EFFECT OF NUTRIENT MANAGEMENT ON RICEBEAN [*Vigna umbellata* (THUNB.) OHWI AND OHASHI] – LINSEED (*Linum usitatissimum* L.) CROPPING SYSTEM

Thesis

submitted to

NAGALAND UNIVERSITY

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of

Doctor of Philosophy

in

Agronomy

by

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This thesis is dedicated to my parents.
I believe that this achievement will complete the dream that you had for me all those years ago when you chose to give me the best education you could

DECLARATION

I, Virosanuo Solo, 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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CERTIFICATE – I

This is to certify that the thesis entitled **"Effect of nutrient management on ricebean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi] – linseed (*Linum usitatissimum* L.) cropping system"** submitted to Nagaland University in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy (Agriculture) in Agronomy is the record of research work carried out by Ms. Virosanuo Solo Registration No. Ph.D./AGR/00209 under my personal supervision and guidance.

The result 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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VIVA VOCE ON THESIS OF DOCTOR OF PHILOSOPHY IN AGRONOMY

This is to certify that the thesis entitled **"Effect of nutrient management on ricebean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi] – linseed (*Linum usitatissimum* L.) cropping system''** submitted by Miss Virosanuo Solo Admission No. Ph-262/18 Registration No. Ph.D./AGR/00209 to the NAGALAND UNIVERSITY in partial fulfillment of the requirements for the award of degree of Doctor of Philosophy in Agronomy has been examined by the Advisory Board and External examiner on ……………….............

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As I conclude this thesis, I look forward to new beginnings, confident that the lessons learned and the bonds forged during this pursuit will continue to shape my future endeavours and hope that this thesis will be beneficial to all researchers striving to improve the society at their own capacity.

Date :   (VIROSANUO SOLO)
Place :

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LIST OF ABBREVIATIONS

%	-	Percentage
@	-	at the rate of
₹	-	Rupees
:	-	Ratio
$^{-1}$ or /	-	Per
BCR	-	Benefit Cost ratio
CD	-	Critical Difference
CV	-	Coefficient of variance
cm	-	Centimetre
DAS	-	Days after sowing
df	-	Degree of freedom
et al.	-	et allia (and others/co-workers)
Fig.	-	Figure
g	-	Gram
g^{-1}	-	per gram
g^{-1} plant	-	gram per plant
ha^{-1}	-	Per hectare
ha	-	Hectare
i.e.	-	Id est (that is)
kg	-	Kilogram
L.	-	Linnaeus
m	-	Metre
mg		Milligram
m^2	-	Metre square
Max.	-	Maximum
Min.	-	Minimum
mm	-	Millimetre
MOP	-	Muriate of Potash
msl	-	Mean sea level
mt	-	Million tonnes
NPK	-	Nitrogen Phosphorus Potassium
NS	-	Not significant
NU	-	Nagaland University
ºC	-	Degree Celsius

RDF	-	Recommended Dose of Fertilizers
RBD	-	Randomised block design
SAS	-	School of Agricultural Sciences
SEm±	-	Standard error of mean
Sl. No.	-	Serial number
SOV	-	Source of Variation
ss	-	Sum of square
SSP	-	Single Superphosphate
t	-	Tonnes
T	-	Treatment
viz.	-	Videlicet (Namely)

ABSTRACT

The experiment entitled "Effect of nutrient management on ricebean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi] – linseed (*Linum usitatissimum* L.) cropping system" was conducted during 2019-2021 in the Agronomy experimental farm of School of Agricultural Sciences (SAS), Medziphema Campus, Nagaland.

The experimental field was laid out in randomized block design with three different organic manures i.e., poultry manure (PM) pig manure (PGM) and farm yard manure (FYM) along with doses of inorganic fertilizers: 100% RDF, 75% RDF, 50% RDF. The treatment combinations T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF. The variety for ricebean and linseed was tested *Bidhan 1* and *Ruchi* respectively.

Combined application of GM (*Sesbania*) + 0.7 t ha^{-1} of poultry manure with 100% RDF (T_1) recorded maximum plant height (171.32cm), number of branches $plant^{-1}$ (9.59), number of nodules $plant^{-1}$ (37.13), dry matter yield (137.13g^{-1} plant) at all growth stages of ricebean crop. T_1 proved to be the best treatment in yield attributes as it produced the number of pods $plant^{-1}$ (14.17), number of seeds pod^{-1} (9.24), pod length (9.20cm), seed yield (1189.80 kg ha^{-1}), stover yield (1898.80 kg ha^{-1}) and harvest index (38.85%) with protein yield (319.97 kg ha^{-1}) and it also showed superiority in the succeeding crop (linseed) with maximum number of pods $plant^{-1}$ (44.65), number of seeds pod^{-1} (9.46) and seed yield (772.68 kg ha^{-1}) and stover yield (1433.55 kg ha^{-1}).

