volume of extract was made to 100 ml with double distilled water and preserved for further analysis.

3.7.3 Estimation of phosphorus in grains and straw (%)

Phosphorus in both grains and straw was determined by vanado-molybdate yellow colour method as outlined by Jackson (1973) using spectrophotometer at 470 nm.

3.7.4 Estimation of potassium in seed and straw (%)

Potassium in both grains and straw was determined by flame photometry after making appropriate dilution as described by Chapman and Pratt (1961).

3.7.5 Estimation of sulphur in seed and straw (%)

Sulphur content in grains and straw was determined turbimetrically as described for soil sulphur (Chesnin and Yien, 1950).

3.8 Nutrient uptake (kg ha^{-1})

The uptake of different nutrients was separately carried out in grains and straw samples multiplying nutrient content (%) in grains and straw samples with their corresponding yield data.

$$\text{Nutrient uptake} = \frac{\text{Yield kg ha}-^{1} \text{ x nutrient content (\%)}}{100}$$

3.9 Soil analysis

After the harvest of the crop, soil sample were collected from surface soil (0-15 cm) from each plot. Collected soil sample were air dried, grinded and sieved through 2 mm sieve and representative samples were collected in the polythene bags with proper labelling for various analysis. All the laboratory analysis was done in the Department of Soil Science, SAS, Nagaland University.

3.9.1 Mechanical analysis

Air dried and processed sample were analyzed for the particle size distribution (sand, silt and clay) following International Pipette Method (Piper, 1966) using 0.5 *N* NaOH as a dispersing agent. Hydrogen peroxide was used to dissolve the organic matter in the soil. After obtaining the percentage sand, silt and clay: textural classes were obtained using textural triangle.

3.9.2 Soil pH

The soil pH was determined in 1:2.5 soil:water suspension using glass electrode pH meter as described by Jackson (1973).

3.9.3 Electrical conductivity

A soil:water suspension was prepared in the ratio of 1:2.5 and electrical conductivity (EC) was determined using Conductivity Bridge at room temperature as described by Richards (1954). Electrical conductivity was expressed in dSm^{-1}.

3.9.4 Organic carbon

Organic carbon content was determined by rapid titration method outlined by Walkley and Black (1934). Potassium dichromate ($K_2Cr_2O_7$) and concentrated sulphuric acid (H_2SO_4) were used to oxidize organic matter in soil. The excess of $K_2Cr_2O_7$ not reduced by organic matter of soil is determined by back titration with ferrous ammonium sulphate in the presence of diphenylamine indicator and expressed in percentage as described by Jackson (1973).

3.9.5 Cation exchange capacity

The cation exchange capacity of the soil was determined using 1 *N* NH_4OAc at pH 7.0 (Chapman, 1965).

3.9.6 Available nitrogen

The available nitrogen in soil was determined using alkaline permanganate method as described by Subbiah and Asijah (1956). Available nitrogen content was expressed in kg ha^{-1}.

3.9.7 Available phosphorus

Available phosphorus content in soil was determined by Bray's 1 method as illustrated Bray and Kurtz (1945) using 0.03 *N* NH_4F + 0.025 *N* HCl (pH 3.5) as extracting solution. In the filtered extract, phosphorus was estimated colorimetrically by adding ammonium molybdate and stannous chloride. The intensity (% transmittance) of characteristics blue colour in the solution gives the measure for the concentration of P in the test solution, which was read in the spectrophotometer at 660 nm wavelength. After getting % transmittance of the P in the test solution, concentration of P was read from the standard curve. The procedure was mainly meant for soils which are moderate to strongly acidic pH. Available phosphorus content was expressed as P_2O_5 kg ha^{-1}.

3.9.8 Available potassium

The available potassium in soil was determined by flame photometric method using neutral normal ammonium acetate (Jackson, 1973). Neutral normal NH_4OAc (pH = 7.0) was used as the equilibrium solution to exchange the exchangeable K ions of the soil. In the filtered extract, K was determined using flame photometer. Available potassium content in the soil solution was converted to and expressed as available K_2O kg ha^{-1}.

3.9.9 Available sulphur

Available sulphur was determined by turbidimetric method as illustrated by Chesnin and Yien, 1950. Sulphate was extracted from soil sample by mono-calcium phosphate solution. In the filtered extract, the adding 25 % HNO_3 and acetic phosphoric acid, sulphur was determined by adding barium sulphate seed suspension, barium chroride crystals and gum acacia. The intensity of the turbidity produced in the sample solution was measured by spectrophotometer at 440 nm wavelength. Available sulphur content in soil was expressed in kg ha^{-1}.

3.9.10 Exchangeable calcium

The exchangeable calcium was extracted with neutral normal ammonium acetate and determined by versanate method, where known volume of soil extract was titrated with standard 0.01 *N* versanate (EDTA) solution using murexide (ammonium purpurate) indicator in the presence of NaOH solution (Black, 1965). Exchangeable Ca was expressed in cmol (p^+) kg^{-1}.

3.9.11 Exchangeable magnesium

The exchangeable magnesium was determined by using erichrome black T indicator with 0.01 *N* (EDTA) methods in the presence of ammonium chloride and ammonium hydroxide buffer (Black, 1965). Exchangeable Mg was expressed in cmol (p^+) kg^{-1}.

3.9.12 Total potential acidity

The total potential acidity of soil includes all the acidity components like extractable acidity, non extractable acidity, weak acidic carboxylic and phenolic hydroxyl Al polymers that could be present even in soils. The total potential acidity was determined by using $BaCl_2$ – triethanolamine extract buffer at pH 8.0-8.2 as described by Baruah and Barthakur (1977).

3.9.13 Soil microbial biomass carbon

Microbial biomass carbon (MBC) was determined by fumigation extraction method as described by Vance *et al*. (1987). Ethanol free chloroform was used to fumigate the fresh soil samples in vacuum desiccator. After 24 hours, vacuum was released and fumigated soil samples along with their non-fumigated counterparts were extracted with 0.5 *M* K_2SO_4. The filtered extract was titrated against 0.005 *N* ferrous ammonium sulphate after adding $K_2Cr_2O_7$, conc. H_2SO_4 and H_3PO_4 in the presence of diphenylamine indicator. Thereafter, total weight of extractable carbon in fumigated and non-fumigated soil samples were calculated out. MBC was calculated by using the following formula:

$$MBC\ (\mu g\ g^{-1}\ soil) = E_{CF}\ - EC_{NF}/\ K_{EC}$$

Where,

E_{CF} = total weight of extractable C in fumigated soil sample

EC_{NF} = total weight of extractable C in non-fumigated soil sample

K_{EC} = calibration factor ~ 0.38

3.9.14 Dehydrogenase activity

Dehydrogenase enzyme activity (DHA) was determined by 2-3-5-triphenyl tetrazolium chloride reduction technique as illustrated by Casida *et al.* (1964). For the determination of DHA, soil sample (10 g) was mixed with 0.1 g $CaCO_3$ and then, the mixture was divided into three parts (each weighed 3 g) and transferred to three screw cap flat bottom test tubes (15 ml capacity). To each test tube 0.5 ml of 1 % 2,3,5-triphenyl tetrazolium chloride (TTC) and 1.25 ml of distilled water were added and mixed thoroughly by gentle tapping and incubated at 37^0C for 24 hours. The soil suspension was filtered through glass funnel fitted with absorbent cotton. Methanol was added to extract the soil suspension until the colour of the cotton plug became white and the final volume was made up to 50 ml. Intensity of reddish colour was measured by using spectrophotometer at 485 nm wavelength. The concentration of triphenyl formazon (TPF) in the supernatant was determined against a standard graph prepared using known concentrations of TPF. The DHA was expressed as µg TPF g^{-1} h^{-1}.

3.10 Economic analysis

Gross return, net return, and benefit-cost ratio were worked out for various treatments at the end of the first crop and also at the end of the crop sequence on the basis of input costs and output prices. Economics of different treatment was worked out as per existing market prices.

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

The cost of cultivation was calculated as per item wise cost incurred in each treatment.

3.10.2 Gross return (Rs ha^{-1})

Gross return in rupees per hectare on the basis of current price of the produce was worked out by multiplying grain and straw yield separately under various treatment combinations. The money value of both grain and straw was added together in order to achieve gross return.

3.10.3 Net return (Rs ha^{-1})

Net return from each treatment was calculated by subtracting the cost of cultivation from the gross return.

Net return = Gross return – Cost of cultivation

3.10.4 Benefit: Cost ratio

The benefit cost ratio was worked out on the basis of net return and cost of cultivation by using the following formula:

$$\text{B:C ratio} = \frac{\text{Net return}}{\text{Cost of cultivation}}$$

3.11 Statistical analysis

The experimental data recorded during the course of investigation from each parameter were tabulated and analyzed statistically to draw a valid conclusion by applying the techniques of randomized block design as described by Gomez and Gomez (1976). The statistical significance of the treatment effect was judged with the help of variance ratio test (F test). Critical Difference (C.D.) at 5% level of significance was worked out to determine the difference between treatment means by using the following formula:

C.D = SEm ± × $\sqrt{2}$ × $t_{0.05}$ for error degree of freedom

Where,

CD = Critical difference

SEm ± = Standard error mean

$t_{0.05}$ = table value of students obtained at 5 % probability test

The standard errors mean (SEm±) was calculated by using the following formula:

$$\textbf{SEm}\pm = \sqrt{\frac{VE}{r}}$$

Where,

VE = Variance of error

r = No. of replication

The ANOVA are annexed under the appendices.

Plate 1: General view of the experimental field

Plate 2: Land preparation

Plate 3: Crop at seedling stage

Plate 4: Crop at tillering stage

Plate 5: Crop at- (A) Booting stage and (B) Flowering stage

Plate 6: Crop at milking and grain filling stage

Plate 7: Crop at maturity stage

Plate 8: Harvesting of crops by the author

CHAPTER IV

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

An attempt has been made in this chapter to assess the "Influence of integrated nutrient management on performance in direct seeded rice and soil properties in dystrudepts of Nagaland" which was carried out during *kharif* season. Therefore, this chapter makes an endeavour to elicit the impact of various treatments on growth, yield and yield attributes, physico-chemical properties, nutrient content, nutrient uptake and economics of direct seeded rice. The observations recorded during both experimental years (2019 and 2020) have been processed statistically in order to assess their degree of variance due to diverse treatments. The results have been presented briefly through relevant tables and graphs with suitable reasoning and evidences based on experiments and literature available on the topic of the investigation to draw a valid conclusion for scientific and practical utility.

Plant nutrients plays vital role in the growth parameters, yield and yield attributes, nutrient content and nutrient uptake and health of the soil. This factor becomes more important when an exhaustive crop like rice is grown. Hence the integrated nutrient management is very important for maintaining the soil health.

4.1 Influence of integrated nutrient management in direct seeded rice at different stages on growth attributes

Growth is an irreversible process that occurs by the division and elongation of cells which to leads to plant biomass, weight and size of leaves and stems. Growth and its attributes due to the presence of the substances in the food nourished the plant cells and allow them to grow/divide. Hence, growth and its attributes is a chemical change in which the molecules present in the food undergo changes to form molecules that enhance the crop growth and achieve the ultimate goal of crop yield. The growth parameters such as plant height, number of tillers plant^{-1} and dry matter accumulation followed sigmoid curve at the initial stage which decreases as it nears maturity. Different growth attributes were recorded at successive stages of crop *i.e.* 30 DAS, 60 DAS and 90 DAS. The result on growth attributes are described here under as follows:-

4.1.1 Plant height (cm)

The two years data on plant height in direct seeded rice as influenced by integrated nutrient management is recorded at 30, 60 and 90 DAS which is presented in Table 4.1 and graphically illustrated in Fig 4.1.

It is evident from the table that the plant height increased successively with the advancement in crop growth stages until harvest. The increase in plant height was peak during 30-60 DAS which coincided with the elongation stage of crops and it reached near plateau at the time of maturity. Significantly, tallest plant height with corresponding value of 68.97 cm and 70.88 cm at 30 DAS, 118.20 cm and 119.88 cm at 60 DAS and 129.33 cm and 130.93 cm at 90 DAS which was recorded in the year 2019 and 2020 respectively, under treatment T_5 (100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB) which is statistically at par with T_4 (100 % RDF + FYM @ 2 tonnes ha^{-1}) and significantly superior to the rest of the treatment at all stages of crop growth. Higher plant height obtained with proper combination of nutrient management to rice crop was the indication of better internodes elongation and good vegetative growth throughout the crop cycle. The shortest plant height was recorded in the control treatment (T_1) with the value of 39.87 cm and 37.95 cm at 30 DAS, 84.45 cm and 83.72 cm at 60 DAS and 93.47 cm and 92.12 cm at 90 DAS in 2019 and 2020 respectively, which might be due to poor availability of nutrient which caused poor growth and poor nutrient mobilization.

Table 4.1: Influence of integrated nutrient management in direct seeded rice at different growth stages on plant height

	30 DAS (cm)			60 DAS (cm)			90 DAS (cm)		
Treatments	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**
T_1: Control	39.87	37.95	38.91	84.45	83.72	84.09	93.47	92.12	92.79
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	57.22	58.29	57.75	104.50	105.40	104.95	114.86	115.69	115.28
T_3: 100% RDF + PSB	59.13	60.48	59.80	106.70	107.69	107.20	117.22	118.22	117.72
T_4: 100% RDF + FYM @ 2 t ha^{-1}	67.07	68.83	67.95	116.08	117.53	116.81	127.02	128.40	127.71
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	68.97	70.88	69.93	118.20	119.88	119.04	129.33	130.93	130.13
T_6: 75% RDF + PSB	51.54	51.49	51.51	97.88	98.33	98.10	107.85	107.90	107.87
T_7: 75% RDF + FYM @ 2 t ha^{-1}	53.47	53.82	53.65	100.22	100.75	100.48	110.27	110.55	110.41
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	55.29	55.84	55.57	102.29	103.05	102.67	112.53	113.01	112.77
T_9: 50% RDF + PSB	45.78	44.25	45.01	91.65	91.21	91.43	101.00	99.85	100.43
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	47.72	46.74	47.23	93.80	93.60	93.70	103.35	102.83	103.09
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	49.59	48.98	49.29	95.72	95.91	95.82	105.45	105.33	105.39
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	61.02	62.59	61.81	108.85	110.03	109.44	119.52	120.70	120.11
SEm±	**1.69**	**1.92**	**1.28**	**2.43**	**2.54**	**1.76**	**2.53**	**2.60**	**1.82**
CD (P=0.05)	**4.96**	**5.62**	**3.64**	**7.14**	**7.46**	**5.02**	**7.43**	**7.63**	**5.17**

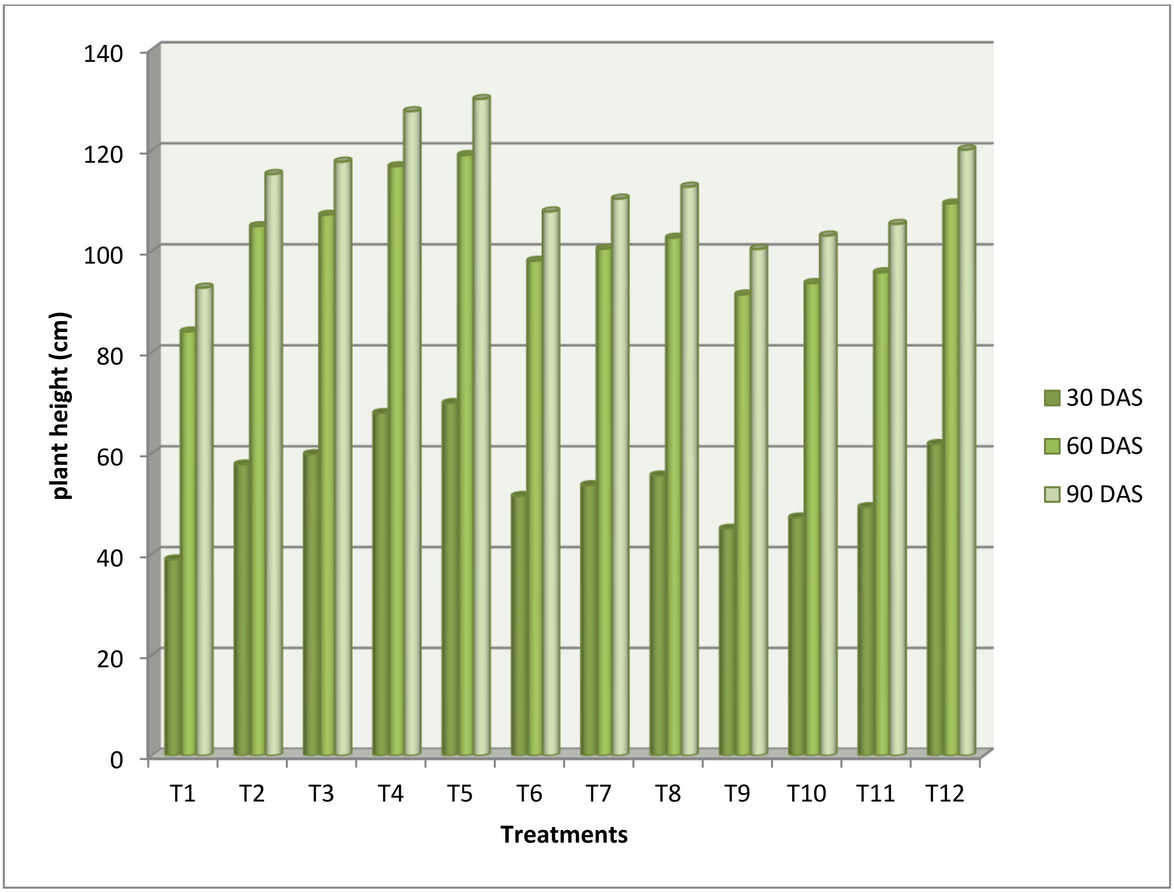

Fig 4.1 Influence of integrated nutrient management at different stages of crop growth on plant height

Plant height increased mainly due to adequate nutrient supply to the plant which resulted into rapid growth by good establishment of root and various metabolic processes and ultimately performed better mobilization of synthesized carbohydrates into amino acid and protein which stimulated the rapid cell division and cell elongation. Similar findings were documented by Tomar *et al*., 2018; Hanamant *et al*., 2019 and Geetha *et al*., 2020. Application of FYM might have increased the soil organic carbon, which holds more moisture in soil and created suitable condition for better root growth and proliferation and also gave opportunity to extract water from larger profile area. In present study, the cumulative effect of RDF + FYM + PSB was noticeable and this combined application maintained higher availability of nitrogen, phosphorus and other nutrients in soil. The application of FYM accelerated the proliferation of algal cells as well as nutrient uptake besides facilitating as substrate for the PSB thus increased the plant height. The results are in conformity with Nanda *et al*. (2015).

4.1.2 Number of leaves plant^{-1}

The two years data on number of leaves plant^{-1} in direct seeded rice as influenced by integrated nutrient management is recorded at 30, 60 and 90 DAS which is presented in Table 4.2 and graphically plotted in Fig 4.2.

It is evident from the table that the number of leaves plant^{-1} in both the season has increased significantly with increasing fertility levels at different stages of crop growth. Highest number of leaves plant^{-1} was recorded in the treatment T_5 (100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB) with the value of 17.88 and 18.65 at 30 DAS, 42.28 and 43.70 at 60 DAS and 45.50 and 46.35 at 90 DAS, respectively in both the years, which is statistically at par with T_4 (100 % RDF + FYM @ 2 tonnes ha^{-1}) and significantly superior to the rest of the treatments at all stages of crop growth during both the years of investigation. The lowest number of leaves plant^{-1} was recorded in the control

Table 4.2: Influence of integrated nutrient management in direct seeded rice at different growth stages on number of leaves plant^{-1}

	30 DAS			60 DAS			90 DAS		
Treatments	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**
T_1: Control	10.13	9.58	9.86	25.69	24.55	25.12	29.38	28.75	29.06
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	14.80	15.17	14.99	35.70	36.25	35.98	39.05	39.48	39.26
T_3: 100% RDF + PSB	15.29	15.75	15.52	36.88	37.68	37.28	40.17	40.76	40.47
T_4: 100% RDF + FYM @ 2 t ha^{-1}	17.39	18.11	17.75	41.17	42.29	41.73	44.42	45.20	44.81
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	17.88	18.65	18.26	42.28	43.70	42.99	45.50	46.35	45.93
T_6: 75% RDF + PSB	13.34	13.42	13.38	32.30	31.96	32.13	35.81	35.76	35.79
T_7: 75% RDF + FYM @ 2 t ha^{-1}	13.83	14.02	13.93	33.45	33.42	33.43	36.92	37.08	37.00
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	14.28	14.58	14.43	34.53	34.81	34.67	37.90	38.23	38.07
T_9: 50% RDF + PSB	11.83	11.55	11.69	28.89	27.75	28.32	32.53	31.95	32.24
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	12.40	12.24	12.32	30.05	29.17	29.61	33.67	33.32	33.50
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	12.84	12.81	12.83	31.10	30.54	30.82	34.72	34.52	34.62
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	15.74	4.90	10.32	38.02	39.08	38.55	41.27	42.00	41.64
SEm±	**0.43**	**0.54**	**0.35**	**1.02**	**1.04**	**0.73**	**1.06**	**1.08**	**0.76**
CD (P=0.05)	**1.26**	**1.59**	**0.99**	**2.99**	**3.06**	**2.08**	**3.10**	**3.17**	**2.15**

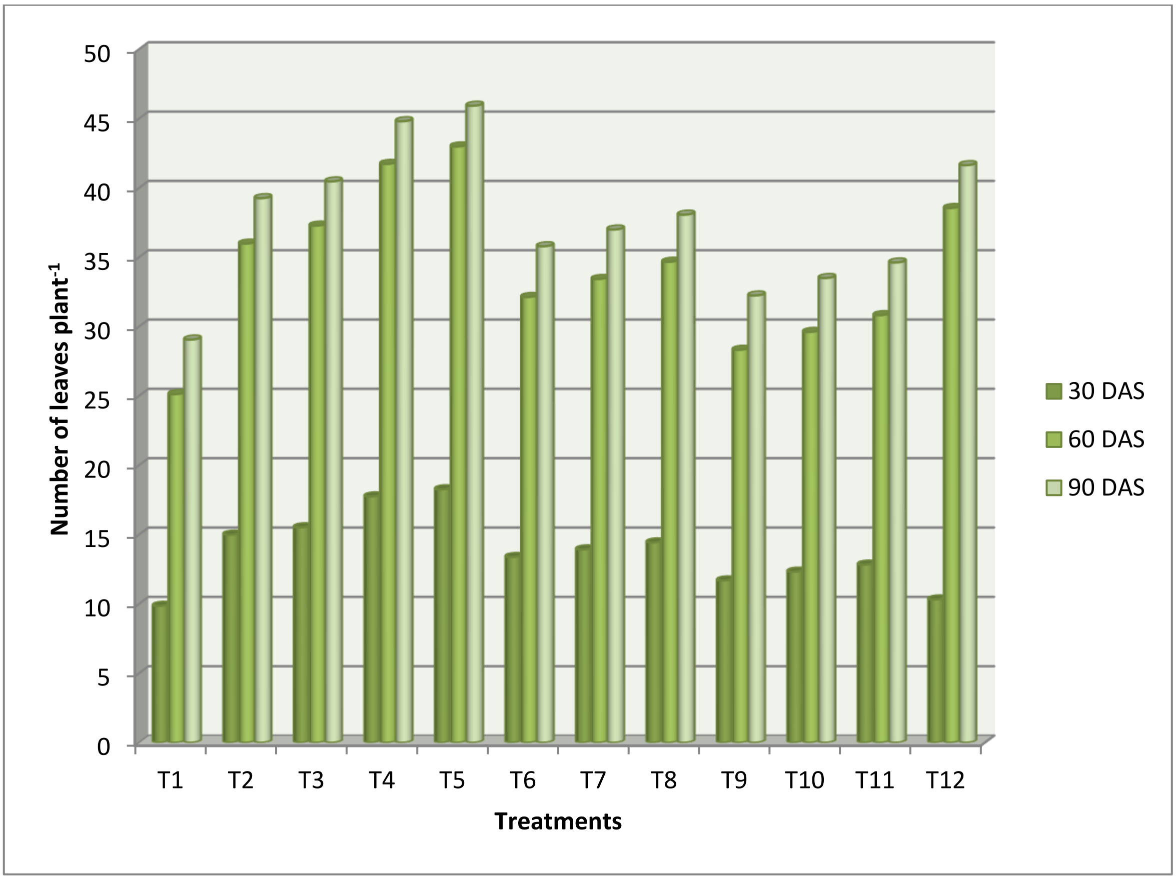

Fig 4.2 Influence of integrated nutrient management at different stages of crop growth on number of leaves plant^{-1}

treatment (T_1) with the value of 10.13 and 9.58 at 30 DAS, 25.69 and 24.55 at 60 DAS and 29.38 and 28.75 at 90 DAS during the two years of field trials respectively. Number of leaves plant^{-1} has direct correlation towards biomass accumulation especially in tillering crops like rice. This effect is felt more towards the later growth of stages.

Result revealed that application of RDF along with FYM and PSB had beneficial effect which ultimately improved the growth parameters which may be attributed to the synergistic effect and the response was augmented when used together. These findings are in direct conformity with that of Verma *et al*. (2008) and Kumar *et al*. (2010). Plants supplied with adequate amount of major nutrients (100% RDF) produced more leaves and prolific roots for supply of nutrients and water and hence brought about greater accumulation of photosynthates which boosted crop growth. The results are in conformity with Singh *et al*. (2014) and Singh *et al*. (2021).

4.1.3 Number of tillers plant^{-1}

The data pertaining to number of tillers plant^{-1} at 30, 60 and 90 DAS for two consecutive years are presented in Table 4.3 and graphically portrayed in Fig 4.3.

The numbers of tillers plant^{-1} showed significant effect with different doses of fertilizers and organic manures at different stages of crop growth. There was rapid increase in tiller number from 30 DAS to 60 DAS with a little increase from 60 DAS to 90 DAS during both years of the experiment. The highest number of tillers plant^{-1} *i.e.* 6.40 and 6.55 at 30 DAS, 8.25 and 8.44 at 60 DAS and 8.52 and 8.65 at 90 DAS, respectively in the year 2019 and 2020 was recorded in the treatment T_5 (100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB) which is found to be at parity with T_4 which received 100 % RDF + FYM @ 2 tonnes ha^{-1} and is significantly higher than the rest of the treatments. The lowest number of tillers plant^{-1} i.e. 4.22 and 4.10 at 30 DAS, 4.36 and 4.30 at

Table 4.3: Influence of integrated nutrient management in direct seeded rice at different growth stages on number of tillers plant^{-1}

	30 DAS			60 DAS			90 DAS		
Treatments	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**
T_1: Control	4.22	4.10	4.16	4.36	4.30	4.33	4.51	4.40	4.46
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	5.45	5.51	5.48	6.71	6.87	6.79	6.95	7.07	7.01
T_3: 100% RDF + PSB	5.55	5.63	5.59	7.01	7.18	7.10	7.26	7.39	7.33
T_4: 100% RDF + FYM @ 2 t ha^{-1}	6.29	6.42	6.35	7.95	8.15	8.05	8.21	8.34	8.28
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	6.40	6.55	6.48	8.25	8.44	8.34	8.52	8.65	8.59
T_6: 75% RDF + PSB	5.16	5.14	5.15	5.82	5.96	5.89	6.05	6.08	6.07
T_7: 75% RDF + FYM @ 2 t ha^{-1}	5.26	5.27	5.27	6.13	6.28	6.20	6.36	6.43	6.40
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	5.35	5.38	5.37	6.40	6.56	6.48	6.64	6.73	6.69
T_9: 50% RDF + PSB	4.85	4.78	4.81	5.00	5.03	5.01	5.14	5.06	5.10
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	4.96	4.90	4.93	5.24	5.36	5.30	5.45	5.41	5.43
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	5.05	5.02	5.04	5.51	5.65	5.58	5.73	5.74	5.74
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	5.65	5.75	5.70	7.30	7.47	7.39	7.56	7.69	7.62
SEm±	**0.17**	**0.19**	**0.13**	**0.20**	**0.21**	**0.14**	**0.21**	**0.21**	**0.15**
CD (P=0.05)	**0.50**	**0.57**	**0.37**	**0.58**	**0.62**	**0.41**	**0.60**	**0.63**	**0.42**

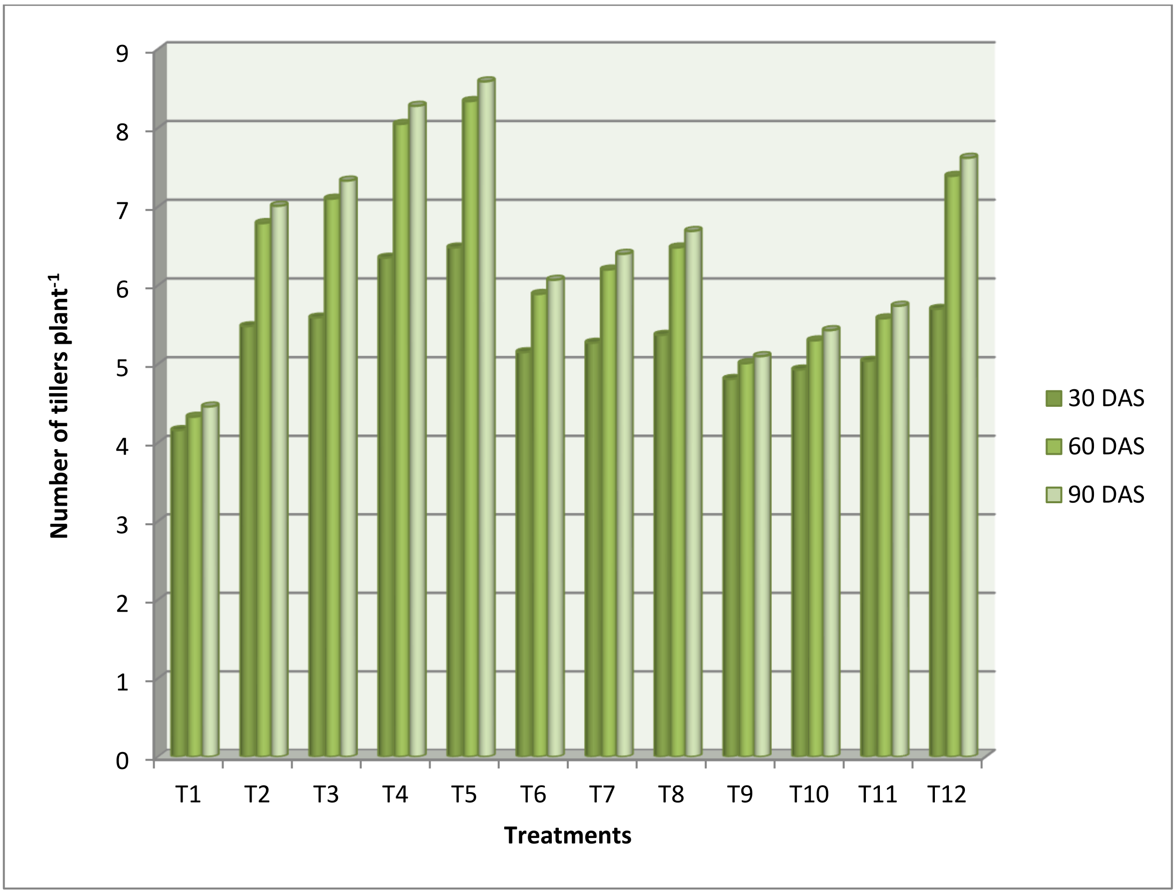

Fig 4.3 Influence of integrated nutrient management at different stages of crop growth on number of tillers plant^{-1}

60 DAS and 4.51 and 4.40 at 90 DAS was witnessed in control treatment (T_1) in the year 2019 and 2020 respectively, which is a consequence of poor nutrients availability. Similar trend was witnessed in the succeeding year.

The production of tillers in rice mainly takes place from the nodes appeared on the shoot and sequences as primary, secondary and tertiary tillers. The increase in number of tillers under said treatments was mainly due to application of sufficient nutrients. The level of nutrients led to the greater availability and steady supply of plant nutrients during the entire period of crop growth also maintained acceptable growth and encouraged the tiller production and thus above treatments assisted in increasing tillers. The Increased plant height probably helped in increasing the photosynthetic area for photosynthesis in plant, which in turn helped in formation of new tillers. The tiller production at higher level of nutrient applications was due to better nutrition of the crop which has been also reported by Bajpai *et al*. (2022).

The increase in number of tillers plant^{-1} might be owing to better availability of nutrients during all the crop growth stages which might have resulted in more nitrogen absorption by the roots for the synthesis of protoplasm responsible for rapid cell division consequently increasing plant shape, size and number of tillers. The result is in accordance with Meena *et al*. (2019) and Tomar *et al*. (2018). Number of tillers increased with integration of organic and inorganic sources of nitrogen than alone. This might be due to integration of chemical and organic sources provided enough nutrients. This ultimately influences the soil environment positively for plant growth and this favorable soil condition might have resulted into higher growth at all stages (Verma and Kaur, 2016). Significantly more number of tillers might be due to better availability of nutrients and reduced mortality of tillers which in turn resulted in higher uptake of nutrients (Hamanant *et al*., 2019).

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

The two years data on dry matter accumulation plant^{-1}in direct seeded rice as influenced by integrated nutrient management is recorded at 30, 60 and 90 DAS which is presented in Table 4.4 and graphically outlined in Fig 4.4.

Results pertaining to both the consecutive years revealed that irrespective of different treatments, dry matter accumulation plant^{-1} of direct seeded rice increased as the growth progressed and the incremental value were found maximum between 60 and 90 days after sowing (DAS) due to the formation of reproductive parts. The data of both the years ranges from 1.49 g to 2.69 g and 1.40 to 2.80 at 30 DAS, 12.35 g to 23.45 g and 11.63 to 24.50 g at 60 DAS and 24.13 to 39.41 g and 23.42 to 40.72 g at 90 DAS, respectively with treatment (T_5) which had positive and significant effect with the increase in fertility levels which is found statistically at par with T_4 and is superior over the rest of the treatments. The least value was noted in the control treatment (T_1) as no external sources of nutrients were added to the soil. Therefore the results clearly showed the need of integration of both organic and inorganic fertilizers for better growth of the crop in terms of dry matter accumulation that ultimately helped in increasing the productivity of rice (Shankar *et al.*, 2020).

Mangaraj *et al*. (2022) also reported that the enhancement rate was slower during the first 30 DAS but got increment after that due to the formation of reproductive parts. The rate of increase was highest during 60–90 DAS. Similar outcomes were also registered by Sahu *et al.* (2015) and Mondal *et al*. (2015). The increase in dry matter accumulation plant^{-1} was the cumulative effect of increase in different growth characters like plant height, number of tiller plant^{-1} and number of leaves plant^{-1}. The dry matter accumulation is considered to be the reliable index of crop growth. These findings are in line with Kumari *et al*. (2019). Shinde *et al*. (2017) and Devi *et al*. (2020) also opined that the application of chemical fertilizers in conjunction

Table 4.4: Influence of integrated nutrient management in direct seeded rice at different growth stages on dry matter accumulation plant^{-1}

	30 DAS (g)			60 DAS (g)			90 DAS (g)		
Treatments	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**
T_1: Control	1.49	1.40	1.45	12.35	11.63	11.99	24.13	23.42	23.78
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	2.21	2.25	2.23	19.21	19.68	19.45	33.32	33.96	33.64
T_3: 100% RDF + PSB	2.29	2.35	2.32	20.07	20.71	20.39	34.30	35.13	34.72
T_4: 100% RDF + FYM @ 2 t ha^{-1}	2.60	2.70	2.65	22.59	23.48	23.03	38.43	39.57	39.00
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	2.69	2.80	2.74	23.45	24.50	23.98	39.41	40.72	40.06
T_6: 75% RDF + PSB	1.95	1.96	1.96	16.61	16.59	16.60	30.31	30.45	30.38
T_7: 75% RDF + FYM @ 2 t ha^{-1}	2.04	2.06	2.05	17.49	17.64	17.57	31.33	31.67	31.50
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	2.12	2.15	2.14	18.32	18.62	18.47	32.30	32.76	32.53
T_9: 50% RDF + PSB	1.72	1.65	1.69	14.02	13.42	13.72	27.26	26.72	26.99
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	1.79	1.77	1.78	14.95	14.54	14.74	28.27	27.95	28.11
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	1.87	1.86	1.87	15.26	15.53	15.40	29.26	29.07	29.17
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	2.37	2.45	2.41	20.92	21.70	21.31	35.31	36.28	35.80
SEm±	**0.06**	**0.07**	**0.05**	**0.54**	**0.58**	**0.40**	**0.99**	**1.05**	**0.72**
CD (P=0.05)	**0.18**	**0.21**	**0.13**	**1.58**	**1.70**	**1.13**	**2.90**	**3.07**	**2.05**

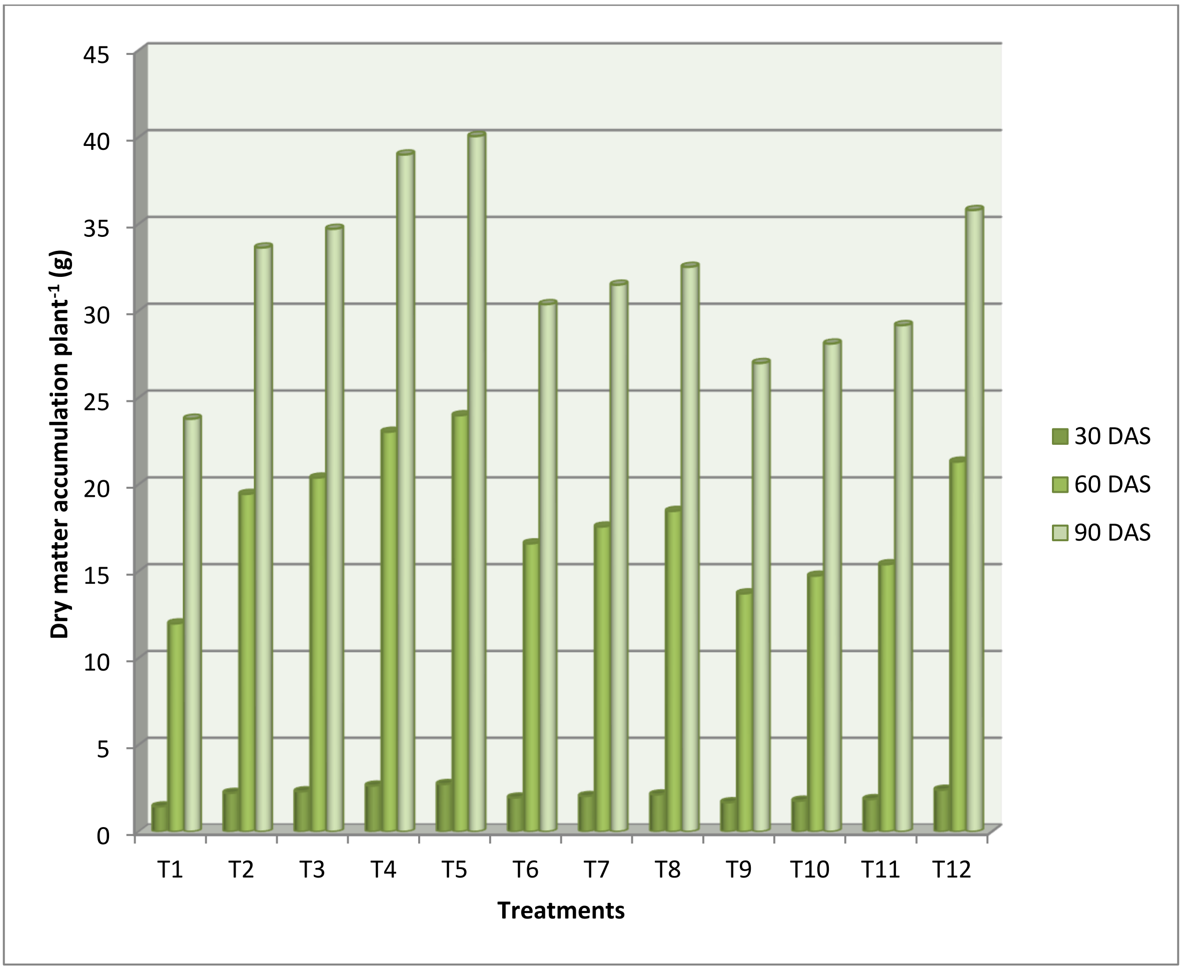

Fig 4.4 Influence of integrated nutrient management at different stages of crop growth on dry matter accumulation plant^{-1}

with organic fertilizer increased the use efficiency of added chemical fertilizer which in turn increased the nutrient availability at later growth period which ultimately resulted in increased dry matter production.

4.1.5 Crop growth rate (g m^{-2} day^{-1})

The data pertaining to crop growth rate as influenced by integrated nutrient management in direct seeded rice at 30-60 DAS and 60-90 DAS are presented in Table 4.5.

Crop growth rate was significantly influenced due to integrated nutrient management practices at 30-60 DAS, but no significant result was noted at 60 DAS. At 30-60 DAS, the highest crop growth rate was recorded in the treatment receiving 100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB (T_5) with the value of 34.61 and 36.17 g m^{-2} day^{-1} in the year 2019 and 2020, respectively which is found to be at parity with T_4 (100% RDF + FYM @ 2 tonnes ha^{-1}) and they are significantly higher than the rest of the treatment. Significantly lowest value of 18.10 and 17.05 g m^{-2} day^{-1} at 30-60 DAS was recorded in the control treatment (T_1) during both the years of investigation due to lack of nutrients.

The crop growth rate increased with the advancement of time and reached to a peak at 30-60 DAS and after which it remained at plateau. The increased in crop growth rate with integrated nutrient management practices resulted from better uptake of nutrients due to better availability of nutrients at its peak time. Similar pattern of CGR was also observed by Laila *et al*. (2022) and Sarkar *et al*. (2016) who stated that CGR was significantly influenced by integrated nutrient management.

Table 4.5: Influence of integrated nutrient management in direct seeded rice at different growth stages on crop growth rate

	30-60 DAS (g m^{-2} day^{-1})			60-90 DAS (g m^{-2} day^{-1})		
Treatments	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**
T_1: Control	18.10	17.05	17.57	19.64	19.65	19.64
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	28.33	29.04	28.69	23.51	23.81	23.66
T_3: 100% RDF + PSB	29.63	30.60	30.12	23.72	24.04	23.88
T_4: 100% RDF + FYM @ 2 t ha^{-1}	33.32	34.63	33.98	26.40	26.82	26.61
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	34.61	36.17	35.39	26.60	27.03	26.81
T_6: 75% RDF + PSB	24.43	24.38	24.41	22.83	23.11	22.97
T_7: 75% RDF + FYM @ 2 t ha^{-1}	25.75	25.97	25.86	23.06	23.38	23.22
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	27.00	27.45	27.23	23.30	23.57	23.43
T_9: 50% RDF + PSB	20.50	19.62	20.06	22.06	22.17	22.12
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	21.93	21.28	21.61	22.20	22.36	22.28
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	22.32	22.78	22.55	23.33	22.57	22.95
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	30.93	32.08	31.50	23.98	24.30	24.14
SEm±	**0.80**	**0.85**	**0.58**	**2.53**	**2.56**	**1.80**
CD (P=0.05)	**2.35**	**2.49**	**1.66**	**NS**	**NS**	**NS**

4.1.6 Relative growth rate (g g^{-1} day^{-1})

The data in connection to relative growth rate in direct seeded rice as influenced by integrated nutrient management practices is recorded at 30-60 DAS and 60-90 DAS are presented in Table 4.6.

It is clear from the data that there was no significant effect on relative growth rate with various treatments in either of the years. However the treatment T_5 (100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB) recorded a value of 0.072 and 0.070 g g^{-1} day^{-1} at 30-60 DAS and 0.017 and 0.016 g g^{-1} day^{-1} at 60-90 DAS during the year 2019 and 2020, respectively.

4.2 Yield attributes

Yield attributes which determine yield is the resultant of the vegetative development of the crop. Distinct positive effect of fertility levels were noticed on these yield attributes. Inorganic fertilizers supply nutrients immediately after application, while organic fertilizers release nutrients slowly through microbial mineralization which ensure that the nutrient availability in the grain-filling stage of crops. All attributes of yield *viz*., panicle length, number of panicle plant^{-1}, number of grain panicle^{-1} and 1000-grain weight were significantly differed by different levels of treatments which is illustrated below:-

4.2.1 Panicle length (cm)

Perusal of data on panicle initiation as affected by various INM practices in direct seeded rice has been presented in Table 4.7 and graphically displayed in Fig 4.5.

Result clearly disclosed that maximum panicle length was recorded in the treatment receiving the highest RDF in conjunction with FYM and PSB *i.e.*, T_5 with 100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB which procured the

Table 4.6: Influence of integrated nutrient management in direct seeded rice at different growth stages on relative growth rate

	30-60 DAS (g g^{-1} day^{-1})			60-90 DAS (g g^{-1} day^{-1})		
Treatments	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**
T_1: Control	0.070	0.072	0.071	0.022	0.023	0.022
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	0.072	0.071	0.071	0.018	0.018	0.018
T_3: 100% RDF + PSB	0.072	0.071	0.071	0.017	0.017	0.017
T_4: 100% RDF + FYM @ 2 t ha^{-1}	0.072	0.070	0.071	0.017	0.017	0.017
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	0.072	0.070	0.071	0.017	0.016	0.017
T_6: 75% RDF + PSB	0.071	0.071	0.071	0.020	0.020	0.020
T_7: 75% RDF + FYM @ 2 t ha^{-1}	0.071	0.071	0.071	0.019	0.019	0.019
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	0.071	0.071	0.071	0.018	0.018	0.018
T_9: 50% RDF + PSB	0.069	0.071	0.070	0.022	0.022	0.022
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	0.070	0.071	0.070	0.021	0.021	0.021
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	0.069	0.070	0.070	0.021	0.020	0.021
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	0.072	0.071	0.072	0.017	0.017	0.017
SEm±	**0.002**	**0.002**	**0.001**	**0.002**	**0.002**	**0.002**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

value of 25.98 cm and 26.17 cm in the year 2019 and 2020 respectively, which is at par with T_4 treatment with a value of 25.76 cm and 25.93 cm in the year 2019 and 2020 respectively, receiving 100 % RDF + FYM @ 2 tonnes ha^{-1}. The minimum panicle length was noted in control treatment (T_1) with a value of 22.13 cm and 21.90 cm in two consecutive years as it did not received any external source of nutrient in the soil which led to poor crop growth when compared with other treatments.

The significant increase in panicle length might be due to higher absorption of different fertilizer by the plant that favoured to produce the longer panicle. These findings corroborates with Mondal *et al*. (2015) who also stated that combined use of inorganic and organic fertilizer increase the panicle length of rice during both the years. Similar outcome was also reported by Hossain *et al*. (2012). The addition of organic manure significantly influenced the beneficial microorganisms to colonize in rhizosphere and stimulate plant growth by providing necessary nutrients besides synthesizing some plant hormones (Venkatasalam *et al*., 2012), which may be the reason for increase in growth and yield attributes in treatments supplied with organic manures. Improvement in yield attributes may be ascribed to adequate and regular nutrients supplying capacity of the soil and translocation of nutrients to the sink. The improvement in yield and yield traits under higher level nutrients might be due to higher absorption of nutrients and increased photosynthesis activity lead higher accumulation of biomass (Chaudhary *et al*., 2020).

4.2.2 Number of panicles plant^{-1}

The data in connection to number of panicle plant^{-1} as influenced by various integrated nutrient management practices in direct seeded rice are presented in Table 4.7 and graphically illustrated in Fig 4.6.

Among the different treatments witnessed, treatment T_5 with 100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB has recorded the highest number of

Table 4.7: Influence of integrated nutrient management in direct seeded rice on yield attributes

Treatments	Panicle length (cm)			Number of panicles $plant^{-1}$			Number of grains $panicle^{-1}$		
	2019	**2020**	**pooled**	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**
T_1: Control	22.13	21.90	22.01	4.05	3.82	3.94	194.85	192.70	193.78
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	24.46	24.49	24.48	5.52	5.68	5.60	229.41	229.64	229.53
T_3: 100% RDF + PSB	24.69	24.73	24.71	5.67	5.89	5.78	233.21	233.53	233.37
T_4: 100% RDF + FYM @ 2 t ha^{-1}	25.76	25.93	25.84	6.36	6.67	6.51	249.53	251.85	250.69
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	25.98	26.17	26.08	6.50	6.88	6.69	253.25	255.70	254.47
T_6: 75% RDF + PSB	23.75	23.70	23.73	5.08	5.06	5.07	218.13	217.94	218.04
T_7: 75% RDF + FYM @ 2 t ha^{-1}	24.02	23.99	24.01	5.23	5.29	5.26	220.59	221.87	221.23
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	24.22	24.22	24.22	5.36	5.47	5.41	225.62	225.70	225.66
T_9: 50% RDF + PSB	22.98	22.85	22.91	4.59	4.42	4.51	207.56	207.30	207.43
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	23.26	23.21	23.24	4.76	4.65	4.71	210.63	210.35	210.49
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	23.48	23.45	23.47	4.91	4.84	4.88	214.36	214.01	214.19
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	24.90	24.98	24.94	5.81	6.09	5.95	236.94	237.35	237.15
SEm±	**0.27**	**0.31**	**0.21**	**0.17**	**0.18**	**0.12**	**4.17**	**4.82**	**3.18**
CD (P=0.05)	**0.81**	**0.91**	**0.59**	**0.49**	**0.53**	**0.35**	**12.22**	**14.13**	**9.08**

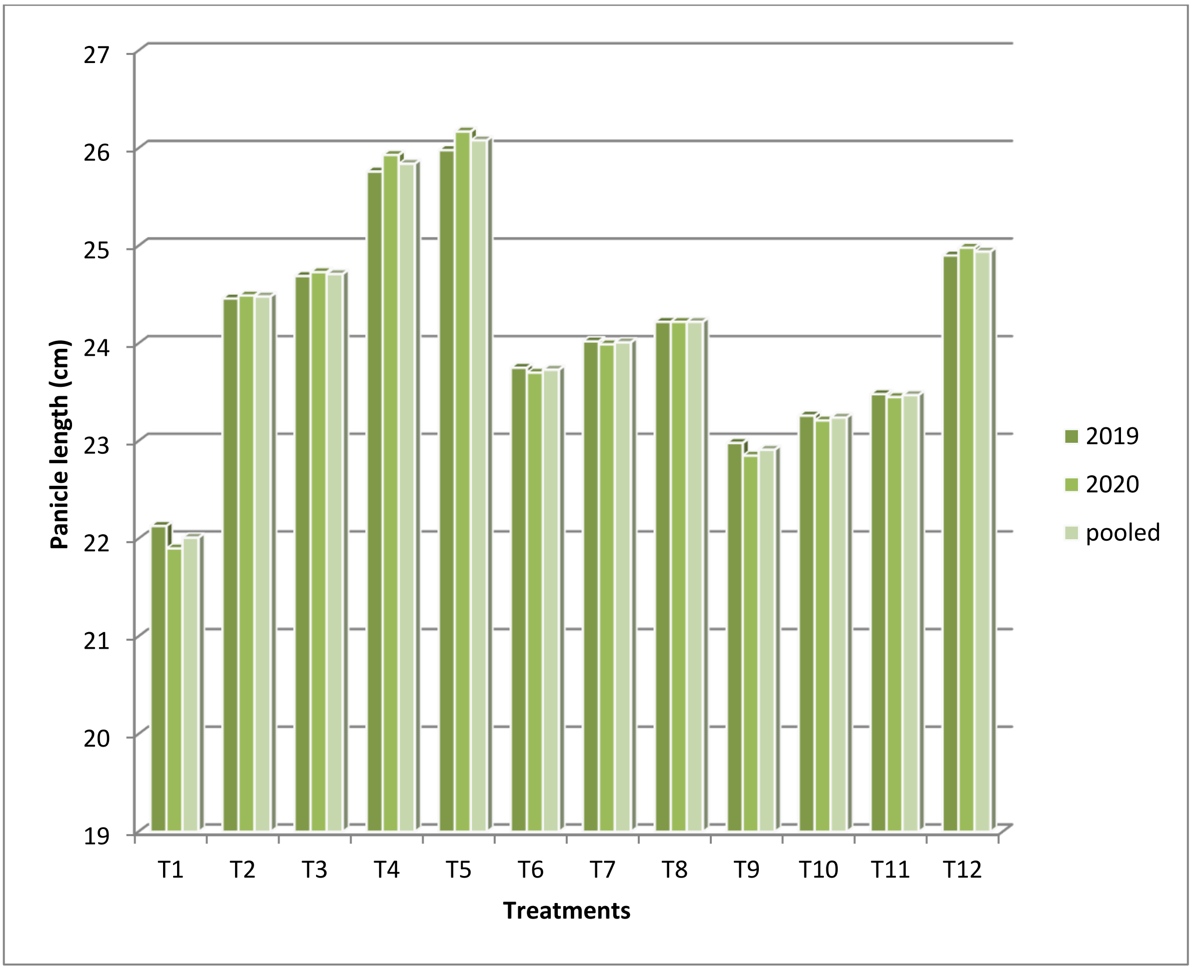

Fig 4.5 Influence of integrated nutrient management on panicle length

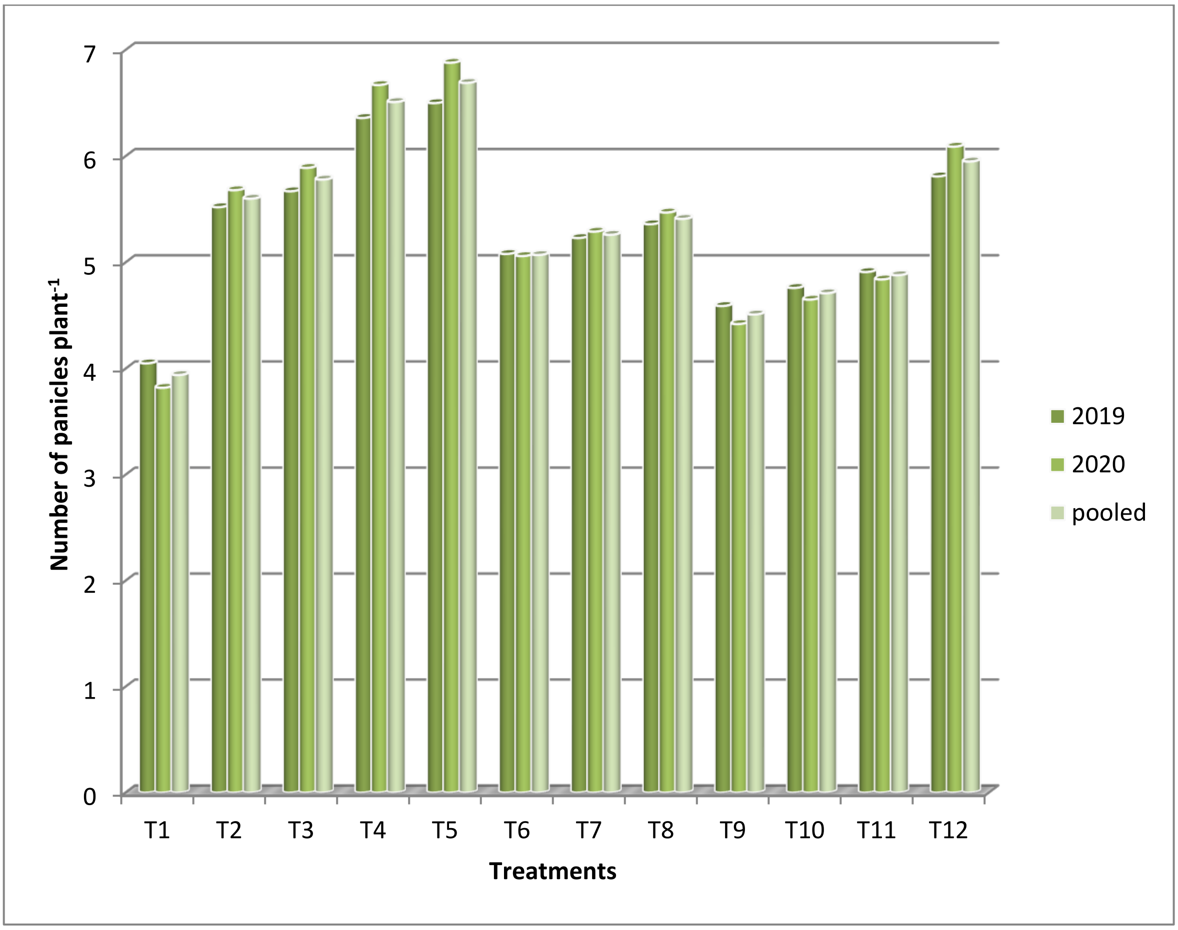

Fig 4.6 Influence of integrated nutrient management on number of panicle plant^{-1}