Application of GM (*Sesbania*) + PM (0.7t ha^{-1}) + 100% RDF proved the maximum nitrogen (61.66 kg ha^{-1}), phosphorus (33.33 kg ha^{-1}) and potassium (56.19 kg ha^{-1}) uptake while in terms of soil parameters, T_1 (GM (*Sesbania*) + PM (0.7t ha^{-1}) + 100% RDF) produced maximum EC (0.244 dS m^{-1}), organic carbon (1.62%), soil available nitrogen (284.67 kg ha^{-1}), phosphorus (37.84 kg ha^{-1}), potassium (157.10 kg ha^{-1}), actinomycetes population (2.02 Cfu x $10^5 g^{-1}$), bacteria population (39.48 Cfu x 10^6 g^{-1}) fungal population (35.45Cfu x $10^3 g^{-1}$), dehydrogenase activity (19.92µg TPF g^{-1} h^{-1}), SMBC (379.01 µg g^{-1} soil), acid phosphatase activity (56.74 µg p-nitrophenol g^{-1} h^{-1}). Similarly, T_1 (GM (*Sesbania*) + PM (0.7t ha^{-1}) + 100% RDF) also recorded maximum soil available nitrogen (290.34 kg ha^{-1}), phosphorus (38.38 kg ha^{-1}), potassium (155.53 kg ha^{-1}) in succeeding linseed crop.

The total cost of cultivation was maximum in T_1 (GM (*Sesbania*) + PM (0.7t ha^{-1}) + 100% RDF) which recorded highest gross return (₹95,379.81in 2019-2020 and ₹98,058.04 with 2020-2021), net return (₹58,249.03 in 2019-20 and ₹60,927.26 in 2020-21) and B:C ratio (1.57in 2019-20 and 2020-21in 1.64) respectively.

From these research findings, it may be concluded that application of GM (*Sesbania*) + PM @ 0.7 t ha^{-1}+ 100% RDF achieve higher seed yield, seed quality and to sustain the quality of soil as well as maximize the monetary returns of the farmers in foothill condition of Nagaland.

Key words: cropping system, FYM, linseed, poultry manure, pig manure and ricebean.

CHAPTER I

INTRODUCTION

INTRODUCTION

In the present century, legumes with high quality protein which are not extensively utilized as food have become a primary target to address the issue of food security. In accordance with the guidelines of WHO and FAO, achieving "Food security and the right to food" can be realized through the utilization of legumes, particularly underutilized ones. These legumes are rich in high-quality protein, dietary fiber, and various micronutrients, offering numerous health benefits, as highlighted by Katoch (2015). Pulse crop are basically the quickest way to augment to protein production and they also constitute a fundamental component in the diet of a significant portion of the impoverished and vegetarian population in India. When supplemented with cereals, pulses offer an ideal combination of high-quality vegetarian protein. Findings from household consumption surveys suggest a decrease in pulse consumption, contributing to an increase in malnutrition and a decline in protein intake (Shalendra *et al*., 2013). Despite this, India still hosts approximately 24% of the undernourished global population (Sharma et al., 2016), underscoring the crucial role of pulses in ensuring food and nutrition security for the Indian populace. They are not only used for food purposes but also for helping and restoring soil fertility and health through symbiotic nitrogen fixation.

Rice bean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi] is grain legume with chromosome number (2n=2x=22), it is one legume crop that is considered as' underutilised crop' or 'minor pulse that has received attention over the past years due to its contribution to the global food supply and has emerged as a potential legume because of its nutritional potential. The seed contains 25% protein, 0.49% fat and 5% fibre which is also rich in methionine and tryptophan as well as vitamins (thiamine, niacin and riboflavin). This crop possesses immense potential due to its high nutritional quality, high grain yield and multipurpose usage as food, animal feed, cover crop, green manure (Tomooka *et al*., 2002; Doanh and Tuan, 2004).

Protein in ricebean is rich in limiting amino acid methionine and tryptophan, the fatty acid present has high percentage of unsaturated fatty viz., linoleic and linolenic acid, which are nutritionally desirable in the diet.

In India, ricebean crop is used as minor *kharif* pulse crop having the qualities of resistance to drought, pests and diseases during their growth period, synchronising habit of pod maturity, resistance to attack of storage pests and high percentage of seed viability. It is widely used as an intercrop or mixed crop with maize, sorghum or cowpea. In the NER of India, it is predominantly grown under the rainfed condition in mixed farming system under shifting cultivation. The dried seeds are usually eaten boiled or as pulse. Young immature pods are used as vegetables. It is also grown as a green manure and an excellent cover crop. Unlike other pulses, rice beans are not easily processed into dhal, due to their fibrous mucilage that prevents hulling and separation of the cotyledons (Rajerison, 2006).