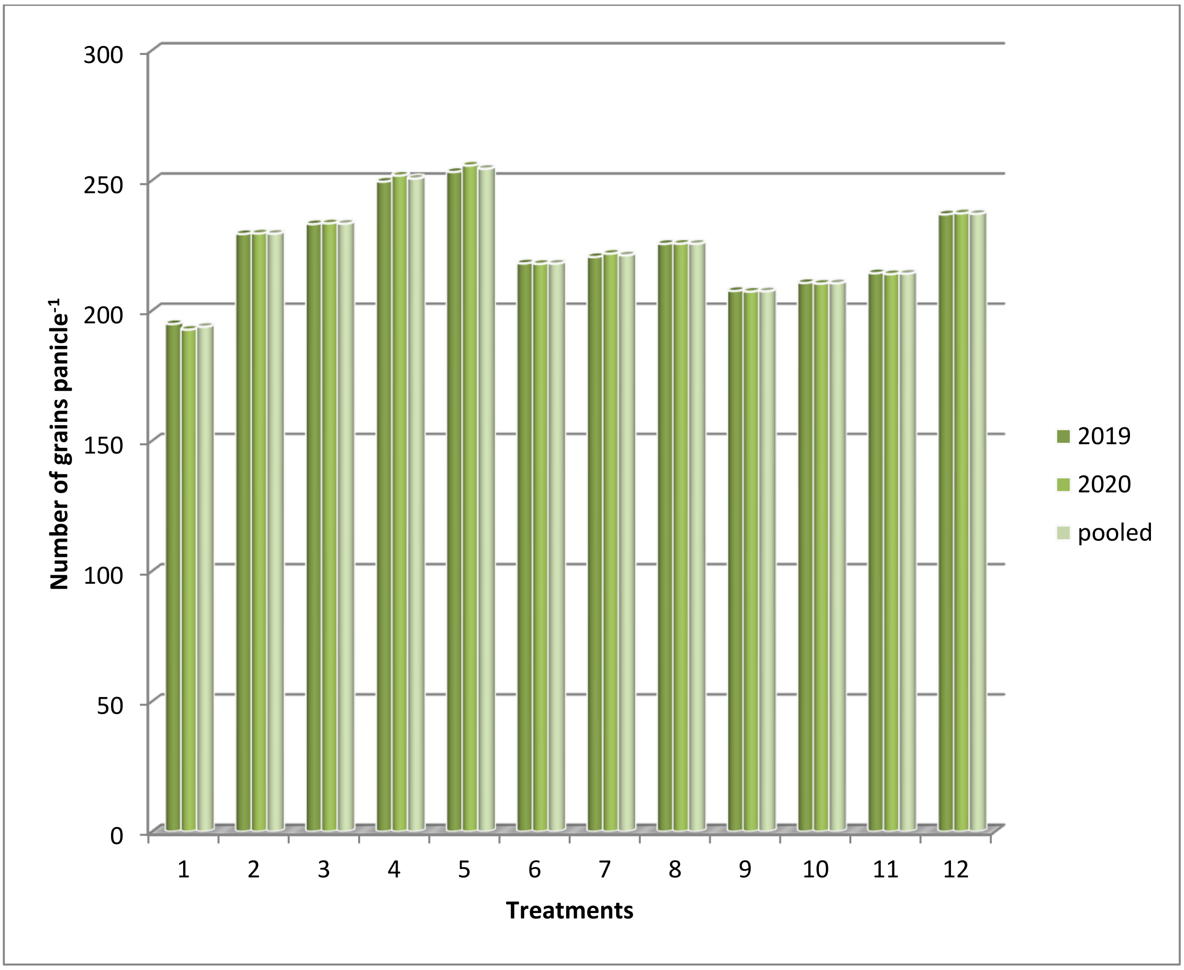

Fig 4.7 Influence of integrated nutrient management on number of grains panicle^{-1}

panicles plant^{-1} and is at par with treatment T_4 having 100 % RDF + FYM @ 2 tonnes ha^{-1} and they are significantly highest than the rest of the treatments. It is found that merging of inorganic with organic fertilizers shows better outcomes due to slow release and continuous supply of nutrients in balance quantity throughout the various growth stages which enables the rice plants to assimilate sufficient photosynthetic products and thus, increased the dry matter and source capacity that resulted in the production of increased panicles with more number of fertile grains. Significantly lowest value was witnessed in the control treatment due to lack of nutrients in the soil.

Bajpai *et al*. (2022) stated that the early emergence of primary and secondary tillers at vegetative stage and supported with proper nutrient supply and translocation of food materials towards reproductive parts contributed to higher number of panicle plant^{-1}. Distinct positive effect of fertility levels were noticed on these yield attributes. All these parameters attained higher values with increasing NPK levels up to the highest level (100% RDF), Kumar *et al*. (2017) and Nanda *et al*. (2016).

The application of biofertilizers *viz*., *Azospirillum* and PSB produce phyto-hormones that induce root growth, improved nutrient and water absorption by plants, which augmented increase in production of shoot biomass which ultimately favoured for higher growth parameters, yield attributes and yield of rice. The above findings are in collaboration with the report of Sunil *et al*. (2014).

4.2.3 Number of grains panicle^{-1}

Critical appraisal of data on number of grains panicle^{-1} in direct seeded are presented in Table 4.7 and graphically depicted in Fig 4.7.

The outcome of integrated nutrient supply confirmed that maximum number of grains panicle^{-1} was recorded in treatment T_5 (100% RDF + FYM @

2 tonnes ha^{-1} + PSB) with a value of 253.25 and 255.70 in the year 2019 and 2020 respectively, and it is found to be at par with T_4 which is significantly highest over rest of the treatments during the course of investigation. The lowest number of grains panicles^{-1} was recorded where crop was grown under control treatment (T_1) as no external source of nutrient was applied.

Mohanty *et al*. (2013) and Stalin and Darthiya (2018) documented that application of chemical fertilizer along with FYM and bio-fertilizer produced significantly highest number of grains panicle^{-1} as compared to 100% recommended dose of fertilizer and control. Even distribution of nutrients at peak demands of crop period, continuous supply of nutrients in balance quantity throughout the growth period enables the rice plants to assimilate sufficient photosynthetic products and thus, increased the dry matter and source capacity, resulted in the production of increased panicles with more number of grains panicle^{-1}. Similar findings were also documented by Mangaraj (2022). More number of grains panicle^{-1} might be due to better translocation of carbohydrates from source to sink (Shalini *et al*., 2017).

4.2.4 Test weight (g)

The size and boldness of rice seed measured as 1000 grain weight as influenced by different INM treatments have been presented in Table 4.8 for both the years.

All the treatments failed to show any significant variation during both the years of experimentation. However, the test weight (1000 grain weight) of rice increased with increasing levels of fertilizer which was applied in conjunction with FYM and PSB. T_5 (100% RDF + FYM @ 2 tonnes ha^{-1} + PSB) recorded higher values (25.71 g and 25.80 g in 2019 and 2020, respectively) when compared with other treatments. Lowest value was recorded in control treatment (T_1) with the value of 24.50 g and 24.45 g during both the years of field investigation respectively.

Table 4.8: Influence of integrated nutrient management in direct seeded rice on test weight

	Test weight (g)		
Treatments	**2019**	**2020**	**Pooled**
T_1: Control	24.50	24.45	24.48
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	24.99	25.02	25.01
T_3: 100% RDF + PSB	25.35	25.41	25.38
T_4: 100% RDF + FYM @ 2 t ha^{-1}	25.59	25.67	25.63
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	25.71	25.80	25.76
T_6: 75% RDF + PSB	24.75	24.82	24.79
T_7: 75% RDF + FYM @ 2 t ha^{-1}	25.11	25.15	25.13
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	25.23	25.28	25.26
T_9: 50% RDF + PSB	24.51	24.57	24.54
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	24.63	24.69	24.66
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	24.87	24.95	24.91
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	25.47	25.54	25.51
SEm±	**0.45**	**0.48**	**0.33**
CD (P=0.05)	**NS**	**NS**	**NS**

4.3 Yield

Yield is the better manifestation of growth and yield attributing characters. The yield potential of rice is determined by the yield attributes and the values of the yield attributes were in accordance with that of growth parameters. Therefore, yield is directly a result of yield attributing characters which showed its increment depending on the various levels of treatment. The results recorded are illustrated below with tables and graph.

4.3.1 Grain Yield (q ha^{-1})

Critical observation of the data recorded on grain yield (q ha^{-1}) have been summarized in Table 4.9 and depicted in graphically plotted in Fig 4.8.

Significantly highest grain yield was registered from the application of 100% RDF + FYM @ 2 tonnes ha^{-1} + PSB (T_5) which increase the grain yield to the extent of 42.47 % and 44.30 % over control during the year 2019 and 2020, respectively. This treatment is at par with T_4 (100% RDF + FYM @ 2 tonnes ha^{-1}) which was significant over all the treatments while significantly lowest value was recorded in the control treatment (T_1) where no external source of nutrient was applied.

Grain yield of rice increased with different levels of inorganic fertilizers as well as their combination with FYM and PSB. This may be due to the higher availability of nutrients and optimum soil properties in the plots receiving inorganic and organic fertilizers (FYM + PSB). The integrated effects of inorganic fertilizer and farm yard manure along with bio-fertilizers were noted to be more beneficial than the use of chemical fertilizer alone or decreased level of fertilizers. The results are in conformity with Behera and Pany (2021) and Sonboir *et al*. (2020).

Bhosale *et al*. (2021) also opined that integrated use of fertilizers increases grain yield which could be due to its greater availability and uptake

Table 4.9: Influence of integrated nutrient management in direct seeded rice on grain yield, straw yield and harvest index

	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})		
Treatments	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**
T_1: Control	22.35	21.97	22.16	41.15	40.60	40.88
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	32.61	32.69	32.65	52.19	52.44	52.32
T_3: 100% RDF + PSB	33.74	33.89	33.82	53.20	53.57	53.39
T_4: 100% RDF + FYM @ 2 t ha^{-1}	37.80	38.33	38.06	58.84	59.45	59.15
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	38.85	39.45	39.15	59.82	60.48	60.15
T_6: 75% RDF + PSB	29.32	29.16	29.24	49.12	49.06	49.09
T_7: 75% RDF + FYM @ 2 t ha^{-1}	30.48	30.46	30.47	50.18	50.29	50.23
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	31.45	31.45	31.45	51.07	51.26	51.17
T_9: 50% RDF + PSB	25.93	25.47	25.70	45.97	45.61	45.79
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	27.13	26.82	26.98	47.05	46.84	46.95
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	28.15	27.86	28.01	48.00	47.88	47.94
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	34.78	35.07	34.93	54.19	54.65	54.42
SEm±	**0.95**	**1.01**	**0.69**	**1.49**	**1.56**	**1.08**
CD (P=0.05)	**2.78**	**2.96**	**1.97**	**4.37**	**4.58**	**3.08**

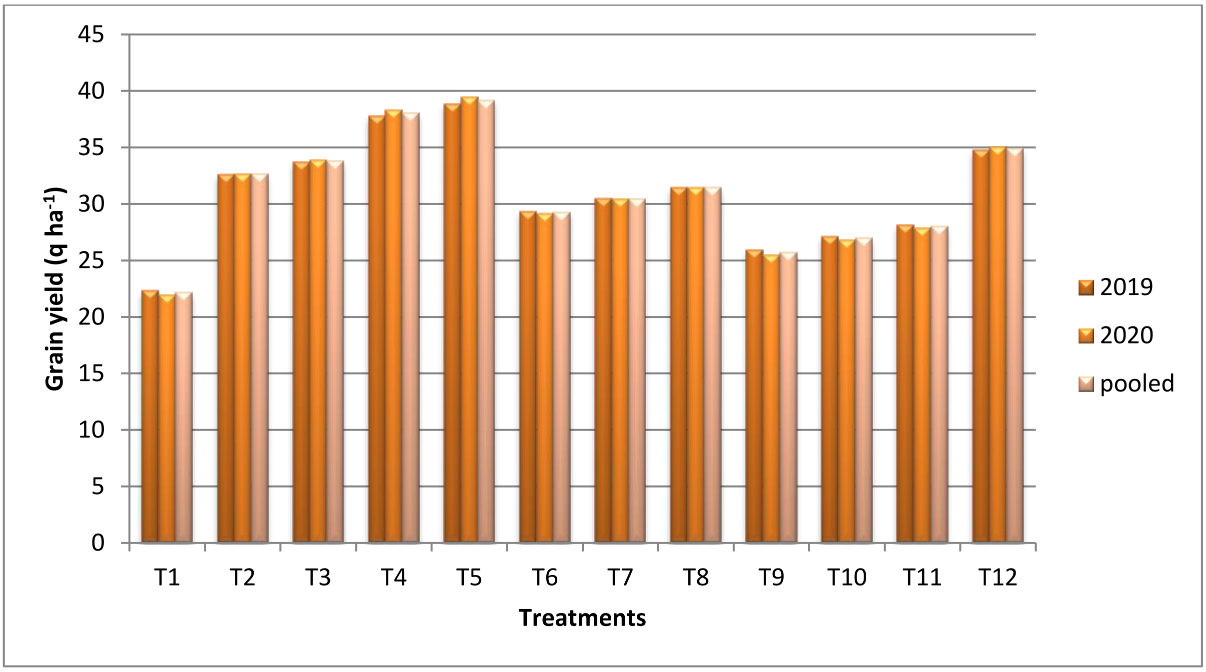

Fig 4.8 Influence of integrated nutrient management on grain yield

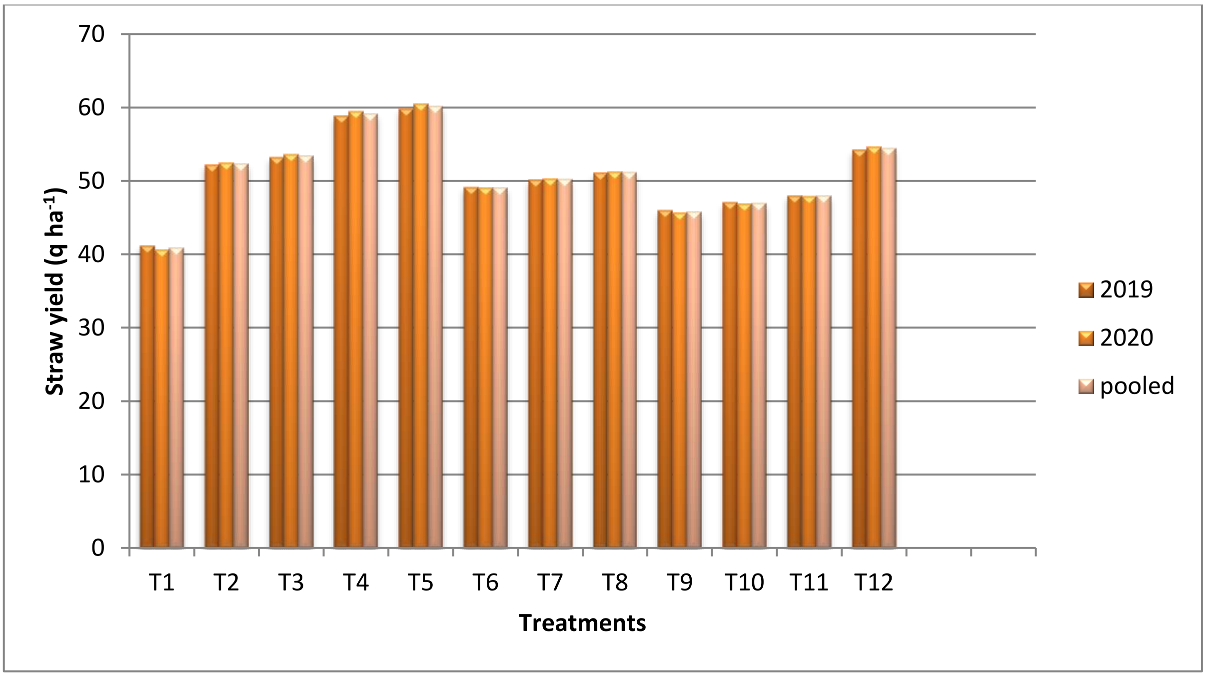

Fig 4.9 Influence of integrated nutrient management on straw yield

of macro and micro-nutrients and active participation in carbon assimilation, photosynthesis, starch formation, translocation of protein and sugar, entry of water into plants root and development. It also enhances the process of tissue differentiation *i.e*., from somatic to reproductive phase leading to higher grain and straw yield.

4.3.2 Straw Yield (q ha^{-1})

The data recorded on straw yield (q ha^{-1}) have been summarized in Table 4.9 and depicted in graphically displayed in Fig 4.9.

A significant increase in straw yield was observed with various treatments applied in an integrated manner. With the application of 100% RDF +FYM @ 2 tonnes ha^{-1} (T_5), the straw yield increased by 31.21 % and 32.87 % over control during both the years of the field investigation respectively, which was noted to be at parity with treatment T_4 (100% RDF + FYM @ 2 tonnes ha^{-1}) which is significantly higher over all the treatments. The higher straw yield might be due to more vegetative growth parameters like plant height, tillers plant^{-1} and dry matter accumulation. The significantly lowest straw yield was recorded in control treatment (T_1) where poor growth and metabolic process was observed mainly due to no external treatments.

Neti *et al*. (2022) documented that the increase in straw yield was due to high inorganic fertilizer to the crop which helped to exhibit growth parameters like dry matter accumulation and number of tillers resulting in the better productivity with the treatments. Similar results corroborate with the finding of earlier researchers Jeyajothi and Durairaj, 2015; Shankar *et al*., 2020; Hayat *et al*., 2019.

Behera and Pany (2021) noted that application of RDF with FYM, improved straw yields which might be due to favourable soil condition. Organic manure in combination with inorganic fertilizers might be increased the vegetative growth of plants and thereby increased straw yield of rice (Mahmud *et al*., 2016). The integrated use of fertilizers with organic manures *viz*., FYM and bio-fertilizers might have added huge quantity of organic matter in soil that increased grain and straw yield (Sahu *et al*., 2015).

4.3.3 Harvest Index (%)

Perusal of data on harvest index as influenced by integrated nutrient management is presented in Table 4.10.

Harvest index indicates the relationship between economic yield and biological yield. It is clearly revealed from the data there was variation in harvest index among various treatments where the maximum value of 39.36 % and 39.49 % was recorded in T_5 (100% RDF +FYM @ 2 tonnes ha^{-1}) and lowest value was recorded in control treatment (T_1) with the value of 35.51 % and 35.12 % during both the years of field trials respectively, however, it could not reach to the level of significance.

Table 4.10: Influence of integrated nutrient management in direct seeded rice on harvest index

	Harvest index (%)		
Treatments	**2019**	**2020**	**pooled**
T_1: Control	35.51	35.12	35.31
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	38.48	38.39	38.44
T_3: 100% RDF + PSB	38.83	38.73	38.78
T_4: 100% RDF + FYM @ 2 t ha^{-1}	39.11	39.20	39.16
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	39.36	39.49	39.42
T_6: 75% RDF + PSB	37.38	37.27	37.32
T_7: 75% RDF + FYM @ 2 t ha^{-1}	37.79	37.72	37.76
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	38.11	38.04	38.07
T_9: 50% RDF + PSB	36.04	35.83	35.93
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	36.61	36.44	36.53
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	36.97	36.77	36.87
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	39.11	39.06	39.09
SEm±	**1.20**	**1.59**	**1.00**
CD (P=0.05)	**NS**	**NS**	**NS**

4.4 Influence of integrated nutrient management in direct seeded rice on nutrient content and uptake

The nutrient content and uptake is a key component of fertilizer management. The more uptakes of nutrients not only increase the yield but also improve the nutrient use efficiency which consequently reduces the potential for groundwater pollution. Integrated nutrient management practices greatly influence the uptake of nutrient by direct seeded rice.

4.4.1 Nitrogen content in grains and straw (%)

The effect of nitrogen content under different treatments in grains and straw which followed the same trend during both the years of experiment has been presented in Table 4.11.

As evident from the result, the significantly highest N content in grains and straw was recorded in the T_5 treatment (100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB) with the value of 1.26 % and 1.27 % in grains and 0.70 % and 0.71 % in straw in the year 2019 and 2020, respectively. This treatment was found to be statistically at par with T_4 treatment (100% RDF + FYM @ 2 tonnes ha^{-1}). The significantly lowest N content with a value of 1.11 % and 1.11% in grains and 0.58 % and 0.57 % in straw was recorded in the control treatment (T_1) which may be a result of mining of nutrient with continuous cropping without incorporation of nutrient during the growth period of the crop.

Increase in N content in plants may be the result of positive inter-relationship between nutrients with enriched compost that had exerted beneficial effects in the release of ammonical and nitrate nitrogen. Similar results have been reported Patra *et al*. (2020) where the addition of nitrogenous fertilizer along with FYM helped in narrowing down of C:N ratio which in return increased mineralization and also speed up the conversion of organically bound N to inorganic forms. The improvement in N content of grain and straw

Table 4.11: Influence of integrated nutrient management in direct seeded rice on nitrogen content in grain and straw

Treatments	N content in grain (%)			N content in straw (%)		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	1.11	1.11	1.11	0.58	0.57	0.58
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	1.20	1.21	1.21	0.66	0.66	0.66
T_3: 100% RDF + PSB	1.21	1.22	1.21	0.66	0.67	0.67
T_4: 100% RDF + FYM @ 2 t ha^{-1}	1.25	1.26	1.25	0.69	0.70	0.70
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	1.26	1.27	1.26	0.70	0.71	0.71
T_6: 75% RDF + PSB	1.17	1.17	1.17	0.63	0.63	0.63
T_7: 75% RDF + FYM @ 2 t ha^{-1}	1.18	1.19	1.18	0.64	0.64	0.64
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	1.19	1.19	1.19	0.65	0.65	0.65
T_9: 50% RDF + PSB	1.14	1.14	1.14	0.60	0.60	0.60
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	1.15	1.15	1.15	0.61	0.61	0.61
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	1.16	1.16	1.16	0.62	0.62	0.62
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	1.22	1.23	1.22	0.67	0.68	0.68
Sem±	**0.009**	**0.010**	**0.007**	**0.007**	**0.007**	**0.005**
CD (P=0.05)	**0.026**	**0.028**	**0.019**	**0.020**	**0.019**	**0.013**

of rice in organic treatment along with inorganic source could possibly be due to slow release of nutrients to the soil along with inorganic source and thus made it available throughout the growing period (Baitilwake *et al.*, 2012; Meetei *et al.*, 2019). Similar results were also reported by Kaisar *et al.* (2020) and Sahu *et al.* (2020) where application of nitrogen from manures and fertilizers increased the N content both in grain and straw of rice.

4.4.2 Phosphorus content in grains and straw (%)

The effect of different treatments on phosphorus content in grains and straw was found to be significant which is presented in Table 4.12.

Phosphorus content in grains ranged from 0.28 % to 0.36 % in 2019 and 0.27 % to 0.37 % in 2020. On the other hand, the phosphorus content in straw ranges from 0.10 % and 0.13 % in 2019 and 0.09 % and 0.14 % in 2020 over control. The maximum phosphorus content was recorded in the treatment receiving higher dose of fertilizers compared to other treatment which is T_5 (100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB) and is statistically at par with T_4 and found to be superior than the rest of the treatments. On the contrary, significantly inferior phosphorus content was witnessed in the control treatment (T_1) where there was no external source of nutrients throughout the growth period of the crop.

The increased phosphorus content in grain and straw could perhaps be due to gradual release of nutrients from organic sources thereby increasing soil nutrients along with inorganic source and made available during the growing season. Similar discovery on higher concentration of P in rice crop was earlier given by Latha *et al.* (2019) and Meetei *et al.* (2019). Release of organic acids during decomposition of organic matter and their reaction with inert rock phosphate resulted to give rise to more inorganic phosphorus (Patra *et al.*, 2020). Chelation of H^+ or Al^{3+} ions might be another reason for enhancement of phosphorus mobilization (Reyes *et al.*, 2006). Incorporation of PSB in the

Table 4.12: Influence of integrated nutrient management in direct seeded rice on phosphorus content in grain and straw

Treatments	P content in grain (%)			P content in straw (%)		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	0.28	0.27	0.27	0.10	0.09	0.09
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	0.33	0.33	0.33	0.12	0.12	0.12
T_3: 100% RDF + PSB	0.33	0.34	0.34	0.12	0.13	0.12
T_4: 100% RDF + FYM @ 2 t ha^{-1}	0.35	0.36	0.36	0.13	0.14	0.13
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	0.36	0.37	0.36	0.13	0.14	0.14
T_6: 75% RDF + PSB	0.31	0.31	0.31	0.11	0.11	0.11
T_7: 75% RDF + FYM @ 2 t ha^{-1}	0.32	0.31	0.32	0.11	0.12	0.11
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	0.32	0.32	0.32	0.12	0.12	0.12
T_9: 50% RDF + PSB	0.29	0.28	0.29	0.10	0.10	0.10
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	0.30	0.29	0.29	0.11	0.10	0.10
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	0.30	0.30	0.30	0.11	0.11	0.11
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	0.34	0.35	0.35	0.12	0.13	0.13
Sem±	**0.004**	**0.003**	**0.003**	**0.002**	**0.002**	**0.001**
CD (P=0.05)	**0.011**	**0.010**	**0.007**	**0.005**	**0.006**	**0.004**

soil also solubilized phosphorus and is made available to the crop (Raki *et al*., 2019).

4.4.3 Potassium content in grains and straw (%)

Potassium content in grains and straw of rice under different treatment combination is given in table 4.13.

The highest K content with a value of 0.27 % and 0.27 % in grains and 1.32 % and 1.33 % in straw was observed in T_5 (100% RDF + FYM @ 2 t ha^{-1} + PSB) in the year 2019 and 2020, respectively which showed parity with T_4 (100% RDF + FYM @ 2 t ha^{-1}) and both these treatments are significantly superior to the rest of the treatments. Control treatment (T_1) recorded significantly lowest value (0.23 and 0.22 in grains and 1.10 % and 1.10 % in straw during both the years on investigation respectively) due to mining of nutrients and continuous cropping for consecutively two years.

Application of either inorganic, organic, bio-fertilizer or their combinations increased the potassium content of rice. This might be due to slow release of nutrients from organic sources thereby increasing potassium in soil along with inorganic source during the growing stage and made it available throughout the growing period (Baitilwake *et al*., 2012; Meetei *et al*., 2019). Similar findings were also documented by Kaisar *et al*. (2020).

Patra *et al*. (2020) also reported that combined application of inorganic fertilizer with organic enhance the microbial activity thus solubilize potassium in the soil.

Table 4.13: Influence of integrated nutrient management in direct seeded rice on potassium content in grain and straw

Treatments	K content in grain (%)			K content in straw (%)		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	0.23	0.22	0.23	1.10	1.10	1.10
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	0.25	0.26	0.26	1.24	1.24	1.24
T_3: 100% RDF + PSB	0.26	0.26	0.26	1.25	1.26	1.26
T_4: 100% RDF + FYM @ 2 t ha^{-1}	0.27	0.27	0.27	1.30	1.31	1.31
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	0.27	0.27	0.27	1.32	1.33	1.32
T_6: 75% RDF + PSB	0.24	0.25	0.24	1.18	1.18	1.18
T_7: 75% RDF + FYM @ 2 t ha^{-1}	0.25	0.25	0.25	1.20	1.20	1.20
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	0.25	0.25	0.25	1.22	1.22	1.22
T_9: 50% RDF + PSB	0.24	0.23	0.23	1.13	1.13	1.13
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	0.24	0.24	0.24	1.15	1.15	1.15
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	0.24	0.24	0.24	1.16	1.16	1.16
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	0.26	0.26	0.26	1.27	1.28	1.27
Sem±	**0.002**	**0.002**	**0.001**	**0.010**	**0.011**	**0.008**
CD (P=0.05)	**0.005**	**0.006**	**0.004**	**0.030**	**0.032**	**0.021**

4.4.4 Sulphur in grains and straw (%)

The S content in grains and straw of direct seeded rice was not influenced significantly by the combined use of fertilizers, FYM and bio-fertilizers which is presented in Table 4.14.

The highest S content of 0.25 % and 0.26% in grains and 0.20 % and 0.21 % in straw during 2019 and 2020, respectively was obtained in T_5 (100% RDF + FYM @ 2 t ha^{-1} + PSB). While, the lowest value of 0.16 % and 0.15 % in grains and 0.15 % and 0.15 % in straw was obtained in control treatment (T_1) during the two consecutive years respectively. However, the various treatments could not reach the level of significance.

4.4.5 Nitrogen uptake by grain and straw (kg ha^{-1})

The data pertaining to nitrogen uptake by grain and straw of direct seeded rice as influenced by integrated fertilization are summarized in Table 4.15 and depicted in Fig 4.10 and graphically portrayed in Fig 4.11.

As evident from the result, the maximum N uptake by grain and straw was recorded in T_5 (100% RDF + FYM @ 2 t ha^{-1} + PSB) with the value of 48.94 kg ha^{-1} and 50.00 kg ha^{-1} by grains and 42.01 kg ha^{-1} and 42.90 kg ha^{-1} by straw during 2019 and 2020, respectively which was followed by T_4 which showed parity with each other and significantly higher than the rest of the treatments. The significantly minimum uptake of 24.85 kg ha^{-1} and 24.34 kg ha^{-1} by grains and 23.90 kg ha^{-1} and 23.31 kg ha^{-1} by straw was noted in the control treatment (T_1) during both the years of field trials respectively.

N uptake in grains and straw of rice was significantly increased when level of nutrients (NPK) increased up to 100% RDF using fertilizer alone or in combination with organic manures (FYM) and bio-fertilizer. The increase might be due to optimum supply of nutrients either through inorganic fertilizers or with integrated approach which resulted in better growth of roots

Table 4.14: Influence of integrated nutrient management in direct seeded rice on sulphur content in grain and straw

Treatments	S content in grain (%)			S content in straw (%)		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	0.16	0.15	0.15	0.15	0.15	0.15
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	0.22	0.22	0.22	0.18	0.18	0.18
T_3: 100% RDF + PSB	0.23	0.23	0.23	0.19	0.19	0.19
T_4: 100% RDF + FYM @ 2 t ha^{-1}	0.25	0.26	0.25	0.20	0.20	0.20
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	0.26	0.26	0.26	0.20	0.21	0.20
T_6: 75% RDF + PSB	0.20	0.19	0.20	0.17	0.17	0.17
T_7: 75% RDF + FYM @ 2 t ha^{-1}	0.21	0.24	0.22	0.18	0.17	0.17
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	0.22	0.21	0.21	0.18	0.18	0.18
T_9: 50% RDF + PSB	0.17	0.16	0.16	0.16	0.15	0.16
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	0.18	0.17	0.18	0.16	0.16	0.16
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	0.19	0.18	0.18	0.17	0.16	0.16
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	0.24	0.24	0.24	0.19	0.19	0.19
Sem±	**0.035**	**0.039**	**0.026**	**0.036**	**0.034**	**0.025**
CD (P=0.05)	**NA**	**NS**	**NS**	**NS**	**NS**	**NS**

Table 4.15: Influence of integrated nutrient management in direct seeded rice on nitrogen uptake by grain and straw

Treatments	N uptake by grain (kg ha^{-1})			N uptake by straw (kg ha^{-1})		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	24.85	24.34	24.60	23.90	23.31	23.61
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	39.24	39.40	39.32	34.23	34.51	34.37
T_3: 100% RDF + PSB	40.94	41.17	41.06	35.35	35.86	35.61
T_4: 100% RDF + FYM @ 2 t ha^{-1}	47.26	48.14	47.70	40.82	41.67	41.25
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	48.94	50.00	49.47	42.01	42.90	42.45
T_6: 75% RDF + PSB	34.38	34.25	34.31	30.81	30.78	30.79
T_7: 75% RDF + FYM @ 2 t ha^{-1}	36.03	36.08	36.06	32.00	32.08	32.04
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	37.52	37.56	37.54	32.96	33.20	33.08
T_9: 50% RDF + PSB	29.58	29.03	29.30	27.63	27.15	27.39
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	31.27	30.93	31.10	28.70	28.38	28.54
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	32.67	32.36	32.51	29.61	29.45	29.53
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	42.50	42.97	42.74	36.45	37.14	36.80
Sem±	**1.08**	**1.14**	**0.78**	**1.26**	**1.27**	**0.89**
CD (P=0.05)	**3.16**	**3.34**	**2.23**	**3.69**	**3.73**	**2.55**

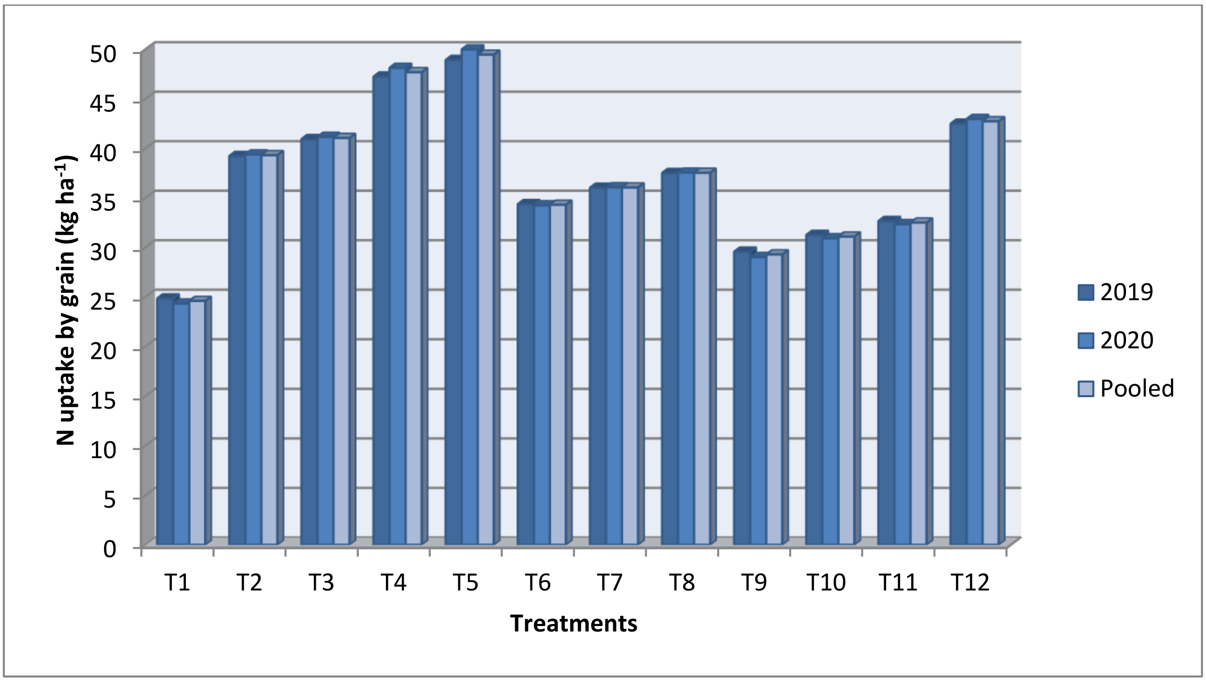

Fig 4.10 Influence of integrated nutrient management on nitrogen uptake by grain

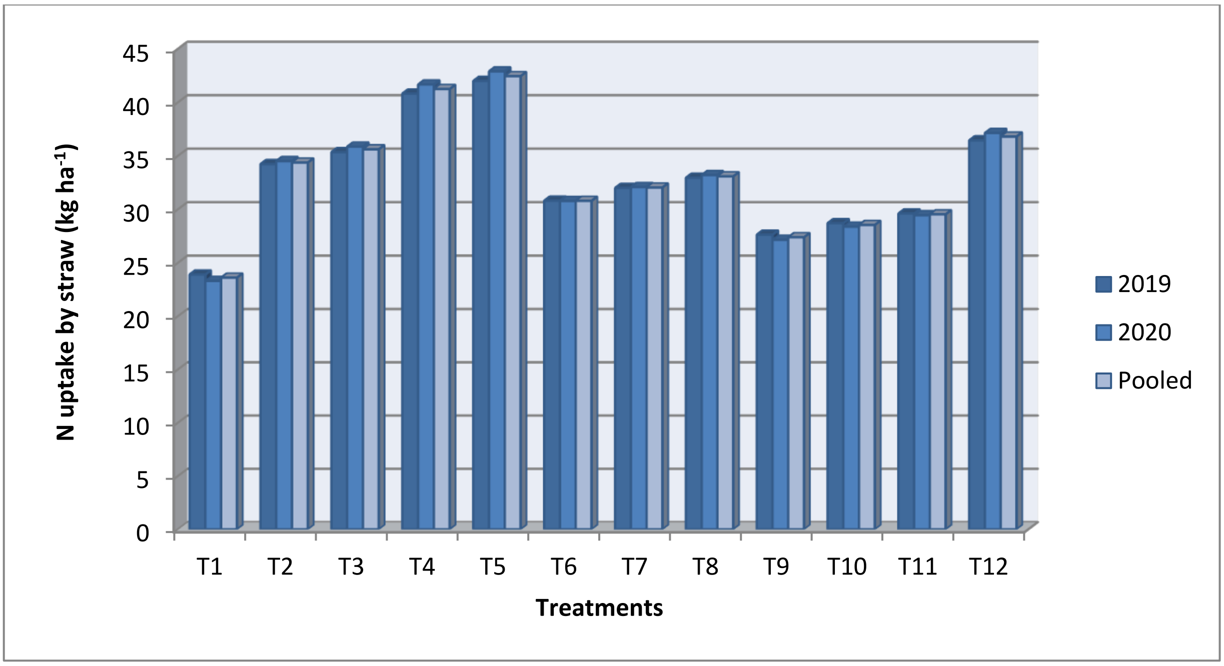

Fig 4.11 Influence of integrated nutrient management on nitrogen uptake by straw

which extracted higher amount of nutrients from soil resulting in higher uptake of nutrients both in grain and straw of the crop. Similar discovery were also documented by Biswas *et al.* (2020).

Sahu *et al.* (2020) also observed that combined application of fertilizers with organic manure encouraged the nitrogen uptake as compared to inorganic fertilizer application alone.

4.4.6 Phosphorus uptake by grain and straw (kg ha^{-1})

It is evident from the data that the P uptake varied significantly by different levels of inorganic fertilizer in various treatments with organic manures which is presented in Table 4.16 and depicted in Fig 4.12 and graphically outlined in Fig 4.13.

The maximum uptake of P by grains with a value of 13.97 kg ha^{-1} and 14.55 kg ha^{-1} and straw of 7.93 kg ha^{-1} and 8.52 kg ha^{-1} during 2019 and 2020, respectively noted in T_5 (100% RDF + FYM @ 2 t ha^{-1} + PSB) which was closely followed by the treatments receiving 100% RDF + FYM @ 2 t ha^{-1} (T_4) where both of this treatment are at par with each other and significantly highest than the rest of the treatment. The lowest phosphorus uptake of 6.17 kg ha^{-1} and 5.97 kg ha^{-1} by grains and 3.96 kg ha^{-1} and 3.66 kg ha^{-1} by straw was found in control during the two consecutive years respectively. The data clearly indicated that treatments comprised of more of inorganic P resulted in more P uptake compared to other treatments.

The results are in conformity with the works of Kumar *et al*. (2018) and Shultana *et al.* (2019). Moreover incorporation of PSB solubilized the fixed P and made it available to plant and hence enhanced the uptake of P by the plants Raki *et al*. (2019).

Table 4.16: Influence of integrated nutrient management in direct seeded rice on phosphorus uptake by grain and straw

Treatments	P uptake by grain (kg ha^{-1})			P uptake by straw (kg ha^{-1})		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	6.17	5.97	6.07	3.96	3.66	3.81
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	10.68	10.81	10.75	6.20	6.37	6.29
T_3: 100% RDF + PSB	11.28	11.50	11.39	6.48	6.74	6.61
T_4: 100% RDF + FYM @ 2 t ha^{-1}	13.33	13.84	13.59	7.67	8.16	7.92
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	13.97	14.55	14.26	7.93	8.52	8.22
T_6: 75% RDF + PSB	9.08	8.94	9.01	5.47	5.47	5.47
T_7: 75% RDF + FYM @ 2 t ha^{-1}	9.64	9.59	9.61	5.72	5.78	5.75
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	10.10	10.14	10.12	5.91	6.04	5.98
T_9: 50% RDF + PSB	7.51	7.25	7.38	4.69	4.49	4.59
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	8.03	7.84	7.94	4.98	4.82	4.90
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	8.52	8.32	8.42	5.21	5.08	5.14
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	11.85	12.23	12.04	6.73	7.11	6.92
Sem±	**0.39**	**0.41**	**0.28**	**0.22**	**0.25**	**0.17**
CD (P=0.05)	**1.15**	**1.21**	**0.81**	**0.64**	**0.73**	**0.47**

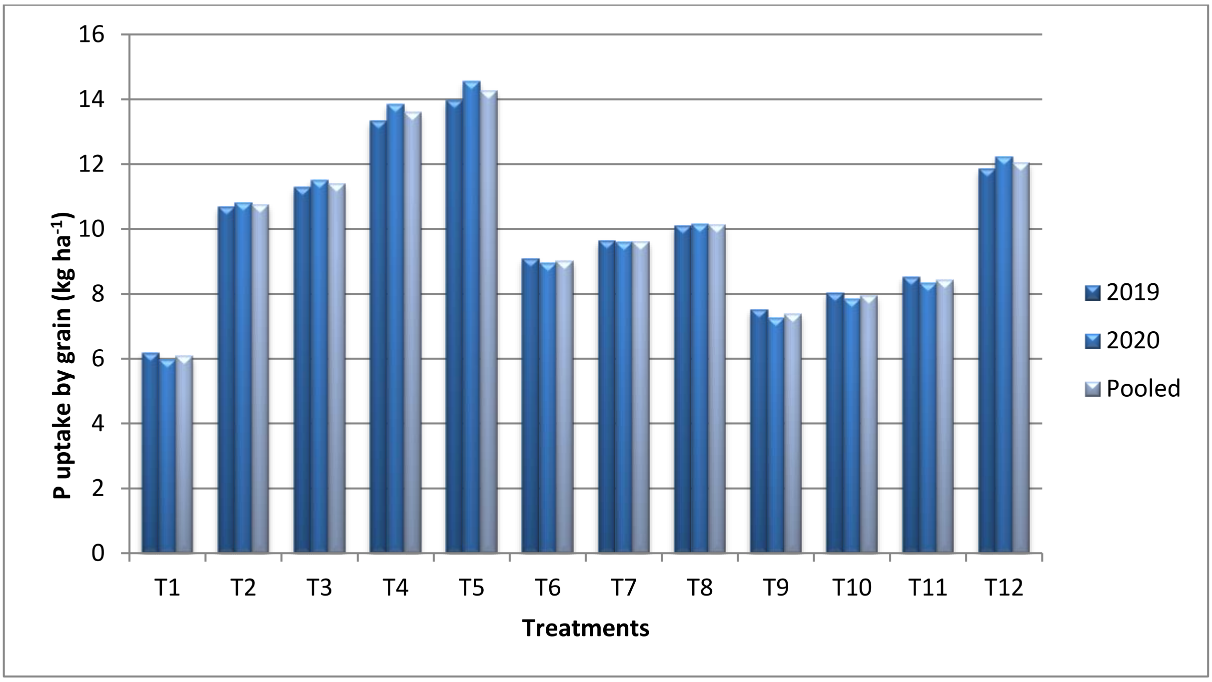

Fig 4.12 Influence of integrated nutrient management on phosphorus uptake by grain

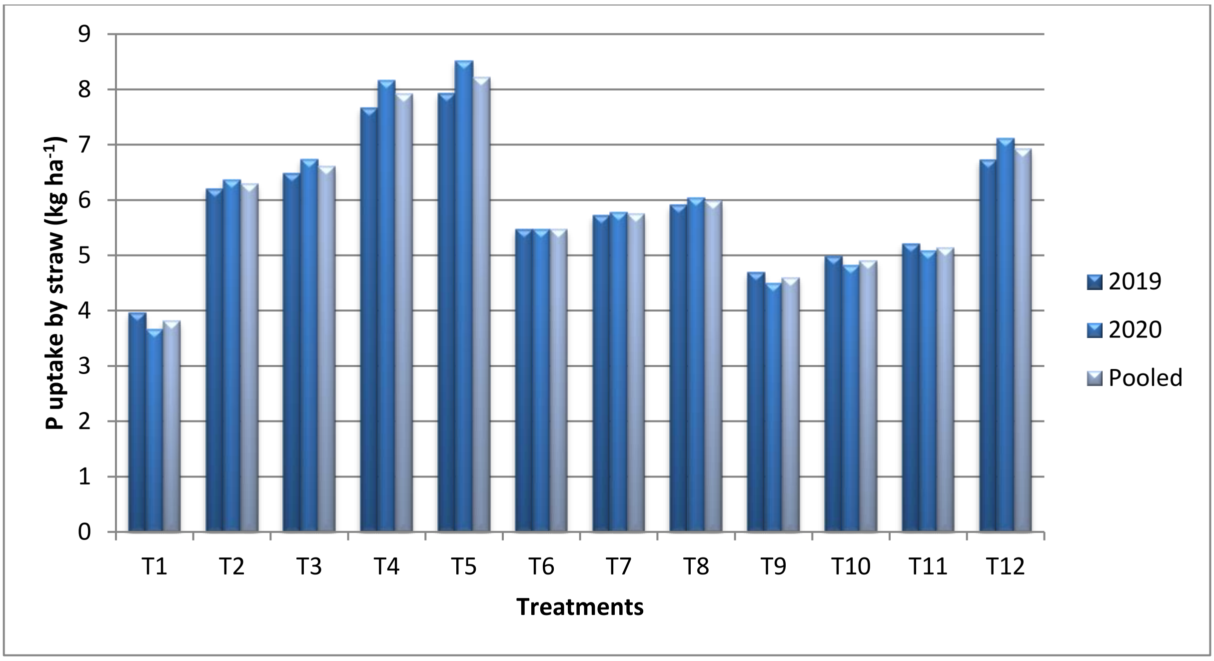

Fig 4.13 Influence of integrated nutrient management on phosphorus uptake by straw

4.4.7 Potassium uptake by grains and straw (kg ha^{-1})

Potassium uptake in grains and straw as influenced by integrated application of nutrients in direct seeded rice is presented in Table 4.17 and graphically depicted in Fig 4.14 and Fig 4.15.

The significantly highest potassium uptake of 10.50 kg ha^{-1} and 10.79 kg ha^{-1} by grains and 78.94 kg ha^{-1} and 80.20 kg ha^{-1} by straw during 2019 and 2020, respectively was recorded with the application of 100% RDF + FYM @ 2 t ha^{-1} + PSB (T_5) which is at par with T_4 (100% RDF + FYM @ 2 t ha^{-1}). The lowest potassium uptake was observed in control treatment (T_1) with the value of 5.11 kg ha^{-1} and 4.93 kg ha^{-1} by grains and 45.40 kg ha^{-1} and 44.53 kg ha^{-1} by straw during both the years of investigation (2019 and 2020) respectively where no external source of nutrients was applied due to which the uptake was low. The data clearly showed that higher potassium uptake was increased where there was application of higher doses of fertilizers in conjunction with organic manures.

Sahu *et al.* (2020) reported that chemical fertilizer released nutrient faster which leads to higher uptake by the plants meanwhile the availability of potassium and its uptake by the plants increased after the proper decomposition of organic manure. The increased in uptake of potassium as documented by Biswas *et al*. (2020) with integrated approach showed better growth of roots which ultimately extract higher amount of nutrients from the soil thus result in better uptake by the plants.

Table 4.17: Influence of integrated nutrient management in direct seeded rice on potassium uptake by grain and straw

Treatments	K uptake by grain (kg ha^{-1})			K uptake by straw (kg ha^{-1})		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	5.11	4.93	5.02	45.40	44.53	44.96
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	8.28	8.37	8.32	64.54	64.88	64.71
T_3: 100% RDF + PSB	8.69	8.81	8.75	66.74	67.32	67.03
T_4: 100% RDF + FYM @ 2 t ha^{-1}	10.09	10.38	10.24	76.70	77.78	77.24
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	10.50	10.79	10.64	78.94	80.20	79.57
T_6: 75% RDF + PSB	7.16	7.15	7.16	58.12	58.11	58.11
T_7: 75% RDF + FYM @ 2 t ha^{-1}	7.55	7.58	7.56	60.29	60.45	60.37
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	7.90	7.93	7.91	62.21	62.56	62.38
T_9: 50% RDF + PSB	6.11	5.94	6.02	52.10	51.61	51.85
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	6.45	6.38	6.41	54.08	53.83	53.96
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	6.80	6.73	6.77	55.87	55.69	55.78
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	9.08	9.22	9.15	68.90	69.65	69.27
Sem±	**0.27**	**0.28**	**0.20**	**1.91**	**2.05**	**1.40**
CD (P=0.05)	**0.79**	**0.83**	**0.56**	**5.61**	**6.00**	**3.99**

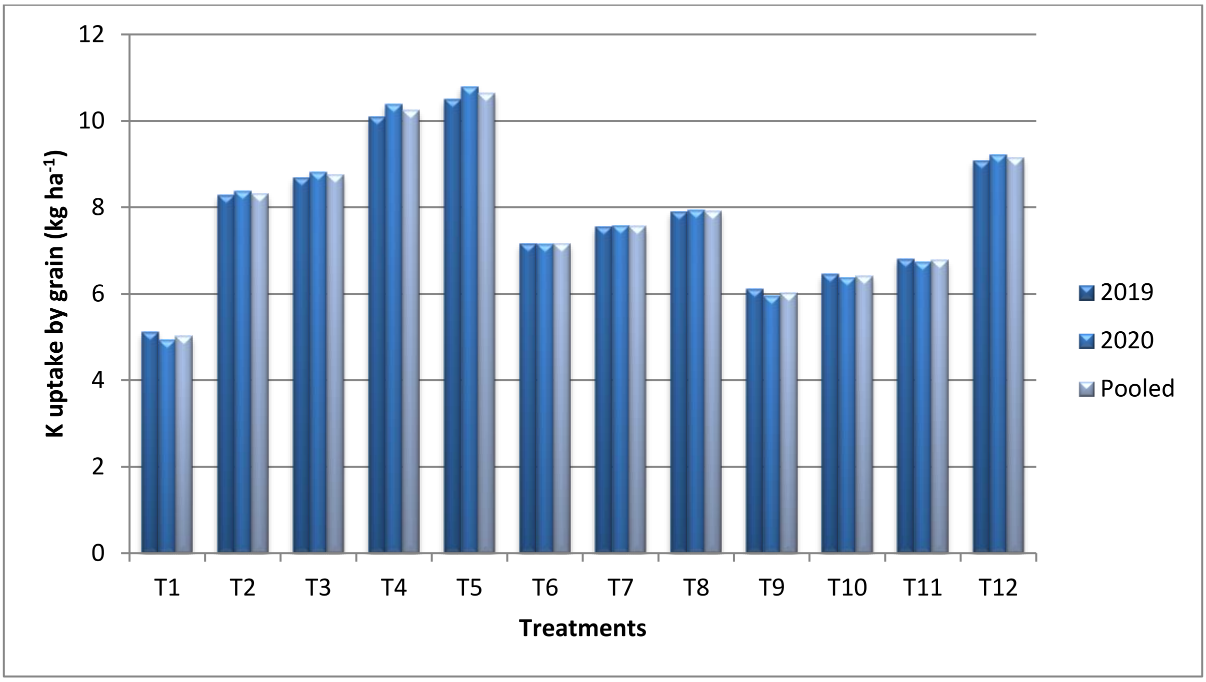

Fig 4.14 Influence of integrated nutrient management on potassium uptake by grain

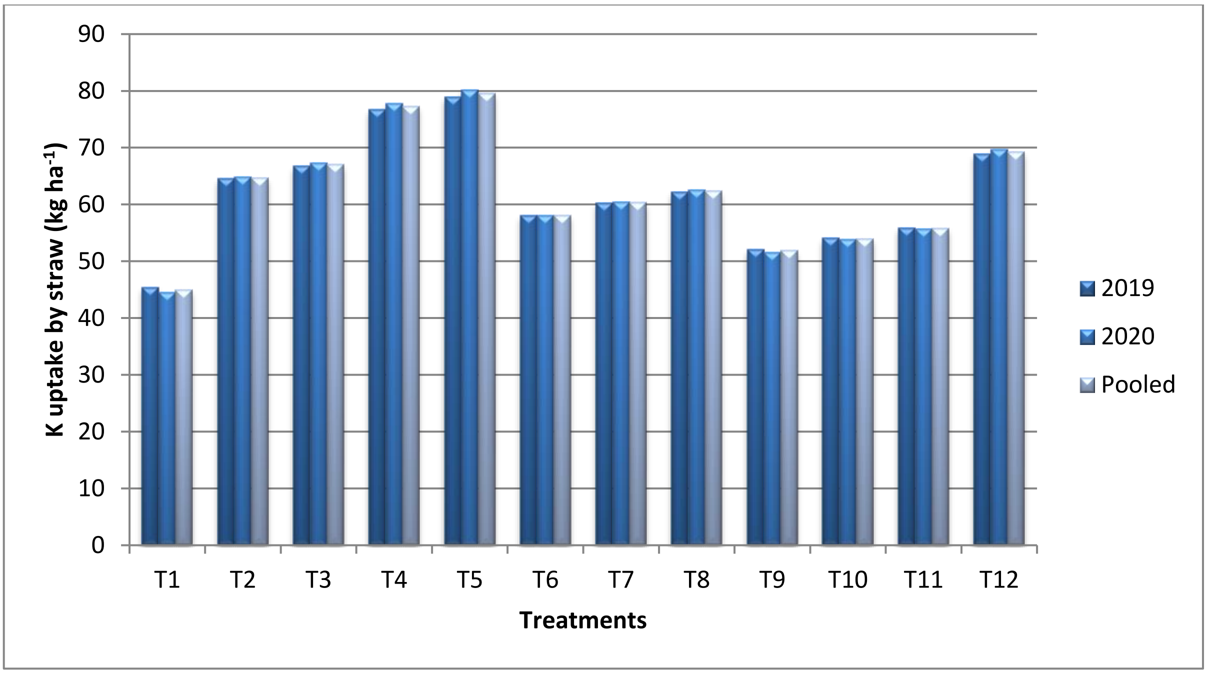

Fig 4.15 Influence of integrated nutrient management on potassium uptake by straw

4.4.8 Sulphur uptake by grains and straw (kg ha^{-1})

Data pertaining to sulphur uptake in grains and straw in direct seeded rice is presented in the table 4.18.