In Nagaland, ricebean is commonly known as Naga *dal* which is mainly grown as one major pulse crop with an area of 4900 ha and production of 5620 Mt (Statistical handbook of Nagaland, 2017). It is one of the predominant crop grown under rainfed condition. Naga dal variety had higher fat, potassium, magnesium, calcium, sodium, iron, copper and chromium content and better cooking quality as compared to the other varieties. A study also revealed that Naga dal variety was superior to other varieties with respect to mineral content, cooking and hence have better potential in the development of value added products (Bepary *et al*., 2017) .

With modern agriculture focusing on chemical additives is observed to be unsuitable resulting to problems such as loss of soil productivity, associated soil-plant nutrient loss, pollution of ground water from pesticides, fertilizer and chemicals, and there is a certain need to reduce the usage and lean towards increasing the use of organics.

The prevalent practice in Nagaland involves cultivating rice during the *kharif* season and leaving the land fallow during the *rabi* season for cattle grazing. Research has shown that approximately 11.7 million hectares of land in India are kept fallow after the rice harvest, with Nagaland alone having 324 hectares dedicated to this purpose (Statistical handbook of Nagaland, 2017). By implementing effective crop management strategies, there is significant potential to transform the dominant cereal-based cropping systems into sustainable and ideal systems by utilizing these fallow lands after rice cultivation. Additionally, in Nagaland, there is an emerging opportunity to consider growing linseed as a succeeding crop following the rice harvest.

Linseed *(Linum usitatissiumum* L.*)* is a common oilseed rabi crop, known for its potentiality and importance to be adopted as an economical crop due to its ability to grow in marginal and poor exhausted soils. The area occupied by linseed covers to about 27.64 lakh ha, 29.25 lakh tonnes and an average productivity of 1058 kg ha^{-1} globally (Anonymous, 2017) whereas India's coverage includes 3.30 lakh ha with production of 1.72 lakh tonnes (DES 2017-18) and the country holds third position in terms of acreage and fifth in total production.

Soil fertility depletion is considered to be one of the most important constraints on improved agricultural production and the maintenance requires a balanced application of inorganic and organic nutrient sources. Organic fertilizers coming from fermented and decomposed organic materials are generally nutritious and safe. The beneficial effect of organic matter on crop productivity is a function of so many factors, which include greater vigor of plant, improvement of soil properties and greater uptake of nutrients. The various organic sources include farm yard manure which supplies macronutrients and micronutrients and also improves physical and chemical properties and health of soil such as aggregation, aeration, permeability, water holding capacity, slow release of nutrients, increase in cation exchange capacity, stimulation of soil flora and fauna etc which contains 0.50%, 0.17% and 0.55 % of N, P and K, meanwhile pig manure is also high rich in nutrients and minerals, which contains 0.60% N, 0.50% P_2O_5 and 0.20% K_2O (Gaur *et al*. 2000).

Inorganic fertilizers are used to improve soil fertility and increase food production, but excessive use of mineral fertilizers has aroused environmental concerns. These are source of plant nutrient that can be added to supplement soil natural fertility and also increase the crop productivity. Crop plants have great demand for nitrogen, phosphorous and potassium as a whole main significance in maintenance of normal physiological function of the cell. The highest productivity can be achieved in a sustainable manner with deterioration to the soil only through application of appropriate combination of inorganic fertilizers and different organic fertilizers (Chandrashekara *et al*., 2000).

Preserving crop residues on cultivated land post-harvest is recognized as a valuable strategy for erosion control. These residual materials play a crucial role in enhancing soil quality by contributing to several benefits. They can enhance soil structure, augment organic matter levels, mitigate evaporation, and facilitate carbon dioxide fixation in the soil. Implementing sound crop residue management practices in agriculture can yield multiple positive outcomes for soil health.

There is no published literature on ricebean regarding its area coverage, production, productivity, utilisation and marketing (Joshi *et al*., 2006). It is grown by subsistence farmers in a very limited scale and most of the produce is consumed at home, although there is a limited market for a short period each year. In Nagaland, agricultural production system always create hazard owing to problems like high loss of nutrient through soil erosion, lower availability and greater fixation of nutrients coupled with little use of external inputs. In the context of sustainable agriculture and the issues related to it, a viable cropping system approach with a feasible and profitable crop management is the need of the hour for sustaining productivity of the land and also for sustaining production for human consumption. Therefore, a technological breakthrough in agro-techniques especially in cropping system and nutrient management is essential so as to improve productivity under ricebean based linseed cropping system:

1. To find out the effect of nutrient management on growth, yield and quality of ricebean- linseed cropping system.
2. To assess the effect of nutrient management on nutrient concentration, their uptake and soil fertility status under ricebean- linseed cropping system.
3. To find out the economics of the treatments under study.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The information and reviews on literature concerning the present investigation have been presented in the following chapter under the following headings.