Result indicated that the influence of integrated nutrient management did not show any significant effect on their uptake during two years of study.

However, the value of sulphur uptake by the grains and straw increased with increased levels of fertilizer doses along with FYM and bio-fertilizer (T_5) where the uptake value in grains ranges from 3.55 to 10.10 kg ha^{-1} (2019) and 3.24 to 10.32 kg ha^{-1} (2020) over control treatments (T_1). In case of uptake by straw, the highest value was recorded in T_5 treatments (100% RDF + FYM @ 2 t ha^{-1} + PSB) where the value ranges from 6.13 to 11.99 kg ha^{-1} in 2019 and 6.10 to 12.13 kg ha^{-1} in 2020 over control treatment (T_1).

Table 4.18: Influence of integrated nutrient management in direct seeded rice on sulphur uptake by grain and straw

Treatments	S uptake by grain (kg ha^{-1})			S uptake by straw (kg ha^{-1})		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	3.55	3.24	3.39	6.13	6.08	6.10
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	7.40	7.24	7.32	9.41	9.49	9.45
T_3: 100% RDF + PSB	7.93	7.79	7.86	9.84	10.00	9.92
T_4: 100% RDF + FYM @ 2 t ha^{-1}	9.58	9.69	9.63	11.43	11.69	11.56
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	10.10	10.32	10.21	11.99	12.28	12.13
T_6: 75% RDF + PSB	5.71	5.69	5.70	8.31	8.25	8.28
T_7: 75% RDF + FYM @ 2 t ha^{-1}	6.38	7.15	6.77	8.90	8.60	8.75
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	6.69	6.75	6.72	9.01	9.24	9.12
T_9: 50% RDF + PSB	4.44	4.04	4.24	7.14	6.89	7.01
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	4.81	4.71	4.76	7.55	7.31	7.43
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	5.30	4.97	5.14	7.87	7.68	7.77
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	8.44	8.42	8.43	10.21	10.52	10.36
Sem±	**2.25**	**2.18**	**1.57**	**1.90**	**1.86**	**1.33**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

4.5 Effect of integrated nutrient management on soil fertility after harvest

Soil chemical properties determined at the end of experimentation after completion of two years sequence clearly disclosed that in general all the soil chemical properties under study improved with the application of different INM treatments over initial values and control. Integrated supply of inorganic fertilizers along with organic manures enhanced the availability of nutrients and sustained the soil fertility status. Application of nutrients in integrated manner acts as a source of energy, organic carbon and available nitrogen for the growth of soil microbes and improvement of soil properties.

Furthermore, organic matter performs as nourishment for the microbes present in the soil and thus boosts in their multiplication, which consecutively improves the mineralization of nitrogen in soil.

4.5.1 Soil pH after harvest

A perusal of data on pH as affected by various treatments under study indicated that application of fertilizer levels, FYM and PSB did not show any significant effect during both the years which is presented in table 4.19.

However, slight increase in pH was observed in the treatment receiving combined application of 100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB (T_5) with the value of 5.04 and 5.05 in 2019 and 2020 respectively. The value of 4.63 and 4.60 in 2019 and 2020 respectively was recorded in the control treatment (T_1) where there was no addition of external source of nutrients.

When inorganic and organic treatments were compared, soil pH was higher in treatments where integrated use of chemical fertilizers and manures was applied. This marginal increase in soil pH might be due to moderating effect of organic manures as it decreases the activity of exchangeable Al^{3+} ions in soil solution due to chelation effect of organic molecules and in addition

Table 4.19: Influence of integrated nutrient management on pH and electrical conductivity of soil after harvest

	pH			EC (dS m^{-1})		
Treatments	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	4.63	4.60	4.62	0.167	0.165	0.166
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	4.82	4.81	4.82	0.178	0.178	0.178
T_3: 100% RDF + PSB	4.94	4.96	4.95	0.185	0.185	0.185
T_4: 100% RDF + FYM @ 2 t ha^{-1}	5.02	5.00	5.01	0.188	0.189	0.189
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	5.04	5.05	5.04	0.191	0.192	0.192
T_6: 75% RDF + PSB	4.73	4.72	4.73	0.174	0.173	0.173
T_7: 75% RDF + FYM @ 2 t ha^{-1}	4.86	4.84	4.85	0.180	0.180	0.180
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	4.90	4.91	4.91	0.182	0.182	0.182
T_9: 50% RDF + PSB	4.66	4.67	4.67	0.170	0.168	0.169
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	4.70	4.69	4.70	0.172	0.170	0.171
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	4.77	4.78	4.78	0.176	0.175	0.175
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	4.97	4.98	4.98	0.186	0.187	0.186
Sem±	**0.12**	**0.25**	**0.14**	**0.005**	**0.011**	**0.006**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Initial Value	**4.68**	**4.82**	**-**	**0.170**	**0.184**	**-**

release of basic cations like K^+, Ca^{2+}, Mg^{2+} and Na+ in soil. Similar results were also reported by Patra *et al*. (2020).

4.5.2 Electrical conductivity of soil after harvest (dS m^{-1})

Data pertaining to electrical conductivity of soil after harvest is presented in the table 4.19.

Data indicated that the influence of integrated nutrient management did not show any significant effect on electrical conductivity during two years of study. However, the value of soil EC numerically ranged from 0.167 dS m^{-1} and 0.165 dS m^{-1} in control plot (T_1) to 0.191 dS m^{-1} and 0.192 dS m^{-1} in treatment T_5 (100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB) during 2019 and 2020 respectively. The higher values obtained might be due to addition of NPK fertilizers which increases accumulation of salt concentration in soil which contributes to increased electrical conductivity of soil. The enhanced electrical conductivity due to FYM was attributed to the decomposition of organic matter (Bhatt *et al*., 2019).

4.5.3 Organic carbon of soil after harvest (%)

The data on soil organic carbon after harvest is presented in Table 4.20 and graphically illustrated in Fig 4.16.

Among the different treatments witnessed, treatment T_5 with 100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB has recorded the maximum organic carbon content with the value of 1.48 % and 1.52 % during 2019 and 2020 respectively, which is found to be at par with treatment T_4 having 100 % RDF + FYM @ 2 tonnes ha^{-1} and they are significantly higher than the rest of the treatments. The significantly lowest organic carbon content was recorded in the control treatment (T_1) with the value of 1.20 % and 1.16 % in both the years respectively.

The increase in organic carbon content was due to better root growth resulting with more organic residue in soil which after decomposition may have increased the soil organic carbon content owing to synergistic effect of inorganic fertilizer, organic sources and bio-fertilizer in a synchronized manner Kumar *et al*. (2018).

Patra *et al*. (2020) also witnessed the positive and significant effect of inorganic fertilization along with manures on soil organic matter content and concluded that the increase might be due to the direct application of carbon input, which was further enhanced through root exudates, root residue of rice and bio-fertilizers application. As a consequence, organic inputs generally enhanced the development of micro-flora and increased the microbial activity of soil.

4.5.4 Cation exchange capacity of soil after harvest {cmol (p^+) kg^{-1}}

The two years data on cation exchange capacity on soil after harvest of direct seeded rice as influenced by integrated nutrient management is presented in table 4.20 and graphically depicted in Fig 4.17.

As noted from the result, the cation exchange capacity of soil was found to be significantly influenced by integrated use of inorganic fertilizers with organic manures along with PSB. The value of CEC ranged from 9.48 cmol (p^+) kg^{-1} and 9.09 cmol (p^+) kg^{-1} in control plot to 15.55 cmol (p^+) kg^{-1} and 15.35 cmol (p^+) kg^{-1} in T_5 receiving 100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB during the year 2019 and 2020 respectively closely followed up by T_4 (100% RDF + FYM @ 2 t ha^{-1}). Therefore, conjunctive use of organic and inorganic fertilizers significantly increased the CEC over control.

The significant build up CEC in soil may be due to formation of more humus due to decomposition of organic matter that might have increased the surface area and developed more negative charge due to dissociation of H^+ ion

Table 4.20: Influence of integrated nutrient management on organic carbon and cation exchange capacity of soil after harvest

	OC (%)			CEC {cmol (p^+) kg^{-1}}		
Treatments	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	1.20	1.16	1.18	9.48	9.09	9.28
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	1.37	1.39	1.38	13.25	13.32	13.29
T_3: 100% RDF + PSB	1.39	1.41	1.40	13.72	13.86	13.79
T_4: 100% RDF + FYM @ 2 t ha^{-1}	1.46	1.49	1.48	15.10	15.35	15.23
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	1.48	1.52	1.50	15.55	15.89	15.72
T_6: 75% RDF + PSB	1.30	1.32	1.31	11.83	11.67	11.75
T_7: 75% RDF + FYM @ 2 t ha^{-1}	1.33	1.35	1.34	12.31	12.21	12.26
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	1.34	1.37	1.36	12.78	12.75	12.76
T_9: 50% RDF + PSB	1.25	1.25	1.25	11.06	10.05	10.56
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	1.26	1.28	1.27	10.90	10.55	10.73
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	1.28	1.30	1.29	11.35	11.09	11.22
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	1.41	1.43	1.42	14.19	14.39	14.29
Sem±	**0.02**	**0.02**	**0.01**	**0.30**	**0.31**	**0.22**
CD (P=0.05)	**0.04**	**0.05**	**0.03**	**0.89**	**0.91**	**0.62**
Initial Value	**1.26**	**1.38**	**-**	**10.55**	**13.20**	**-**

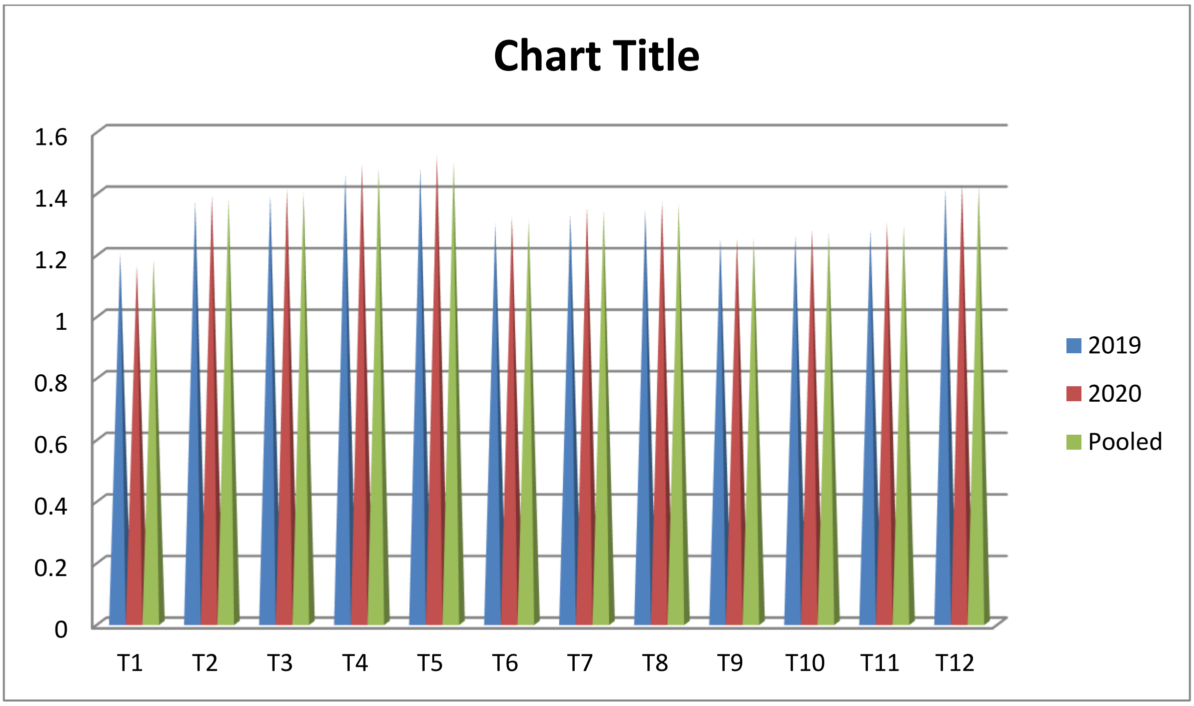

Fig 4.16 Influence of integrated nutrient management on organic carbon of soil after harvest

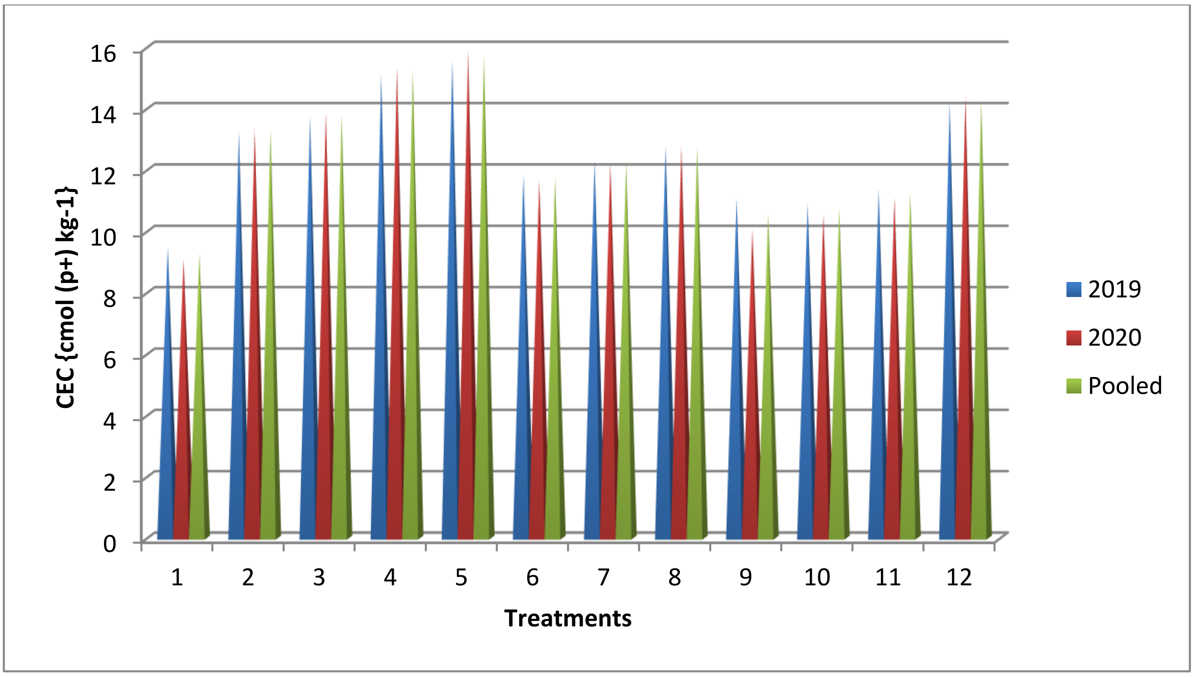

Fig 4.17 Influence of integrated nutrient management on cation exchange capacity of soil after harvest

from functional group which ultimately contributed to increase in CEC of soil and thus maintained higher value than control. The result of the present investigation is in harmony with the findings of Parewa *et al*. (2014) where the addition of FYM served as a store house for exchangeable cations. A gradual increase in CEC due to graded levels of NPK was also recorded by Bhatt *et al*. (2019) probably due to higher content of crop residues.

4.5.5 Available nitrogen of soil after harvest (kg ha^{-1})

The result on the influence of integrated nutrient management on available nitrogen in soil after harvest of the crop is presented in Table 4.21 and graphically portrayed in Fig 4.18.

As evident from the result, the available nitrogen was significantly influenced by the integrated use of fertilizers. The maximum available N was recorded in the treatment (T_5) receiving 100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB with the value of 284.45 kg ha^{-1} and 286.50 kg ha^{-1} in 2019 and 2020 respectively which is at par with T_4 (100% RDF + FYM @ 2 t ha^{-1}) and is significantly superior to the rest of the treatment. Significantly inferior value of 255.32 kg ha^{-1} and 254.10 kg ha^{-1} was recorded in the control treatment (T_1) which may be due to mining of nutrients with continuous cropping without fertilization over the years.

The increase in soil nitrogen might be due to direct addition of N through fertilizer and organic materials that enhance the multiplication of soil microbes, which converts organically bound nitrogen to inorganic form. The application of organic manures could reduce N losses thereby augmenting mineralization of N in organically treated plots thus maintaining a continuous availability of N in entire life cycle of rice plant. The results are in agreement with the findings of Harikesh *et al*. (2017).

Guo *et al*.(2016) also reported that application of nitrogenous fertilizer along with farm yard manure keeps the C:N ratio down and rate of mineralization outperform immobilization and ultimately there was increase in nitrogen content.

4.5.6 Available phosphorus of soil after harvest (kg ha^{-1})

The data pertaining to available phosphorus in soil as influenced by integrated fertilization in direct seeded rice are summarized in Table 4.21 and graphically outlined in Fig 4.19.

From the table, it is obvious that the significantly highest value of 22.83 kg ha^{-1} in 2019 and 23.65 kg ha^{-1} in 2020 was recorded in the T_5 (100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB) which is found to be at par with T_4 (100% RDF + FYM @ 2 t ha^{-1}). The significantly lowest value was recorded in the control treatment (T_1) with the value of 15.34 kg ha^{-1} and 14.72 kg ha^{-1} during the consecutive years respectively as there was no external source of nutrients and continuous cropping may have lead to exhaustion of nutrients which leads to more reduction of available P in soil.

Build-up in available P with the conjoint use of fertilizers and organics could be ascribed to the release of CO_2 and organic acids during decomposition which in turn helped in releasing native phosphorus through solubilizing action of these acids. Also, organic matter forms a coating on sesquioxides and makes them inactive and thus reduces the phosphate fixing capacity of soil, which ultimately helps in release of ample quantity of plant available P. The substantial build-up of available P with continuous use of fertilizers alone or in combination with organics is in agreement with the findings of Bhatt *et al*. (2019) and Sandhu *et al*. (2020).

Jyoti *et al*. (2016) also reported that addition of organic manure like FYM with inorganic fertilizers had the beneficial effect in increasing phosphate availability. Application of phosphate solubilizing bacteria (PSB) as bio-inoculants can solubilize the fixed soil phosphorus and applied phosphates resulting in higher crop yields. Therefore, PSB are critical for the transfer of phosphorus from poorly available soil pools to plant available forms and are important for maintaining phosphorus in readily available pools of soil. Seed or soil inoculation with PSB has been known to improve in solubilization of fixed soil phosphorus and applied phosphates resulting in higher crop yields.

4.5.7 Available potassium of soil after harvest (kg ha^{-1})

Perusal of data on available potassium after harvest of crop is given in Table 4.21 and graphically portrayed in Fig 4.20.

Data revealed that the integrated use of nutrients had a significant effect on available K in soil after the harvest of the crop. The result indicated that T_5 (100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB) recorded the maximum value of 149.78 kg ha^{-1} and 151.90 kg ha^{-1} in 2019 and 2020 respectively which is found to be at parity with T_4 (100% RDF + FYM @ 2 t ha^{-1}) they are significantly higher than the rest of the treatments. Significantly lowest potassium value of 136.20 kg ha^{-1} in 2019 and 135.08 kg ha^{-1} in 2020 was recorded in the control treatment due to lack of nutrients moreover continuous cropping system led to more mining of the nutrients from the soil over the years, thus resulted in poor growth and low available K in the soil.

Available potassium content in surface soil increased appreciably with the application of chemical fertilizer, manures and bio fertilizers. Higher availability of available K could be ascribed to direct addition of potassium to the available pool of soil besides reduction in potassium fixation and release of potassium due to interaction of organic matter with clay may be responsible for increase in available K in soil over the years. Similar findings were also reported by Jyoti *et al*. (2016) and Tlustos *et al*. (2018).

Table 4.21: Influence of integrated nutrient management on available nitrogen, phosphorus and potassium content of soil after harvest

	N (kg ha^{-1})			P (kg ha^{-1})			K (kg ha^{-1})		
Treatments	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**	**2019**	**2020**	**pooled**
T_1: Control	255.32	254.10	254.71	15.34	14.72	15.03	136.20	135.08	135.64
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	273.32	274.23	273.78	19.97	20.26	20.12	144.40	145.35	144.88
T_3: 100% RDF + PSB	275.64	276.78	276.21	20.56	20.99	20.78	145.32	146.59	145.96
T_4: 100% RDF + FYM @ 2 t ha^{-1}	282.16	283.98	283.07	22.21	22.95	22.58	148.87	150.67	149.77
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	284.45	286.50	285.48	22.83	23.65	23.24	149.78	151.90	150.84
T_6: 75% RDF + PSB	266.23	266.59	266.41	18.17	18.15	18.16	141.58	141.64	141.61
T_7: 75% RDF + FYM @ 2 t ha^{-1}	268.73	269.17	268.95	18.79	18.87	18.83	142.56	142.91	142.74
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	270.98	271.65	271.32	19.35	19.53	19.44	143.45	144.10	143.78
T_9: 50% RDF + PSB	259.54	258.90	259.22	16.36	15.97	16.17	138.85	137.95	138.40
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	261.83	261.49	261.66	16.99	16.74	16.87	139.82	139.18	139.50
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	263.84	264.02	263.93	17.55	17.42	17.49	140.63	140.38	140.51
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	277.94	279.28	278.61	21.16	21.70	21.43	146.22	147.81	147.02
Sem±	**1.38**	**1.51**	**1.02**	**0.32**	**0.39**	**0.25**	**0.86**	**0.92**	**0.63**
CD (P=0.05)	**4.04**	**4.43**	**2.91**	**0.94**	**1.14**	**0.72**	**2.53**	**2.71**	**1.80**
Initial value	**258.54**	**277.80**	**-**	**16.05**	**20.50**	**-**	**138.05**	**142.64**	**-**

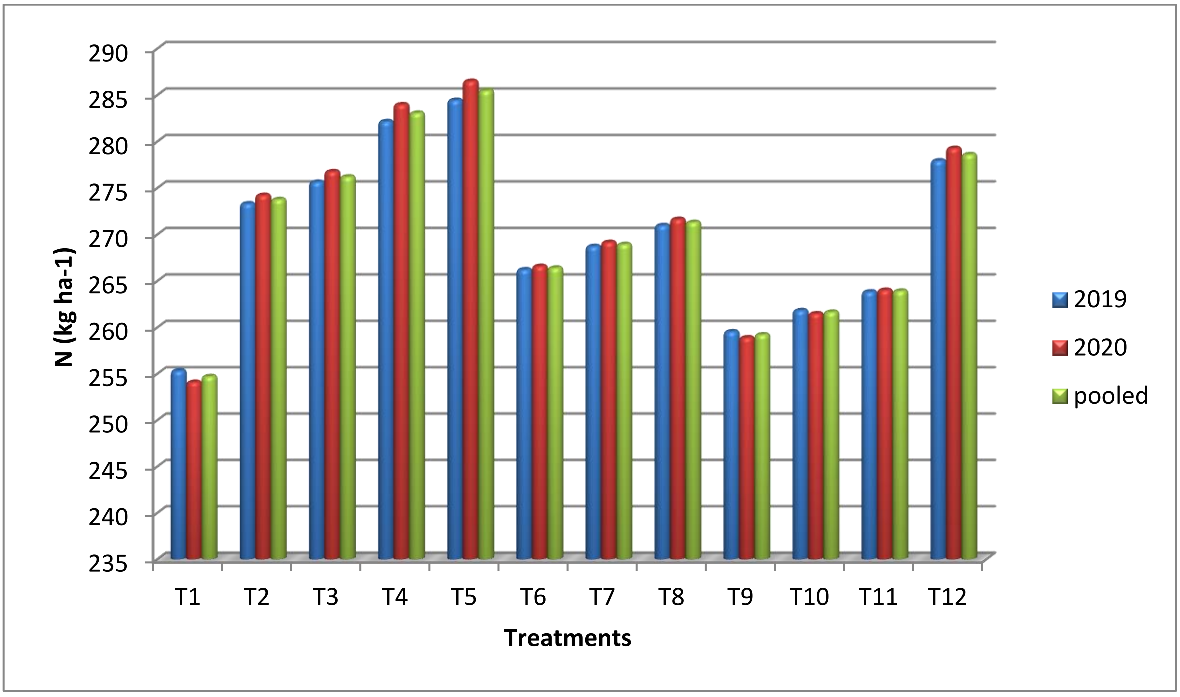

Fig 4.18 Influence of integrated nutrient management on available nitrogen of soil after harvest

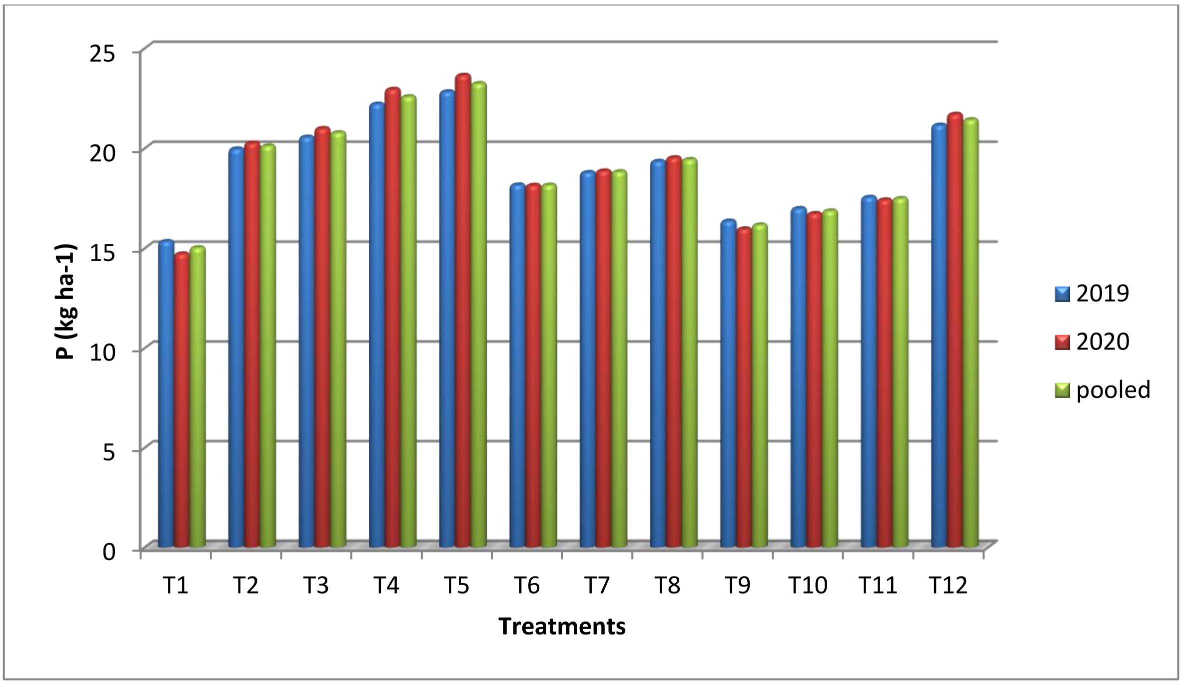

Fig 4.19 Influence of integrated nutrient management on available phosphorus of soil after harvest

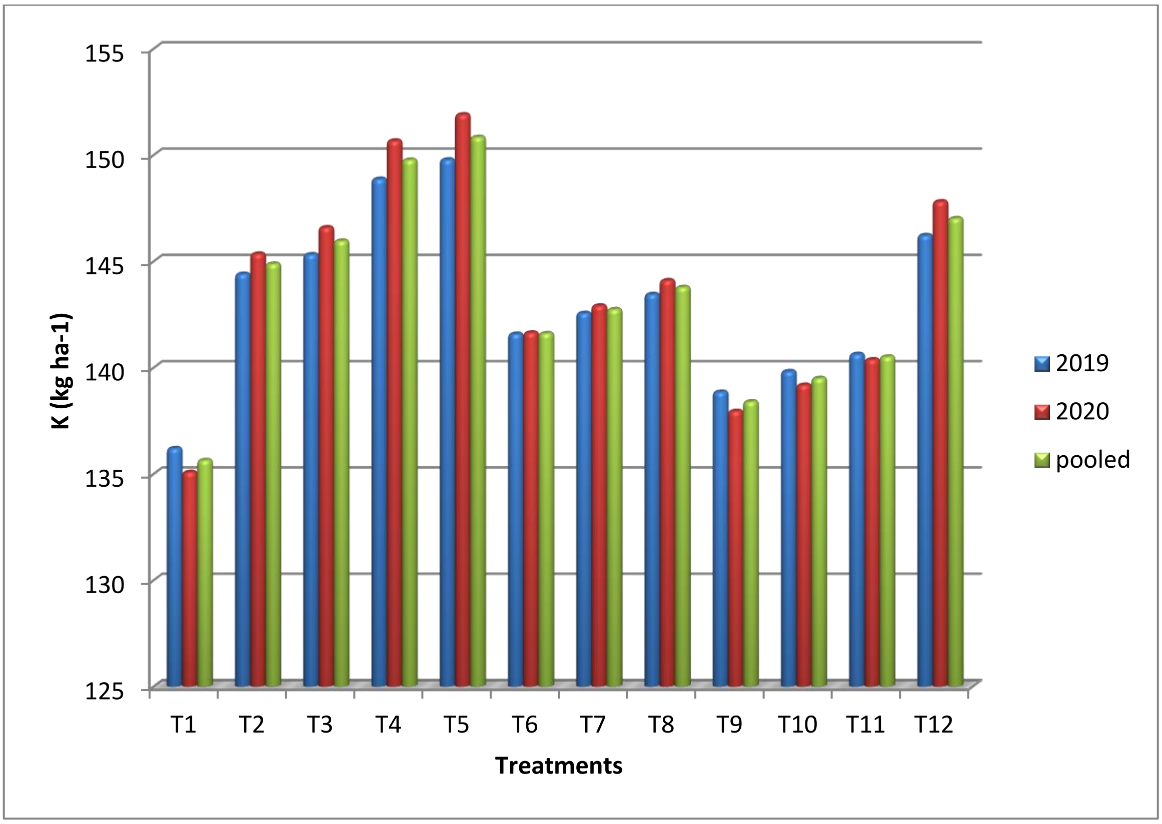

Fig 4.20 Influence of integrated nutrient management on available potassium of soil after harvest

Application of FYM enhanced the K availability in the soil as it solubilize the action of certain organic acids liberated during FYM decomposition and greater capacity to hold K in the available form. Beneficial effects of manure on K availability were also reported by Harikesh *et al*. (2017). 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 soil (Urkurkar *et al*., 2010).

4.5.8 Available sulphur of soil after harvest (kg ha^{-1})

From the data depicted in Table 4.22, it is evident that the integrated use of fertilizers with organic manures and PSB did not have any significant effect on the available sulphur in the soil after harvest.

However higher values of 7.73 kg ha^{-1} in 2019 and 7.85 kg ha^{-1} in 2020 was observed in T_5 (100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB) and the lowest value of 4.71 kg ha^{-1} in 2019 and 4.53 kg ha^{-1} in 2020 was recorded in the control treatment (T_1).

4.5.9 Total potential acidity of soil after harvest (meq/100g)

The effect of integrated nutrient management on total potential acidity in soil after harvest is presented in Table 4.22.

It is evident from the data that the integrated use on different levels of fertilizers along with FYM and PSB did not showed any significant effect on total potential acidity during both the years of the experiment. However incorporation of higher dose of fertilizer along with FYM and PSB decreased the TPA up to some extend when compared with control. T_5 (100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB) recorded the value of 7.73 and 7.85 meq/100g while control treatment (T_1) recorded the value of 20.85 and 20.63 meq/100g during 2019 and 2020 respectively.

Table 4.22: Influence of integrated nutrient management on available sulphur and total potential acidity of soil after harvest

	S (kg ha^{-1})			TPA (meq/100g)		
Treatments	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	4.71	4.53	4.62	20.85	20.63	20.74
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	6.06	6.19	6.12	18.76	18.60	18.68
T_3: 100% RDF + PSB	6.87	7.02	6.95	18.43	18.29	18.36
T_4: 100% RDF + FYM @ 2 t ha^{-1}	7.42	7.55	7.49	17.81	17.66	17.74
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	7.73	7.85	7.79	17.52	17.38	17.45
T_6: 75% RDF + PSB	5.54	5.51	5.53	19.74	19.52	19.63
T_7: 75% RDF + FYM @ 2 t ha^{-1}	6.34	6.44	6.39	19.41	19.21	19.31
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	6.59	6.71	6.65	19.09	18.92	19.01
T_9: 50% RDF + PSB	4.98	4.83	4.91	20.65	20.42	20.54
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	5.26	5.21	5.23	20.38	20.13	20.26
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	5.78	5.89	5.83	20.07	19.85	19.96
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	7.17	7.30	7.23	18.13	17.98	18.06
Sem±	**0.66**	**1.37**	**0.76**	**1.11**	**1.19**	**0.81**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Initial value	**4.85**	**6.92**	**-**	**20.03**	**18.35**	**-**

4.5.10 Exchangeable calcium of soil after harvest {cmol (p^+) kg^{-1}}

A perusal of data on exchangeable calcium as affected by various treatments of integrated nutrient management under study is presented in Table 4.23.

Data indicated that application of fertilizer levels, FYM and PSB did not show any significant effect during both the years of the experiment. But incorporation of higher quantity of fertilizer with FYM and PSB did decrease the exchangeable Ca in soil imperceptibly where T_5 (100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB) recorded the value of 1.66 and 1.47 cmol (p^+) kg^{-1} while control treatment (T_1) recorded the value of 3.28 and 3.34 cmol (p^+) kg^{-1} during 2019 and 2020 respectively.

4.5.11 Exchangeable magnesium of soil after harvest {cmol (p^+) kg^{-1}}

The influence of integrated nutrient management on exchangeable magnesium of soil after harvest is presented in Table 4.22,

It is clearly evident that the integrated use of nutrient did not show any significant effect on exchangeable magnesium in soil. However, the highest value of 0.49 and 0.51 cmol (p^+) kg^{-1} was recorded in T_5 treatment where the crops received 100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB (T_1) and the lowest value was recorded in control treatment with the value of 0.34 and 0.32 cmol (p^+) kg^{-1} during 2019 and 2020 respectively.

Table 4.23: Influence of integrated nutrient management on exchangeable calcium and magnesium of soil after harvest

	Exch. Ca {cmol (p^+) kg^{-1}}			Exch. Mg {cmol (p^+) kg^{-1}}		
Treatments	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	3.28	3.34	3.31	0.34	0.32	0.33
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	2.12	2.07	2.10	0.43	0.44	0.43
T_3: 100% RDF + PSB	1.93	1.87	1.90	0.45	0.45	0.45
T_4: 100% RDF + FYM @ 2 t ha^{-1}	1.70	1.50	1.60	0.47	0.49	0.48
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	1.66	1.47	1.57	0.49	0.51	0.50
T_6: 75% RDF + PSB	2.60	2.52	2.56	0.39	0.39	0.39
T_7: 75% RDF + FYM @ 2 t ha^{-1}	2.41	2.43	2.42	0.41	0.40	0.40
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	2.30	2.25	2.28	0.42	0.42	0.42
T_9: 50% RDF + PSB	3.13	3.52	3.33	0.36	0.33	0.34
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	2.83	2.98	2.91	0.37	0.35	0.36
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	2.77	2.77	2.77	0.38	0.37	0.38
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	1.78	1.69	1.74	0.46	0.47	0.46
Sem±	***0.40***	***0.82***	***0.46***	**0.03**	**0.08**	**0.04**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Initial value	**1.98**	**2.95**	**-**	**0.38**	**0.43**	**-**

4.5.12 Microbial biomass carbon of soil after harvest (µg g^{-1})

Data regarding soil microbial biomass carbon as influenced by integrated nutrient management is presented in Table 4.24 and graphically plotted in Fig 4.21.

It is apparent that soil microbial biomass carbon (SMBC) varied significantly under different levels of treatment. The treatment T_5 (100 % RDF+ FYM @ 2 tonnes ha^{-1} + PSB) recorded the maximum value of 213.95 µg g^{-1} in 2019 and 215.30 µg g^{-1} in 2020 which is found to be at par with T_4 (100% RDF + FYM @ 2 t ha^{-1}) and they are significantly highest than the rest of the treatment. On the other hand the significantly lowest value was recorded in the control treatment (T_1) with the value of 172.43 µg g^{-1} in 2019 and 170.10 µg g^{-1} in 2020. The content of SMBC in control treatment (T_1) had decreased from its initial status due to lack of external nutrients. Therefore, results of this study showed that the addition of organic amendments integrated with chemical fertilizer increased the SMBC compared to control.

Parewa *et al*. (2014) reported that the increase in soil microbial biomass carbon with increase in doses of chemical fertilizers could be due to increase in microbial population which enhance the formation of root exudates, mucigel soughed off cells and underground roots of previous cut crops, which also play a vital role in increasing soil biomass carbon. Addition of FYM also boosted up the development of micro-flora that ultimately increased the global activity of soil due improvement of hydrothermal regime and supply of large amount of carbon, a major food source for several bacteria and all fungi involved in decomposition (Gautami *et al*., 2015). Long term integrated supply of nutrients increased the SMBC content in two ways- first which is due to higher biomass production and their decomposition with consequent steady nutrient release mainly C and N, and secondly due to constant supply of readily metabolizable organic C and N to support microbial proliferation (Tripura *et al*., 2018; Tao *et*

Table 4.24: Influence of integrated nutrient management on soil microbial biomass carbon and dehydrogenase activity of soil after harvest

	SMBC (µg g^{-1})			DHA (µg TPF g^{-1} h^{-1})		
Treatments	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1: Control	172.43	170.10	171.27	15.92	15.35	15.64
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	197.20	198.01	197.61	25.59	25.98	25.78
T_3: 100% RDF + PSB	200.46	201.48	200.97	26.82	27.30	27.06
T_4: 100% RDF + FYM @ 2 t ha^{-1}	210.71	211.95	211.33	30.27	30.90	30.58
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	213.95	215.30	214.63	31.42	32.18	31.80
T_6: 75% RDF + PSB	187.22	187.54	187.38	21.91	22.10	22.00
T_7: 75% RDF + FYM @ 2 t ha^{-1}	190.67	191.12	190.90	23.14	23.39	23.26
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	193.85	194.46	194.16	24.34	24.67	24.50
T_9: 50% RDF + PSB	178.20	177.15	177.68	18.20	18.07	18.14
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	181.05	180.62	180.84	19.45	19.48	19.47
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	183.95	184.02	183.99	20.69	20.78	20.73
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	203.74	204.90	204.32	28.03	28.60	28.32
Sem±	**2.11**	**2.27**	**1.55**	**0.73**	**0.76**	**0.52**
CD (P=0.05)	**6.18**	**6.65**	**4.41**	**2.14**	**2.21**	**1.50**
Initial value	**177.35**	**185.60**	**-**	**17.50**	**21.65**	**-**

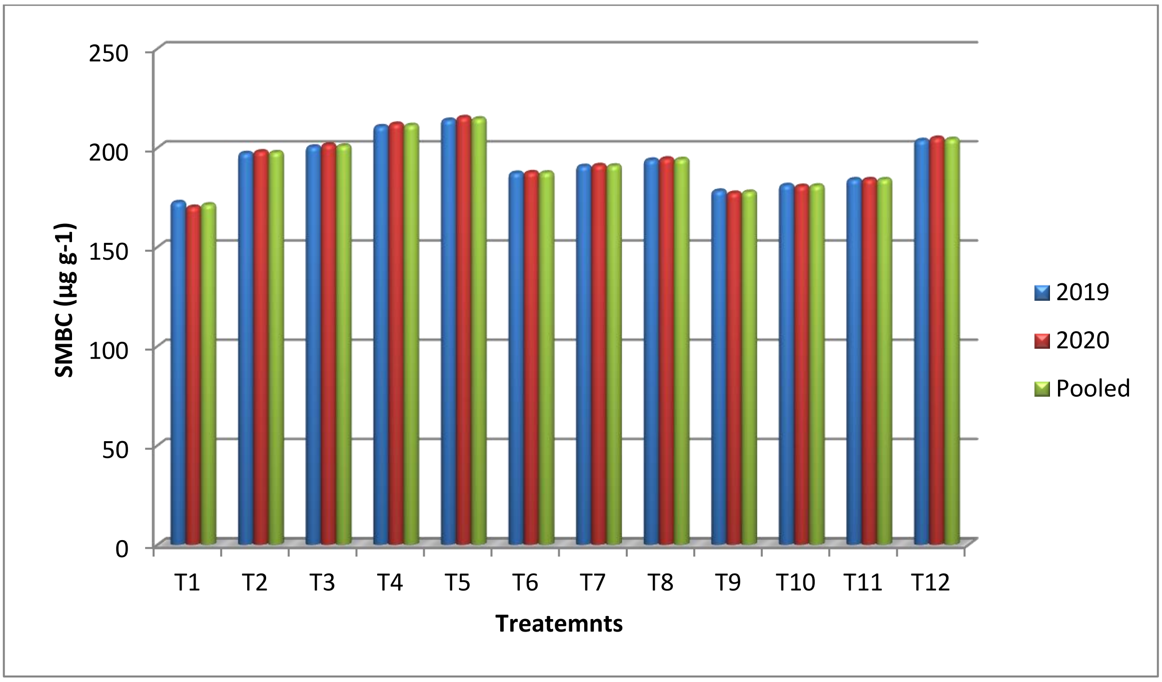

Fig 4.21 Influence of integrated nutrient management on microbial biomass carbon of soil after harvest

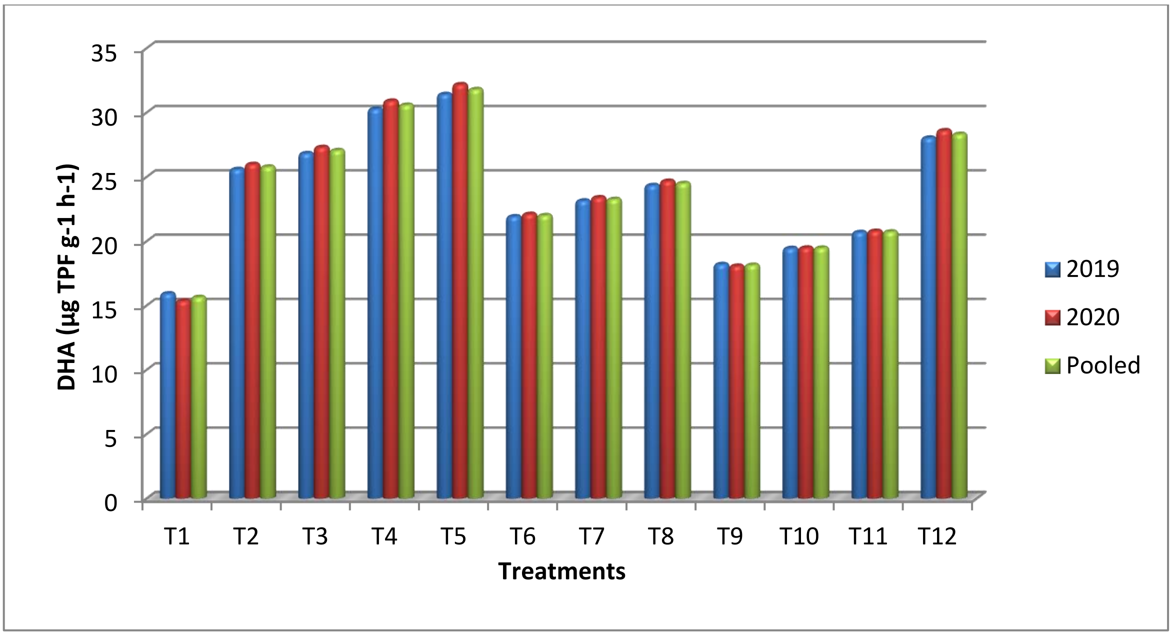

Fig 4.22 Influence of integrated nutrient management on dehydrogenase activity of soil after harvest

al., 2020). Furthermore, application of bio-fertilizers, besides showing their primary effect are also known to produce diverse growth promoting substances that might contribute intense proliferation of microbial growth and augmented MBC (Nath *et al*., 2015). Similar findings were also reported by Kumari *et al*. (2017) where integrated use of inorganic fertilizers along with organic amendments play a dominant role in promoting soil microbial biomass and its activity.

4.5.13 Dehydrogenase activity of soil after harvest (µg TPF g^{-1} h^{-1})

Data on dehydrogenase activity of soil showed a significant effect of different levels of treatments which is presented in Table 4.24 and graphically depicted in Fig 4.22.

The highest dehydrogenase activity was observed in treatment T_5 receiving 100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB with a value of 31.42 µg TPF g^{-1} h^{-1} in 2019 and 32.18 µg TPF g^{-1} h^{-1} in 2020 which is statistically at par with T_4 (100% RDF + FYM @ 2 t ha^{-1}), while significantly lowest value of 15.92 µg TPF g^{-1} h^{-1} in 2019 and 15.35 µg TPF g^{-1} h^{-1} in 2020 was obtained from control treatment (T_1) which decrease in dehydrogenase activity over the first year as there was no external source of nutrients and continuous cropping have led to mining of nutrients.

Dehydrogenase is involved in the respiratory chain of micro organisms and their activities often serve as an index of microbial biomass. Mallikarjun and Maity (2018) reported that the increase in dehydroenase activity in INM treatments might be due to formation of humic acids that enhanced the activity of micro-organisms in soil that ultimately resulted in increase of dehydrogenase activity in soil. Parewa *et al.* (2014) also reported that the increased activity by increasing levels of fertilizer application might be attributed to the fact that inorganic source of nutrient stimulated the activity of microorganisms to utilize the native pool of organic carbon as a source of carbon, which acts as substrate for these enzyme. The applied organic sources were able to get mineralized rapidly in early days of incubation. Hence, there was more mineralization than immobilization which consequently provided sufficient nutrition for the proliferation of microbes and their activities in terms of soil dehydrogenase. Similar observations were noted by Nagendra, 2015.

Bhatt *et al*. (2019) also documented that addition of FYM promotes biological and microbial activities and accelerated the breakdown of organic substances in the added manure, which is known to stimulate the dehydrogenase activity. Furthermore, inoculation of bio-fertilizer enhanced the enzyme activity which may be possibly due to the improvement in the porosity and availability of nutrients (especially Phosphorus) to the plants.

4.6 Economics

Economics of any treatment is the deciding factor in many situations, to judge its applicability in the field condition to recommend farming community to obtain better return with minimum investment in cultivation. It is the final criteria to evaluate the best treatment which is economically sound and can be accepted as viable one. It is calculated on the basis of input and output analysis. The economic gains of the different treatments were calculated to estimate the net returns and cost of cultivation. The cost of cultivation was greatly influenced with various treatments by integrated supply of nutrients. The gross return which is related to the yield of crop and its market price had a striking variance which is accompanied by the cost of cultivation which in turn influenced the overall net return and return per rupee invested.

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

The grain yield and straw yield recorded in respective years was used for profitability calculation. Data presented in Table 4.25 disclosed that the cost of cultivation increased steadily with increased in the rate of fertilizer and

Table 4.25: Influence of integrated nutrient management in direct seeded rice on economics of treatments

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross Return (Rs. ha^{-1})		Net Return (Rs. ha^{-1})		B:C Ratio	
		2019	2020	2019	2020	2019	2020
T_1: Control	26800.00	48815.00	48006.67	22015.00	21206.67	0.82	0.79
T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O)	34406.50	70439.33	70624.00	36032.83	36217.50	1.05	1.05
T_3: 100% RDF + PSB	34486.50	72800.00	73137.00	38313.50	38650.50	1.11	1.12
T_4: 100% RDF + FYM @ 2 t ha^{-1}	37406.50	81484.00	82598.67	44077.50	45192.17	1.18	1.21
T_5: 100% RDF + FYM @ 2 t ha^{-1} + PSB	37486.50	83682.33	84947.67	46195.83	47461.17	1.23	1.27
T_6: 75% RDF + PSB	32584.75	63552.00	63219.67	30967.25	30634.92	0.95	0.94
T_7: 75% RDF + FYM @ 2 t ha^{-1}	35504.75	65971.00	65949.00	30466.25	30444.25	0.86	0.86
T_8: 75% RDF + FYM @ 2 t ha^{-1} + PSB	35584.75	68014.00	68025.67	32429.25	32440.92	0.91	0.91
T_9: 50% RDF + PSB	30683.25	56457.33	55501.33	25774.08	24818.08	0.84	0.81
T_{10}: 50% RDF + FYM @ 2 t ha^{-1}	33603.25	58958.67	58330.33	25355.42	24727.08	0.75	0.74
T_{11}: 50% RDF + FYM @ 2 t ha^{-1} + PSB	33683.25	61100.00	60514.33	27416.75	26831.08	0.81	0.80
T_{12}: SSNM (109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O)	33899.30	74972.33	75611.67	41073.03	41712.37	1.21	1.23

inclusion of FYM along with PSB. Maximum cost of cultivation with a value of Rs. 37486.5 ha^{-1} was recorded in treatment T_5 where 100% RDF + FYM @ 2 t ha^{-1} + PSB was applied closely followed by T_4 treatment (100% RDF + FYM @ 2 t ha^{-1}) in both the years. The result showed that integrated use of inorganic and organic nutrients became costlier as compared to control or lesser rate of fertilizer doses or sole application of fertilizer. The lowest cost of cultivation having a value of Rs. 26800 ha^{-1} was observed in control treatment (T_1) where no nutrient was applied except for the labor charge. Mandal *et al*. (2018) also reported similar findings where cost of cultivation increased with increase in fertilizer quantity.

4.6.2 Gross return (Rs. ha^{-1})

Appraisal of the data pertaining to gross return of the two year experiment revealed that maximum gross return was noted in treatment T_5 where the crop received 100% RDF + FYM @ 2 t ha^{-1} + PSB with the value of Rs. 83682.33 ha^{-1} in 2019 and Rs. 84947.67 ha^{-1} in 2020 followed by T_4 with 100% RDF + FYM @ 2 t ha^{-1}. The lowest gross return of Rs. 48815 ha^{-1} in 2019 and Rs. 48006.67 ha^{-1} in 2020 was recorded in control treatment (T_1) followed by treatment T_9 where the crops received the least amount of fertilizer rate without addition of FYM *i.e.*, 50% RDF + PSB. These results are in conformity with the findings of Patro *et al*. (2011).

4.6.3 Net return (Rs. ha^{-1})

A cursory glance over the data presented in Table 4.25 unveiled that the maximum net return of Rs. 45195.83 ha^{-1} and Rs. 47461.17 ha^{-1} during 2019 and 2020 respectively was noted in treatment T_5 where the crop received 100% RDF + FYM @ 2 t ha^{-1} + PSB respectively, followed by T_4 with 100% RDF + FYM @ 2 t ha^{-1}. The lowest net return was recorded in control treatment (T_1) with the value of Rs. 22015 ha^{-1} in 2019 and Rs. 21206.67 ha^{-1} in 2020 followed by treatment T_9 where the crops received the least amount of fertilizer rate without addition of FYM *i.e*., 50% RDF + PSB. Shinde *et al*. (2017) also reported similar findings.

4.6.4 Benefit:cost ratio

Benefit:cost ratio followed an interesting trend. The crops receiving highest dose of fertilizer *i.e*., 100% RDF (120 kg N ha^{-1} + 40 kg P_2O_5 + 30 kg K_2O) + FYM @ 2 t ha^{-1} + PSB (T_5) paid the highest benefit:cost ratio with the value of 1.23 % in 2019 and 1.27 % followed by T_{12} treatment receiving 109 kg N ha^{-1} + 30 kg P_2O_5 + 46 kg K_2O (SSNM) which could be due to high cost of fertilizer and organic manure with increase in fertilizer quantity. On the other hand, the lowest return per rupee with the value of 0.75 % and 0.74 % was observed in treatment T_{10} (50% RDF + FYM @ 2 t ha^{-1}). The result was similar with Borkar *et al*. (2008) and Mandal *et al*. (2018).

CHAPTER V

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

The present investigation entitled "Influence of integrated nutrient management on performance in direct seeded rice and soil properties in dystrudepts of Nagaland" was carried out to elicit the following objectives:-

1. To study the influence of integrated nutrient management on growth and yield of rice.
2. To study the influence of integrated nutrient management on nutrient content and uptake of rice.
3. To study the influence of integrated nutrient management on soil properties and nutrient status.

Therefore, obtain the above objectives a field investigation was carried out during *kharif* season of 2019 and 2020 at the experimental farm of School of Agricultural Sciences (SAS), Medziphema Campus, Nagaland University. The experiment was laid out in 'Randomized Block Design' consisting of three replications with 12 treatments. The treatment details are:- T_1: Control, T_2: RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O), T_3: 100% RDF +PSB, T_4: 100% RDF + 2 t FYM ha^{-1}, T_5: 100% RDF + 2 t FYM ha^{-1} + PSB, T_6: 75% RDF + PSB, T_7: 75% RDF + 2 t FYM ha^{-1}, T_8: 75 % RDF + 2 t FYM ha^{-1} + PSB, T_9: 50% RDF + PSB, T_{10}: 50% RDF + 2 t FYM ha^{-1}, T_{11}: 50% RDF + 2 t FYM ha^{-1} + PSB and T_{12}: 109 kg ha^{-1} N + 30 kg ha^{-1} P_2O_5 + 46 kg ha^{-1} K_2O (SSNM). The performance of various treatments in direct seeded rice was measured in terms of quantitative expressions. The quantitative indices includes scrutiny of plant height, number of leaves $plant^{-1}$, number of tillers $plant^{-1}$, dry matter accumulation $plant^{-1}$, crop growth rate, relative growth rate, panicle length, number of panicles $plant^{-1}$, number of grains $panicle^{-1}$, test weight, grain yield, straw yield and harvest index. Perusal on physico-chemical properties and enzymatic activities on the available soil after harvest was recorded. Economical analysis was calculated on the basis of input and output analysis to estimate the net returns and cost of cultivation.

The soil of the experimental field was sandy clay loam in texture having a pH of 4.70 in the first trial while 4.85 in the second trial, high in organic carbon with a value of 1.26 % and 1.40 %, cation exchange capacity comprising of 16.75 {cmol (p^+) kg^{-1}} and 19.20 {cmol (p^+) kg^{-1}} during both the years respectively. Initial status of available nitrogen in soil was observed to be low in the first trial with a value of 260.54 kg ha^{-1} while 276.80 kg ha^{-1} was recorded in the second trial which is medium. Available phosphorus in soil initial status was reported to be low in both the years with a value of 16.93 kg ha^{-1} and 20.85 kg ha^{-1}. Available potassium in soil with a value of 133.45 kg ha^{-1} (low) and 142.64 kg ha^{-1} (medium) was observed during both the years of trials respectively. Soil microbial biomass carbon with a value of 177.35 µg g^{-1} and 120.88 µg g^{-1} and dehydrogenase activity with a value of 108.60 µg TPF g^{-1} h^{-1} and 201.46 µg TPF g^{-1} h^{-1} during the investigation of both the years, respectively. Nutrients were applied to crop as per the treatments. Nitrogen, phosphorus and potassium were applied through urea (46 %), single super phosphate (16 %) and muriate of potash (60 %), respectively. One-third dose of nitrogen and full dose of phosphorus and potassium were applied as basal and remaining two-third dose of nitrogen was applied as top dressing by urea in two splits doses which was at tillering stages and panicle initiation stages respectively. Farm yard manure at the rate of 2 tonnes ha^{-1} was applied to the field one month prior to sowing. Seeds were coated prior to sowing with phosphate solubilizing bacteria such as *Phosphotika* which was further dried in the shades for 15 minutes after which it was sown immediately to the plots as per the treatments.

The salient features thus recorded from the study are summarized below:-

5.1. Growth attributes

The growth parameters were measured in terms of plant height, number of leaves plant^{-1}, number of tillers plant^{-1}, dry matter accumulation plant^{-1}, crop growth rate and relative growth rate at 30 DAS, 60 DAS and 90 DAS respectively.

The growth parameters differed significantly due to the application of nutrients in an integrated manner. Significantly, highest plant height, number of leaves plant^{-1}, number of tillers plant^{-1} and dry matter accumulation plant^{-1} was recorded in T_5 treatment (100% RDF + 2 t FYM ha^{-1} + PSB) with pooled value of 130.13 cm, 45.93, 8.59 and 40.06 g plant^{-1} at 90 DAS respectively which is found to be at par with T_4 treatment (100% RDF + 2 t FYM ha^{-1}) where they are found to be significantly superior than the rest of the treatments. On the other hand, significantly lowest value of the growth attributes was noticed in the T_1 (control) treatment in both the years of experimentation where there was no external source of any nutrients. The data pertaining to crop growth rate showed that it was significantly influenced due to various treatments of integrated nutrient management practices at 30-60 DAS, where significantly highest value was noticed in T_5 treatment (100% RDF + 2 t FYM ha^{-1} + PSB) which is at par with T_4 treatment (100% RDF + 2 t FYM ha^{-1}) while the lowest value was observed in the control (T_1) treatment. On the other hand, no significant outcome was observed after 60 days of sowing. There was no significant effect on relative growth rate in either of the years during the years of investigation.

5.2. Yield attributes

The outcome of the yield attributing characters disclosed that there was significant variation among the treatments according to the different levels of nutrients applied. Maximum panicle length, number of panicles plant^{-1} and number of grains panicle^{-1} was recorded in the treatment receiving the highest RDF in conjunction with FYM and PSB i.e., T_5 with 100 % RDF + FYM @ 2 tonnes ha^{-1} + PSB which procured the pooled value of 26.08 cm, 6.69 and 254.47 of the year 2019 and 2020, respectively where it is found to be at par with T_4 (100% RDF + 2 t FYM ha^{-1}) which is significantly reported to be higher than all the other treatments. Conversely, the significantly lowest value was recorded in T_1 (control) treatment followed by T_9 treatment (50% RDF + PSB). The test weight (1000 grain weight) of rice varied from 24.50 g to 25.71 g in 2019 and 24.45 g to 25.80 g in 2020. However, all the treatments failed to show any significant variation during both the years of experimentation.

5.3. Yield

Critical observation of the data recorded on grain yield (q ha^{-1}) and straw yield (q ha^{-1}) revealed that there was significant effect with various dose of fertilizers applied with organic manures and PSB in an integrated manner. On the basis of pooled data (2019 & 2020) maximum grain yield (39.15 q ha^{-1}) and straw yield (60.48 q ha^{-1}) were recorded with the treatment T_5 (100% RDF + FYM @ 2 tonnes ha^{-1} + PSB). This treatment is at par with T_4 (100% RDF + FYM @ 2 tonnes ha^{-1}) which was significant over all the treatments followed by T_{12} treatment {109 kg N ha^{-1} + 30 kg P_2O_5 ha^{-1} + 46 kg K_2O ha^{-1} (SSNM)}. On the other hand, significantly lowest value was recorded in the control treatment (T_1) where no external source of nutrient was applied. Furthermore, observation noticed form the trials revealed that harvest index showed some variation according to various treatments but could not reached the level of significance.

5.4. Nutrient content in grain and straw

Nutrient content in grain and straw of direct seeded rice under different treatment combination disclosed that there was significant variation among various treatments. Maximum value of nitrogen, phosphorus and potassium content in grain and straw of rice was recorded in treatment T_5 (100% RDF + FYM @ 2 tonnes ha^{-1} + PSB) with the pooled value of 1.26 %, 0.36 % and 0.27 % in grains and 0.71 %, 0.14 % and 1.32 % in straw during both the years of investigation respectively where it is noted to be at par with treatment T_4 (100% RDF + FYM @ 2 tonnes ha^{-1}) which is significantly higher than the rest of the treatments while minimum value of nutrient content in grain and straw was recorded in control treatment (T_1) due to lack of nutrients. The S content in grains and straw of direct seeded rice was not influenced significantly by the combined use of fertilizers, farm yard manure and bio-fertilizers.

5.5. Nutrient uptake by grain and straw

Nutrients uptake in grain and straw of rice was significantly increased when level of nutrients (NPK) increased up to 100% RDF using fertilizer alone or combination with organic manures (FYM) and bio-fertilizer. Maximum nitrogen, phosphorus and potassium uptake by grain and straw was recorded in T_5 (100% RDF + FYM @ 2 t ha^{-1} + PSB) followed by T_4 (100% RDF + FYM @ 2 tonnes ha^{-1}) which showed parity with each other and significantly higher than the rest of the treatments. The significantly minimum uptake was noted in the control treatment (T_1). Data pertaining to sulphur uptake in grain and straw of direct seeded rice indicated that the influence of integrated nutrient management did not show any significant effect on their uptake during two years of study.

5.6. Soil fertility status after harvest

As per the experiment examined, it can be summarized that integrated nutrient management practices certainly improved the fertility status of the soil over initial values and control. No significant variation was noted on soil pH however marginal increase was noticed which might be due to moderating effect of organic manures as it decreases the activity of exchangeable Al^{3+} ions in soil solution. Organic carbon was increased by 21.33 %. The significant build up of cation exchange capacity was also observed which could be due to the formation of more humus as a result of the decomposition of organic matter and thus maintained higher values than control. The available NPK in soil after harvest was increased by 10.77 %, 35.32 % and 10.07 % during both the years of investigation respectively. Application of nutrients in integrated manner performed as a source of energy, thus, organic manures enhanced the availability of nutrients and sustained the soil fertility status. PSB are critical for the transfer of phosphorus from poorly available soil pools to plant available forms and are important for maintaining phosphorus in readily available pools of soil, therefore a significant increase in available phosphorus was observed.

5.7. Soil biological status after the harvest

The soil microbial biomass carbon (SMBC) and dehydrogenase activity showed a significant effect under different levels of treatment with the maximum value of 214.63 µg g^{-1} and 31.80 µg TPF g^{-1} h^{-1} in treatment T_5 (100 % RDF+ FYM @ 2 tonnes ha^{-1} + PSB) respectively, which is found to be at par with T_4 (100% RDF + FYM @ 2 tonnes ha^{-1}) during both the years of experimentation and they are significantly highest than the rest of the treatment. On the other hand the significantly lowest value was recorded in the control treatment (T_1). The applied organic sources were able to get mineralized rapidly in early days of incubation. Hence, there was more mineralization than immobilization which consequently provided sufficient nutrition for the proliferation of microbes and their activities in terms of soil dehydrogenase. Furthermore, inoculation of bio-fertilizer enhanced the enzyme activity which may be possibly due to the improvement in soil porosity and availability of nutrients (especially P) to the plants.

5.8. Economics of the treatments

A cursory glance over the data on economical analysis unveiled that the maximum cost of cultivation, gross return and net return was noted in treatment T_5 where the crop received 100% RDF + FYM @ 2 t ha^{-1} + PSB followed by T_4 with 100% RDF + FYM @ 2 t ha^{-1}. The significantly lowest value was recorded in control treatment (T_1) followed by treatment T_9 where the crops received the least amount of fertilizer rate without addition of FYM *i.e.*, 50% RDF + PSB. Benefit:cost ratio followed an interesting trend where it was noted that the crops receiving highest dose of fertilizer *i.e.*, 100% RDF (120 kg ha^{-1} N + 40 kg ha^{-1} P_2O_5 + 30 kg ha^{-1} K_2O) + FYM @ 2 t ha^{-1} + PSB (T_5) paid the highest benefit:cost ratio followed by T_{12} treatment receiving 109 kg ha^{-1} N + 30 kg P_2O_5 ha^{-1} + 46 kg K_2O ha^{-1} (SSNM) which could be due to high cost of fertilizer and organic manure with increase in fertilizer quantity. On the other hand, the lowest B:C ratio was observed in control treatment (T_1).

Conclusion

As per the investigation studied, it can be concluded that application of 100 % RDF + 2 tonnes ha^{-1} FYM + PSB not only boosted the growth, yield and yield attributing characters but also had positive impact on soil physico-chemical and biological characteristics. The higher yield procured with integrated usage of FYM, PSB and inorganic fertilizers was attributed to enhanced the nutrient availability in soil and nutrient content in rice plant resulting in longer panicle length, greater number of panicle plant^{-1}, number of grains panicle^{-1}, test weight, grain yield, straw yield and harvest index. The available nutrient status of the soil after harvest of the crop disclosed significant increase in available NPK and CEC of the soil where nutrient was applied in an integrated manner. Marginal increase was noted in the soil pH with higher levels RDF along with FYM and PSB.

Since rice is an exhaustive crop, poor soil fertility management and moisture stress could become limiting factor for sustainable production. According to the outcome of many researchers, soil productivity and health was more sustainable with integrated application of farmyard manure and inorganic fertilizers rather than with the use of inorganic fertilizers alone or organic fertilizer alone. Therefore, integrated nutrient management practices emerged as a solution to degraded soil fertility and sustainable crop production. Hence, it is recommended for farmer that judicious application of inorganic fertilizers in combination with farm yard manure and phosphate solubilizing bacteria is in dire need to nutrify the soil and crop for better quality which would create a good environment for growth and development of the rice crop as well as balance enzymatic activity.

However, these results provide some information on integrated nutrient management on rice. It is suggested that the experiment may be repeated at different sites for at least one or two years with more specific treatment combination to get clear-cut recommendation for farmers.

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APPENDICES

Appendix - A

ANOVA-I (a): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on plant height at 30 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	1.38	0.69	0.08	3.44	NS
Treatment	11	2426.57	220.60	25.67	2.26	S
Error	22	189.07	8.59			
Total	35	2617.02				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	16.83	8.42	0.76	3.44	NS
Treatment	11	3201.45	291.04	26.42	2.26	S
Error	22	242.33	11.01			
Total	35	3460.62				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	1.51	1.51	0.15	4.06	NS
Replication	4	18.21	4.55	0.46	2.58	NS
Treatment	10	5599.59	559.96	57.11	2.05	S
Years x Treatment	10	28.43	2.84	0.29	2.05	NS
Error	44	431.40	9.80			
Total	69	6079.15				

ANOVA-I (b): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on plant height at 60 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.04	0.02	0.00	3.44	NS
Treatment	11	3230.92	293.72	16.52	2.26	S
Error	22	391.07	17.78			
Total	35	3622.03				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.27	0.14	0.01	3.44	NS
Treatment	11	3727.70	338.88	17.48	2.26	S
Error	22	426.44	19.38			
Total	35	4154.41				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	5.69	5.69	0.31	4.06	NS
Replication	4	0.32	0.08	0.00	2.58	NS
Treatment	10	6949.41	694.94	37.40	2.05	S
Years x Treatment	10	9.21	0.92	0.05	2.05	NS
Error	44	817.50	18.58			
Total	69	7782.13				

ANOVA-I (c): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on plant height at 90 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.00	3.44	NS
Treatment	11	3660.91	332.81	17.30	2.26	S
Error	22	423.12	19.23			
Total	35	4084.03				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.09	0.05	0.00	3.44	NS
Treatment	11	4340.44	394.59	19.42	2.26	S
Error	22	446.99	20.32			
Total	35	4787.52				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	1.68	1.68	0.09	4.06	NS
Replication	4	0.09	0.02	0.00	2.58	NS
Treatment	10	7986.07	798.61	40.38	2.05	S
Years x Treatment	10	15.28	1.53	0.08	2.05	NS
Error	44	870.11	19.78			
Total	69	8873.24				

ANOVA-II (a): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on number of leaves plant^{-1} at 30 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	2.91	1.46	2.63	3.44	NS
Treatment	11	167.33	15.21	27.45	2.26	S
Error	22	12.19	0.55			
Total	35	182.43				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	1.55	0.77	0.88	3.44	NS
Treatment	11	232.89	21.17	24.06	2.26	S
Error	22	19.36	0.88			
Total	35	253.79				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.78	0.78	1.08	4.06	NS
Replication	4	4.46	1.11	1.55	2.58	NS
Treatment	10	397.45	39.75	55.42	2.05	S
Years x Treatment	10	2.76	0.28	0.39	2.05	NS
Error	44	31.56	0.72			
Total	69	437.00				

ANOVA-II (b): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on number of leaves plant^{-1} at 60 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	8.63	4.31	1.39	3.44	NS
Treatment	11	809.13	73.56	23.66	2.26	S
Error	22	68.38	3.11			
Total	35	886.14				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	4.82	2.41	0.74	3.44	NS
Treatment	11	1125.17	102.29	31.24	2.26	S
Error	22	72.03	3.27			
Total	35	1202.01				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.16	0.16	0.05	4.06	NS
Replication	4	13.44	3.36	1.05	2.58	NS
Treatment	10	1920.70	192.07	60.19	2.05	S
Years x Treatment	10	13.60	1.36	0.43	2.05	NS
Error	44	140.41	3.19			
Total	69	2088.31				

ANOVA-II (c): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on number of leaves plant^{-1} at 90 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.25	0.13	0.04	3.44	NS
Treatment	11	755.71	68.70	20.51	2.26	S
Error	22	73.69	3.35			
Total	35	829.65				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.02	0.01	0.00	3.44	NS
Treatment	11	926.79	84.25	24.11	2.26	S
Error	22	76.88	3.49			
Total	35	1003.69				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.53	0.53	0.15	4.06	NS
Replication	4	0.28	0.07	0.02	2.58	NS
Treatment	10	1677.88	167.79	49.03	2.05	S
Years x Treatment	10	4.61	0.46	0.13	2.05	NS
Error	44	150.56	3.42			
Total	69	1833.86				

ANOVA-III (a): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on number of tillers plant^{-1} at 30 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.01	3.44	NS
Treatment	11	11.77	1.07	12.41	2.26	S
Error	22	1.90	0.09			
Total	35	13.67				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.02	0.01	0.09	3.44	NS
Treatment	11	15.26	1.39	12.34	2.26	S
Error	22	2.47	0.11			
Total	35	17.75				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.01	0.01	0.07	4.06	NS
Replication	4	0.02	0.01	0.05	2.58	NS
Treatment	10	26.91	2.69	27.10	2.05	S
Years x Treatment	10	0.12	0.01	0.12	2.05	NS
Error	44	4.37	0.10			
Total	69	31.43				

ANOVA-III (b): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on number of tillers plant^{-1} at 60 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.03	0.01	0.12	3.44	NS
Treatment	11	47.01	4.27	35.97	2.26	S
Error	22	2.61	0.12			
Total	35	49.65				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.00	3.44	NS
Treatment	11	52.04	4.73	35.72	2.26	S
Error	22	2.91	0.13			
Total	35	54.95				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.31	0.31	2.44	4.06	NS
Replication	4	0.03	0.01	0.05	2.58	NS
Treatment	10	98.96	9.90	78.78	2.05	S
Years x Treatment	10	0.09	0.01	0.07	2.05	NS
Error	44	5.53	0.13			
Total	69	104.91				

ANOVA-III (c): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on number of tillers plant^{-1} at 90 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.01	0.01	0.05	3.44	NS
Treatment	11	49.94	4.54	35.61	2.26	S
Error	22	2.80	0.13			
Total	35	52.75				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.21	0.10	0.76	3.44	NS
Treatment	11	56.83	5.17	37.67	2.26	S
Error	22	3.02	0.14			
Total	35	60.05				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.04	0.04	0.33	4.06	NS
Replication	4	0.22	0.05	0.41	2.58	NS
Treatment	10	106.64	10.66	80.59	2.05	S
Years x Treatment	10	0.13	0.01	0.09	2.05	NS
Error	44	5.82	0.13			
Total	69	112.85				

ANOVA-IV (a): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on dry matter accumulation plant^{-1} at 30 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.21	3.44	NS
Treatment	11	4.20	0.38	33.88	2.26	S
Error	22	0.25	0.01			
Total	35	4.46				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.01	0.00	0.17	3.44	NS
Treatment	11	5.78	0.53	35.55	2.26	S
Error	22	0.33	0.01			
Total	35	6.11				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.01	0.01	0.70	4.06	NS
Replication	4	0.01	0.00	0.19	2.58	NS
Treatment	10	9.92	0.99	76.11	2.05	S
Years x Treatment	10	0.06	0.01	0.50	2.05	NS
Error	44	0.57	0.01			
Total	69	10.58				

ANOVA-IV (b): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on dry matter accumulation plant^{-1} at 60 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.03	0.02	0.02	3.44	NS
Treatment	11	395.57	35.96	41.50	2.26	S
Error	22	19.06	0.87			
Total	35	414.67				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.59	0.29	0.29	3.44	NS
Treatment	11	533.47	48.50	47.84	2.26	S
Error	22	22.30	1.01			
Total	35	556.35				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.97	0.97	1.03	4.06	NS
Replication	4	0.62	0.16	0.16	2.58	NS
Treatment	10	923.48	92.35	98.23	2.05	S
Years x Treatment	10	5.56	0.56	0.59	2.05	NS
Error	44	41.37	0.94			
Total	69	971.99				

ANOVA-IV (c): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on dry matter accumulation plant^{-1} at 90 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.15	0.07	0.03	3.44	NS
Treatment	11	670.18	60.93	20.71	2.26	S
Error	22	64.73	2.94			
Total	35	735.06				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.00	3.44	NS
Treatment	11	880.47	80.04	24.34	2.26	S
Error	22	72.36	3.29			
Total	35	952.83				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	2.08	2.08	0.67	4.06	NS
Replication	4	0.15	0.04	0.01	2.58	NS
Treatment	10	1543.26	154.33	49.53	2.05	S
Years x Treatment	10	7.40	0.74	0.24	2.05	NS
Error	44	137.08	3.12			
Total	69	1689.97				

ANOVA-V (a): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on crop growth rate at 30-60 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.14	0.07	0.04	3.44	NS
Treatment	11	884.43	80.40	41.76	2.26	S
Error	22	42.36	1.93			
Total	35	926.93				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.26	0.13	0.06	3.44	NS
Treatment	11	1189.98	108.18	49.96	2.26	S
Error	22	47.64	2.17			
Total	35	1237.87				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	2.19	2.19	1.07	4.06	**NS**
Replication	4	0.40	0.10	0.05	2.58	**NS**
Treatment	10	2062.03	206.20	100.81	2.05	**S**
Years x Treatment	10	12.38	1.24	0.61	2.05	**NS**
Error	44	90.00	2.05			
Total	69	2167.00				

ANOVA-V (b): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on crop growth rate at 60-90 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.89	0.45	0.02	3.44	NS
Treatment	11	112.58	10.23	0.53	2.26	NS
Error	22	423.02	19.23			
Total	35	536.49				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	1.89	0.94	0.05	3.44	NS
Treatment	11	130.06	11.82	0.60	2.26	NS
Error	22	433.67	19.71			
Total	35	565.62				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.58	0.58	0.03	4.06	NS
Replication	4	2.78	0.70	0.04	2.58	NS
Treatment	10	240.95	24.10	1.24	2.05	NS
Years x Treatment	10	1.69	0.17	0.01	2.05	NS
Error	44	856.69	19.47			
Total	69	1102.70				

ANOVA-VI (a): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on relative growth rate at 30-60 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.05	3.44	NS
Treatment	11	0.00	0.00	0.32	2.26	NS
Error	22	0.00	0.00			
Total	35	0.00				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.01	3.44	NS
Treatment	11	0.00	0.00	0.08	2.26	NS
Error	22	0.00	0.00			
Total	35	0.00				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.00	0.00	0.04	4.06	NS
Replication	4	0.00	0.00	0.03	2.58	NS
Treatment	10	0.00	0.00	0.22	2.05	NS
Years x Treatment	10	0.00	0.00	0.19	2.05	NS
Error	44	0.00	0.00			
Total	69	0.00				

ANOVA-VI (b): Analysis of variance as influenced by integrated nutrient management in direct seeded rice on relative growth rate at 60-90 DAS

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.00	3.44	NS
Treatment	11	0.00	0.00	0.78	2.26	NS
Error	22	0.00	0.00			
Total	35	0.00				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.01	3.44	NS
Treatment	11	0.00	0.00	1.09	2.26	NS
Error	22	0.00	0.00			
Total	35	0.00				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.00	0.00	0.00	4.06	NS
Replication	4	0.00	0.00	0.00	2.58	NS
Treatment	10	0.00	0.00	2.02	2.05	NS
Years x Treatment	10	0.00	0.00	0.06	2.05	NS
Error	44	0.00	0.00			
Total	69	0.00				

ANOVA-VII: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on panicle length

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.00	3.44	NS
Treatment	11	41.29	3.75	16.60	2.26	S
Error	22	4.97	0.23			
Total	35	46.27				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.07	0.03	0.12	3.44	NS
Treatment	11	50.19	4.56	15.95	2.26	S
Error	22	6.30	0.29			
Total	35	56.56				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.00	0.00	0.00	4.06	NS
Replication	4	0.07	0.02	0.07	2.58	NS
Treatment	10	91.26	9.13	35.63	2.05	S
Years x Treatment	10	0.22	0.02	0.09	2.05	NS
Error	44	11.27	0.26			
Total	69	102.82				

ANOVA-VIII: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on number of panicle plant^{-1}

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.01	0.00	0.04	3.44	NS
Treatment	11	16.71	1.52	18.03	2.26	S
Error	22	1.85	0.08			
Total	35	18.58				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.01	0.00	0.03	3.44	NS
Treatment	11	27.14	2.47	25.16	2.26	S
Error	22	2.16	0.10			
Total	35	29.30				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.11	0.11	1.17	4.06	NS
Replication	4	0.01	0.00	0.03	2.58	NS
Treatment	10	43.20	4.32	47.39	2.05	S
Years x Treatment	10	0.65	0.07	0.71	2.05	NS
Error	44	4.01	0.09			
Total	69	47.99				

ANOVA-IX: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on number of grains panicle^{-1}

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	8.70	4.35	0.08	3.44	NS
Treatment	11	9677.68	879.79	16.91	2.26	S
Error	22	1144.93	52.04			
Total	35	10831.31				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.31	0.16	0.00	3.44	NS
Treatment	11	10986.38	998.76	14.34	2.26	S
Error	22	1532.11	69.64			
Total	35	12518.81				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	1.85	1.85	0.03	4.06	NS
Replication	4	9.02	2.25	0.04	2.58	NS
Treatment	10	20638.46	2063.85	33.92	2.05	S
Years x Treatment	10	25.60	2.56	0.04	2.05	NS
Error	44	2677.04	60.84			
Total	69	23351.97				

ANOVA-X: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on test weight

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.00	3.44	NS
Treatment	11	5.78	0.53	0.87	2.26	NS
Error	22	13.37	0.61			
Total	35	19.15				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.44	0.22	0.32	3.44	NS
Treatment	11	6.39	0.58	0.83	2.26	NS
Error	22	15.42	0.70			
Total	35	22.25				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.05	0.05	0.08	4.06	NS
Replication	4	0.44	0.11	0.17	2.58	NS
Treatment	10	12.15	1.21	1.86	2.05	NS
Years x Treatment	10	0.02	0.00	0.00	2.05	NS
Error	44	28.78	0.65			
Total	69	41.45				

ANOVA-XI: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on grain yield

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	12.20	6.10	2.26	3.44	**NS**
Treatment	11	777.28	70.66	26.23	2.26	**S**
Error	22	59.27	2.69			
Total	35	848.75				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	14.26	7.13	2.33	3.44	**NS**
Treatment	11	888.26	80.75	26.44	2.26	**S**
Error	22	67.19	3.05			
Total	35	969.71				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.00	0.00	0.00	4.06	**NS**
Replication	4	26.46	6.61	2.30	2.58	**NS**
Treatment	10	1663.57	166.36	57.88	2.05	**S**
Years x Treatment	10	1.97	0.20	0.07	2.05	**NS**
Error	44	126.46	2.87			
Total	69	1818.46				

ANOVA-XII: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on straw yield

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	26.36	13.18	1.98	3.44	NS
Treatment	11	920.16	83.65	12.56	2.26	S
Error	22	146.53	6.66			
Total	35	1093.04				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	7.16	3.58	0.49	3.44	NS
Treatment	11	1055.55	95.96	13.10	2.26	S
Error	22	161.13	7.32			
Total	35	1223.85				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.22	0.22	0.03	4.06	NS
Replication	4	33.52	8.38	1.20	2.58	NS
Treatment	10	1973.30	197.33	28.22	2.05	S
Years x Treatment	10	2.41	0.24	0.03	2.05	NS
Error	44	307.66	6.99			
Total	69	2317.11				

ANOVA-XIII: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on harvest index

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.92	0.46	0.11	3.44	NS
Treatment	11	54.47	4.95	1.15	2.26	NS
Error	22	94.68	4.30			
Total	35	150.08				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	13.86	6.93	0.91	3.44	NS
Treatment	11	65.47	5.95	0.78	2.26	NS
Error	22	166.81	7.58			
Total	35	246.15				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.18	0.18	0.03	4.06	NS
Replication	4	14.79	3.70	0.62	2.58	NS
Treatment	10	119.64	11.96	2.01	2.05	NS
Years x Treatment	10	0.31	0.03	0.01	2.05	NS
Error	44	261.50	5.94			
Total	69	396.41				

ANOVA-XIV: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on nitrogen content in grain

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	0.43	3.44	NS
Treatment	11.00	0.06	0.01	25.56	2.26	S
Error	22.00	0.01	0.00			
Total	35.00	0.07				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	0.49	3.44	NS
Treatment	11.00	0.07	0.01	23.87	2.26	S
Error	22.00	0.01	0.00			
Total	35.00	0.08				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1.00	0.00	0.00	0.25	4.06	NS
Replication	4.00	0.00	0.00	0.46	2.58	NS
Treatment	10.00	0.14	0.01	54.14	2.05	S
Years x Treatment	10.00	0.00	0.00	0.06	2.05	NS
Error	44.00	0.01	0.00			
Total	69.00	0.15				

ANOVA-XV: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on nitrogen content in straw

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	1.26	3.44	NS
Treatment	11.00	0.05	0.00	31.04	2.26	S
Error	22.00	0.00	0.00			
Total	35.00	0.05				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	1.18	3.44	NS
Treatment	11.00	0.06	0.01	42.35	2.26	S
Error	22.00	0.00	0.00			
Total	35.00	0.06				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1.00	0.00	0.00	0.28	4.06	NS
Replication	4.00	0.00	0.00	1.22	2.58	NS
Treatment	10.00	0.10	0.01	80.04	2.05	S
Years x Treatment	10.00	0.00	0.00	0.35	2.05	NS
Error	44.00	0.01	0.00			
Total	69.00	0.11				

ANOVA-XVI: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on phosphorus content in grain

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	1.75	3.44	NS
Treatment	11.00	0.02	0.00	44.86	2.26	S
Error	22.00	0.00	0.00			
Total	35.00	0.02				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	1.93	3.44	NS
Treatment	11.00	0.03	0.00	84.35	2.26	S
Error	22.00	0.00	0.00			
Total	35.00	0.03				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1.00	0.00	0.00	0.66	4.06	NS
Replication	4.00	0.00	0.00	1.83	2.58	NS
Treatment	10.00	0.05	0.01	135.11	2.05	S
Years x Treatment	10.00	0.00	0.00	1.21	2.05	NS
Error	44.00	0.00	0.00			
Total	69.00	0.06				

ANOVA-XVII: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on phosphorus content in straw

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	1.56	3.44	NS
Treatment	11.00	0.00	0.00	37.98	2.26	S
Error	22.00	0.00	0.00			
Total	35.00	0.00				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	3.01	3.44	NS
Treatment	11.00	0.01	0.00	57.13	2.26	S
Error	22.00	0.00	0.00			
Total	35.00	0.01				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1.00	0.00	0.00	3.08	4.06	NS
Replication	4.00	0.00	0.00	2.38	2.58	NS
Treatment	10.00	0.01	0.00	104.47	2.05	S
Years x Treatment	10.00	0.00	0.00	3.02	2.05	S
Error	44.00	0.00	0.00			
Total	69.00	0.01				

ANOVA-XVIII: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on potassium content in grain

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	2.97	3.44	NS
Treatment	11.00	0.01	0.00	51.90	2.26	S
Error	22.00	0.00	0.00			
Total	35.00	0.01				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	1.33	3.44	NS
Treatment	11.00	0.01	0.00	48.09	2.26	S
Error	22.00	0.00	0.00			
Total	35.00	0.01				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1.00	0.00	0.00	1.05	4.06	NS
Replication	4.00	0.00	0.00	1.99	2.58	NS
Treatment	10.00	0.01	0.00	108.45	2.05	S
Years x Treatment	10.00	0.00	0.00	0.75	2.05	NS
Error	44.00	0.00	0.00			
Total	69.00	0.01				

ANOVA-XIX: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on potassium content in straw

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	0.54	3.44	NS
Treatment	11.00	0.15	0.01	44.88	2.26	S
Error	22.00	0.01	0.00			
Total	35.00	0.16				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	0.78	3.44	NS
Treatment	11.00	0.17	0.02	41.61	2.26	S
Error	22.00	0.01	0.00			
Total	35.00	0.18				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1.00	0.00	0.00	0.10	4.06	NS
Replication	4.00	0.00	0.00	0.67	2.58	NS
Treatment	10.00	0.32	0.03	94.78	2.05	S
Years x Treatment	10.00	0.00	0.00	0.06	2.05	NS
Error	44.00	0.01	0.00			
Total	69.00	0.34				

ANOVA-XX: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on sulphur content in grain

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	0.06	3.44	NS
Treatment	11.00	0.04	0.00	0.89	2.26	NS
Error	22.00	0.08	0.00			
Total	35.00	0.12				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	0.14	3.44	NS
Treatment	11.00	0.05	0.00	0.92	2.26	NS
Error	22.00	0.10	0.00			
Total	35.00	0.15				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1.00	0.00	0.00	0.00	4.06	NS
Replication	4.00	0.00	0.00	0.11	2.58	NS
Treatment	10.00	0.08	0.01	1.97	2.05	NS
Years x Treatment	10.00	0.00	0.00	0.04	2.05	NS
Error	44.00	0.18	0.00			
Total	69.00	0.27				

ANOVA-XXI: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on sulphur content in straw

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	0.44	3.44	NS
Treatment	11.00	0.01	0.00	0.18	2.26	NS
Error	22.00	0.08	0.00			
Total	35.00	0.10				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.00	0.00	0.00	0.00	3.44	NS
Treatment	11.00	0.01	0.00	0.30	2.26	NS
Error	22.00	0.08	0.00			
Total	35.00	0.09				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1.00	0.00	0.00	0.00	4.06	NS
Replication	4.00	0.00	0.00	0.23	2.58	NS
Treatment	10.00	0.02	0.00	0.52	2.05	NS
Years x Treatment	10.00	0.00	0.00	0.01	2.05	NS
Error	44.00	0.16	0.00			
Total	69.00	0.18				

ANOVA-XXII: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on nitrogen uptake by grain

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	7.37	3.69	1.06	3.44	NS
Treatment	11	1682.22	152.93	43.90	2.26	S
Error	22	76.64	3.48			
Total	35	1766.23				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	10.20	5.10	1.31	3.44	NS
Treatment	11	1927.12	175.19	45.15	2.26	S
Error	22	85.37	3.88			
Total	35	2022.69				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.14	0.14	0.04	4.06	NS
Replication	4	17.57	4.39	1.19	2.58	NS
Treatment	10	3604.97	360.50	97.91	2.05	S
Years x Treatment	10	4.37	0.44	0.12	2.05	NS
Error	44	162.01	3.68			
Total	69	3789.06				

ANOVA-XXIII: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on nitrogen uptake by straw

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	7.03	3.52	0.74	3.44	NS
Treatment	11	925.76	84.16	17.68	2.26	S
Error	22	104.73	4.76			
Total	35	1037.53				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	4.30	2.15	0.44	3.44	NS
Treatment	11	1105.95	100.54	20.72	2.26	S
Error	22	106.73	4.85			
Total	35	1216.98				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.48	0.48	0.10	4.06	NS
Replication	4	11.34	2.83	0.59	2.58	NS
Treatment	10	2027.54	202.75	42.19	2.05	S
Years x Treatment	10	4.16	0.42	0.09	2.05	NS
Error	44	211.46	4.81			
Total	69	2254.99				

ANOVA-XXIV: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on phosphorus uptake by grain

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.24	0.12	0.26	3.44	NS
Treatment	11	181.02	16.46	35.52	2.26	S
Error	22	10.19	0.46			
Total	35	191.46				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.30	0.15	0.29	3.44	NS
Treatment	11	227.52	20.68	40.75	2.26	S
Error	22	11.17	0.51			
Total	35	238.98				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.09	0.09	0.18	4.06	NS
Replication	4	0.54	0.13	0.28	2.58	NS
Treatment	10	407.11	40.71	83.87	2.05	S
Years x Treatment	10	1.43	0.14	0.29	2.05	NS
Error	44	21.36	0.49			
Total	69	430.53				

ANOVA-XXV: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on phosphorus uptake by straw

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.84	0.42	2.92	3.44	NS
Treatment	11	45.46	4.13	28.58	2.26	S
Error	22	3.18	0.14			
Total	35	49.49				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.01	0.01	0.03	3.44	NS
Treatment	11	69.77	6.34	33.89	2.26	S
Error	22	4.12	0.19			
Total	35	73.90				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.21	0.21	1.28	4.06	NS
Replication	4	0.86	0.21	1.29	2.58	NS
Treatment	10	113.91	11.39	68.67	2.05	S
Years x Treatment	10	1.32	0.13	0.80	2.05	NS
Error	44	7.30	0.17			
Total	69	123.60				

ANOVA-XXVI: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on potassium uptake by grain

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.01	3.44	NS
Treatment	11	85.76	7.80	35.70	2.26	S
Error	22	4.80	0.22			
Total	35	90.57				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.01	0.01	0.03	3.44	NS
Treatment	11	102.73	9.34	38.70	2.26	S
Error	22	5.31	0.24			
Total	35	108.06				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.03	0.03	0.13	4.06	NS
Replication	4	0.02	0.00	0.02	2.58	NS
Treatment	10	188.10	18.81	81.84	2.05	S
Years x Treatment	10	0.39	0.04	0.17	2.05	NS
Error	44	10.11	0.23			
Total	69	198.65				

ANOVA-XXVII: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on potassium uptake by straw

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	32.37	16.19	1.47	3.44	NS
Treatment	11	3214.17	292.20	26.59	2.26	S
Error	22	241.80	10.99			
Total	35	3488.34				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.01	0.00	0.00	3.44	NS
Treatment	11	3637.75	330.70	26.32	2.26	S
Error	22	276.39	12.56			
Total	35	3914.15				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.93	0.93	0.08	4.06	NS
Replication	4	32.38	8.09	0.69	2.58	NS
Treatment	10	6845.30	684.53	58.12	2.05	S
Years x Treatment	10	6.62	0.66	0.06	2.05	NS
Error	44	518.19	11.78			
Total	69	7403.42				

ANOVA-XXVIII: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on sulphur uptake by grain

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.91	0.45	0.03	3.44	NS
Treatment	11	139.53	12.68	0.84	2.26	NS
Error	22	333.14	15.14			
Total	35	473.58				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	3.06	1.53	0.11	3.44	NS
Treatment	11	161.17	14.65	1.02	2.26	NS
Error	22	314.74	14.31			
Total	35	478.97				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.01	0.01	0.00	4.06	NS
Replication	4	3.97	0.99	0.07	2.58	NS
Treatment	10	299.10	29.91	2.03	2.05	NS
Years x Treatment	10	1.59	0.16	0.01	2.05	NS
Error	44	647.88	14.72			
Total	69	952.56				

ANOVA-XXIX: Analysis of variance as influenced by integrated nutrient management in direct seeded rice on sulphur uptake by straw

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	1.69	0.84	0.08	3.44	NS
Treatment	11	98.42	8.95	0.82	2.26	NS
Error	22	238.89	10.86			
Total	35	338.99				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.20	0.10	0.01	3.44	NS
Treatment	11	119.59	10.87	1.05	2.26	NS
Error	22	228.47	10.39			
Total	35	348.26				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.01	0.01	0.00	4.06	NS
Replication	4	1.89	0.47	0.04	2.58	NS
Treatment	10	217.16	21.72	2.04	2.05	NS
Years x Treatment	10	0.85	0.09	0.01	2.05	NS
Error	44	467.36	10.62			
Total	69	687.26				

ANOVA-XXX: Analysis of variance as influenced by integrated nutrient management on soil pH of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.22	0.11	2.46	3.44	*NS*
Treatment	11	0.65	0.06	1.31	2.26	*NS*
Error	22	0.99	0.04			
Total	35	1.85				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.24	0.12	0.62	3.44	*NS*
Treatment	11	0.71	0.06	0.33	2.26	*NS*
Error	22	4.24	0.19			
Total	35	5.19				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.00	0.00	0.00	4.06	*NS*
Replication	4	0.46	0.12	0.97	2.58	*NS*
Treatment	10	1.35	0.13	1.14	2.05	*NS*
Years x Treatment	10	0.00	0.00	0.00	2.05	*NS*
Error	44	5.23	0.12			
Total	69	7.04				

ANOVA-XXXI: Analysis of variance as influenced by integrated nutrient management on electrical conductivity of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.000	0.000	0.000	0.376	3.443	NS
Treatment	11.000	0.002	0.000	2.220	2.259	NS
Error	22.000	0.002	0.000			
Total	35.000	0.004				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2.000	0.000	0.000	0.014	3.443	NS
Treatment	11.000	0.002	0.000	0.646	2.259	NS
Error	22.000	0.008	0.000			
Total	35.000	0.010				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1.000	0.000	0.000	0.015	4.062	NS
Replication	4.000	0.000	0.000	0.078	2.584	NS
Treatment	10.000	0.004	0.000	2.024	2.054	NS
Years x Treatment	10.000	0.000	0.000	0.012	2.054	NS
Error	44.000	0.009	0.000			
Total	69.000	0.014				

ANOVA-XXXII: Analysis of variance as influenced by integrated nutrient management on organic carbon of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	3.07	3.44	NS
Treatment	11	0.25	0.02	32.39	2.26	S
Error	22	0.02	0.00			
Total	35	0.27				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	1.72	3.44	NS
Treatment	11	0.34	0.03	29.89	2.26	S
Error	22	0.02	0.00			
Total	35	0.36				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.00	0.00	3.71	4.06	NS
Replication	4	0.01	0.00	2.27	2.58	NS
Treatment	10	0.58	0.06	67.31	2.05	S
Years x Treatment	10	0.01	0.00	0.67	2.05	NS
Error	44	0.04	0.00			
Total	1	0.00	0.00	3.71	4.06	NS

ANOVA-XXXIII: Analysis of variance as influenced by integrated nutrient management on cation exchange capacity of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.39	0.19	0.70	3.44	*NS*
Treatment	11	109.38	9.94	35.83	2.26	*S*
Error	22	6.11	0.28			
Total	35	115.87				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	1.35	0.67	2.33	3.44	*NS*
Treatment	11	149.91	13.63	47.11	2.26	*S*
Error	22	6.36	0.29			
Total	35	157.62				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.21	0.21	0.75	4.06	*NS*
Replication	4	1.74	0.43	1.53	2.58	*NS*
Treatment	10	257.03	25.70	90.69	2.05	*S*
Years x Treatment	10	2.26	0.23	0.80	2.05	*NS*
Error	44	12.47	0.28			
Total	69	273.71				

ANOVA-XXXIV: Analysis of variance as influenced by integrated nutrient management on available nitrogen of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.18	0.09	0.02	3.44	*NS*
Treatment	11	2727.87	247.99	43.54	2.26	*S*
Error	22	125.31	5.70			
Total	35	2853.36				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.34	0.17	0.02	3.44	*NS*
Treatment	11	3339.21	303.56	44.34	2.26	*S*
Error	22	150.62	6.85			
Total	35	3490.17				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	5.62	5.62	0.90	4.06	*NS*
Replication	4	0.52	0.13	0.02	2.58	*NS*
Treatment	10	6051.39	605.14	96.49	2.05	*S*
Years x Treatment	10	15.69	1.57	0.25	2.05	*NS*
Error	44	275.93	6.27			
Total	69	6349.15				

ANOVA-XXXV: Analysis of variance as influenced by integrated nutrient management on available phosphorus of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	1.52	0.76	2.45	3.44	*NS*
Treatment	11	180.63	16.42	53.19	2.26	*S*
Error	22	6.79	0.31			
Total	35	188.93				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	2.11	1.05	2.34	3.44	*NS*
Treatment	11	256.38	23.31	51.80	2.26	*S*
Error	22	9.90	0.45			
Total	35	268.38				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.35	0.35	0.91	4.06	*NS*
Replication	4	3.62	0.91	2.39	2.58	*NS*
Treatment	10	433.69	43.37	114.33	2.05	*S*
Years x Treatment	10	3.31	0.33	0.87	2.05	*NS*
Error	44	16.69	0.38			
Total	69	457.66				

ANOVA-XXXVI: Analysis of variance as influenced by integrated nutrient management on available potassium of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	2.48	1.24	0.56	3.44	*NS*
Treatment	11	538.33	48.94	21.96	2.26	*S*
Error	22	49.02	2.23			
Total	35	589.83				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	3.46	1.73	0.67	3.44	*NS*
Treatment	11	863.02	78.46	30.57	2.26	*S*
Error	22	56.46	2.57			
Total	35	922.94				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	4.32	4.32	1.80	4.06	*NS*
Replication	4	5.93	1.48	0.62	2.58	*NS*
Treatment	10	1381.83	138.18	57.64	2.05	*S*
Years x Treatment	10	19.52	1.95	0.81	2.05	*NS*
Error	44	105.48	2.40			
Total	69	1517.09				

ANOVA-XXXVII: Analysis of variance as influenced by integrated nutrient management on available sulphur of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	3.44	1.72	1.33	3.44	*NS*
Treatment	11	31.82	2.89	2.24	2.26	*NS*
Error	22	28.41	1.29			
Total	35	63.67				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.28	0.14	0.03	3.44	*NS*
Treatment	11	38.81	3.53	0.63	2.26	*NS*
Error	22	123.53	5.62			
Total	35	162.62				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.04	0.04	0.01	4.06	*NS*
Replication	4	3.72	0.93	0.27	2.58	*NS*
Treatment	10	70.40	7.04	2.04	2.05	*NS*
Years x Treatment	10	0.23	0.02	0.01	2.05	*NS*
Error	44	151.94	3.45			
Total	69	226.34				

ANOVA-XXXVIII: Analysis of variance as influenced by integrated nutrient management on exchangeable calcium of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.61	0.30	0.62	3.44	*NS*
Treatment	11	10.16	0.92	1.90	2.26	*NS*
Error	22	10.70	0.49			
Total	35	21.47				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.89	0.44	0.22	3.44	*NS*
Treatment	11	15.62	1.42	0.70	2.26	*NS*
Error	22	44.89	2.04			
Total	35	61.40				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.00	0.00	0.00	4.06	*NS*
Replication	4	1.49	0.37	0.30	2.58	*NS*
Treatment	10	25.36	2.54	2.01	2.05	*NS*
Years x Treatment	10	0.42	0.04	0.03	2.05	*NS*
Error	44	55.60	1.26			
Total	69	82.87				

ANOVA-XXXIX: Analysis of variance as influenced by integrated nutrient management on exchangeable magnesium of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.00	0.00	0.02	3.44	*NS*
Treatment	11	0.07	0.01	2.23	2.26	*NS*
Error	22	0.06	0.00			
Total	35	0.14				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.01	0.01	0.31	3.44	*NS*
Treatment	11	0.13	0.01	0.71	2.26	*NS*
Error	22	0.37	0.02			
Total	35	0.52				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.00	0.00	0.01	4.06	*NS*
Replication	4	0.01	0.00	0.26	2.58	*NS*
Treatment	10	0.20	0.02	2.00	2.05	*NS*
Years x Treatment	10	0.01	0.00	0.05	2.05	*NS*
Error	44	0.44	0.01			
Total	69	0.65				

ANOVA-XL: Analysis of variance as influenced by integrated nutrient management on total potential acidity of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.86	0.43	0.12	3.44	*NS*
Treatment	11	41.91	3.81	1.03	2.26	*NS*
Error	22	81.67	3.71			
Total	35	124.43				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	1.07	0.53	0.13	3.44	*NS*
Treatment	11	39.32	3.57	0.85	2.26	*NS*
Error	22	92.76	4.22			
Total	35	133.15				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	0.63	0.63	0.16	4.06	*NS*
Replication	4	1.93	0.48	0.12	2.58	*NS*
Treatment	10	81.20	8.12	2.05	2.05	*NS*
Years x Treatment	10	0.03	0.00	0.00	2.05	*NS*
Error	44	174.42	3.96			
Total	69	258.21				

ANOVA-XLI: Analysis of variance as influenced by integrated nutrient management on microbial biomass carbon of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	4.87	2.43	0.18	3.44	*NS*
Treatment	11	5541.44	503.77	37.77	2.26	*S*
Error	22	293.43	13.34			
Total	35	5839.74				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	4.89	2.44	0.16	3.44	*NS*
Treatment	11	6419.30	583.57	37.79	2.26	*S*
Error	22	339.72	15.44			
Total	35	6763.91				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	1.29	1.29	0.09	4.06	*NS*
Replication	4	9.76	2.44	0.17	2.58	*NS*
Treatment	10	11941.36	1194.14	82.99	2.05	*S*
Years x Treatment	10	19.38	1.94	0.13	2.05	*NS*
Error	44	633.15	14.39			
Total	69	12604.94				

ANOVA-XLII: Analysis of variance as influenced by integrated nutrient management on dehydrogenase activity of soil after harvest

ANOVA for first year 2019						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.01	0.00	0.00	3.44	*NS*
Treatment	11	769.25	69.93	43.79	2.26	*S*
Error	22	35.13	1.60			
Total	35	804.38				

ANOVA for second year 2020						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Replication	2	0.01	0.00	0.00	3.44	*NS*
Treatment	11	886.68	80.61	47.13	2.26	*S*
Error	22	37.63	1.71			
Total	35	924.31				

ANOVA Pooled						
Source of variance	**df**	**SS**	**MSS**	**F cal**	**F tab at 5 %**	**S/NS**
Years	1	1.13	1.13	0.68	4.06	*NS*
Replication	4	0.01	0.00	0.00	2.58	*NS*
Treatment	10	1653.70	165.37	100.00	2.05	*S*
Years x Treatment	10	2.22	0.22	0.13	2.05	*NS*
Error	44	72.76	1.65			
Total	69	1729.83				

APPENDIX – B

(A)	COMMON COST OF CULTIVATION			
Sl. No.	**Operations**	**Qty/Units**	**Rate(Rs)**	**Cost (Rs ha^{-1})**
1.	Field preparation			
	a. Primary tillage	1	1500	1500
	b. Secondary tillage	1	1500	1500
	c. Preparation of layout	10 labours	282	2820
2.	Seed (Local)	80 kg	20	1600
3.	Sowing	10 labours	282	2820
4.	Thinning, gap filling, weeding	20 labours	282	5460
5.	Application of manures and fertilizers	10 labours	282	2820
6.	Harvesting, threshing and winnowing	20 labours	282	5460
7.	Drying and bagging	10 labours	282	2820
TOTAL				**26,800**

(B)	COST OF VARIABLE INPUTS			
Sl. No.	**Operations**	**Qty/Units (kg ha^{-1})**	**Rate(Rs)**	**Cost (Rs ha^{-1})**
Nutrient Management				
T_1	-	-	-	-
T_2	Urea	260.4	10	2604
	SSP	250	15	3750
	MOP	50.1	25	1252.5
TOTAL				**7606.50**
T_3	Urea	260.4	10	2604
	SSP	250	15	3750
	MOP	50.1	25	1252.5
	PSB	1.6	50	80
TOTAL				**7686.50**
T_4	Urea	260.4	10	2604

	SSP	250	15	3750
	MOP	50.1	25	1252.5
	FYM	2 tonnes	1500	3000
TOTAL				**10,606.50**
T_5	Urea	260.4	10	2604
	SSP	250	15	3750
	MOP	50.1	25	1252.5
	FYM	2 tonnes	1500	3000
	PSB	1.6	50	80
TOTAL				**10,686.50**
T_6	Urea	195.3	10	1953
	SSP	187.5	15	2812.5
	MOP	37.57	25	939.25
	PSB	1.6	50	80
TOTAL				**5784.75**
T_7	Urea	195.3	10	1953
	SSP	187.5	15	2812.5
	MOP	37.57	25	939.25
	FYM	2 tonnes	1500	3000
TOTAL				**8704.75**
T_8	Urea	195.3	10	1953
	SSP	187.5	15	2812.5
	MOP	37.57	25	939.25
	FYM	2 tonnes	1500	3000
	PSB	1.6	50	80
TOTAL				**8784.75**
T_9	Urea	130.2	10	1302
	SSP	125	15	1875
	MOP	25.05	25	626.25
	PSB	1.6	50	80
TOTAL				**3883.25**
T_{10}	Urea	130.2	10	1302
	SSP	125	15	1875
	MOP	25.05	25	626.25
	FYM	2 tonnes	1500	3000
TOTAL				**6803.25**
T_{11}	Urea	130.2	10	1302
	SSP	125	15	1875
	MOP	25.05	25	626.25
	FYM	2 tonnes	1500	3000
	PSB	1.6	50	80
TOTAL				**6883.25**

T_{12}	Urea	236.53	10	2365.3
	SSP	187.5	15	2813.5
	MOP	76.82	25	1920
TOTAL				**7099.3**