2.1 Effect of green manuring

Bana and Pant (2000) remarked that green manuring was an inexpensive, eco – friendly alternative to mounting prices of fertilizer nitrogen and has become an effective technology in economizing the agricultural production system ensuring productive capacity of soil without causing environmental problem.

Gana and Busari (2001) reported that sugarcane yield can be improved with the incorporation of leguminous green manure crop, increase in stalk height, tiller number/plant, crop vigour and yield was observed after 6 and 12 months of planting.

Palaniappan and Siddeswaran (2001) reported that dhaincha was an ideal crop for green manure, as it is quick-growing, succulent, easily decomposable with low moisture requirements, and produces maximum amount of organic matter and nitrogen in the soil.

Ramos *et al.* (2001) marked that leguminous crops were preferred for green manuring compared to nonleguminous crops due to their superior qualities. This preference was particularly evident in water-scarce farming systems where moisture conservation is crucial. Leguminous crops, such as alfalfa, beans, clovers, lupines, and vetches, exhibit superiority in green manuring because of their unique ability to fix nitrogen through symbiosis and this nitrogen-fixing process contributes to an increase in soil nitrogen levels, providing a valuable resource that can be utilized by subsequent crops.

Mandal *et al*. (2003) while conducting a study on the effect of green manuring on physical properties, organic matter and nitrogen status of soil in rice /wheat cropping system, observed that the addition of green manure in the form of *Sesbania* and green gram resulted in an improved organic matter status, which led to a better soil aggregation, reduced bulk density and improved water flow characteristics which ultimately increased the crop growth of rice.

Yadav *et al*. (2003) investigated the impact of cowpea green manuring on succeeding wheat crops and found a substantial 19-20% increase in wheat grain yield compared to the treatment without green manuring.

Maiksteniene and Arlauskiene (2004) concluded that the highest wheat yield is attained when wheat is grown after lucerne as a preceding crop, the yield being 18.5% higher than after clover. Higher grain yields are usually associated with lower protein concentration.

Ramesh and Chandrasekaran (2004) found that the repeated use of Sesbania rostrata as a green manure crop led to an increase in soil organic carbon. This had notable effects on both the rate of soil organic carbon loss in cropping systems and the overall soil carbon levels. When compared to the traditional rice-rice cropping system, the system incorporating three green manures—S. rostrata-rice, S. rostrata-rice, and S. rostrata—exhibited significantly higher soil organic carbon, showing a 10.63% increase.

Das *et al*. (2009) conducted an experiment in a rice-rapeseed-green gram cropping sequence to assess the impact of organic manures and inorganic fertilizers on the yield and nutrient uptake by green gram, as well as residual soil fertility after green gram harvest. The study revealed gains in organic carbon, total nitrogen, and accessible P2O5 of 0.324%, 0.023%, and 2.8 kg/ha, respectively, over the original soil nutrient content. Integrated nutrient management significantly enhanced residual soil fertility following green gram cultivation.

Talgre *et al*. (2010) conducted an experiment to investigate the effect of green manure treatments on the yield and yield quality of winter wheat. The total phytomass of leguminous green manures ploughed into soil in 2007 varied from 10.3 Mg ha^{-1} with the bird's foot trefoil to 13.9 Mg ha^{-1} with the white sweet clover. The root mass of legumes comprised 37-54% of the total biomass. The amount of carbon applied into the soil with the green material and roots of legumes varied from 4.43 Mg ha^{-1} to 5.98 Mg ha^{-1}, and the amounts of nitrogen were up to 274 kg of N ha^{-1}. The highest wheat yields were attained in treatments with lucerne and red clover as preceding crops compared to the N_0 treatment, the extra yield reached 3.26 Mg ha^{-1} with green manures.

Alam (2010) remarked that compost, cover crops and green manure crops needed to be grown as models and sustainable agriculture for soil care physical, chemical and biological properties that were also very important for better production of each component crop in the cropping pattern.

Thakuria and Thakuria (2018) remarked that the inclusion of additional green material, such as dhaincha, into the soil resulted in the introduction of higher amounts of organic matter. This, in turn, led to an augmentation of essential nutrients available to plants, ultimately leading to an improvement in growth and yield. The practice of green manuring offers numerous benefits for enhancing rice production, as confirmed by several researchers (Deshpande and Devasenapathy (2010); Kumari *et al*., (2010).

Ali *et al*. (2012) stated that the green manuring and leguminous cropping patterns gave higher paddy yield compared to rice-wheat cropping pattern.

Rahman *et al*. (2012) reported that the incorporation of green manure dhaincha biomass increased rice yield 7 to 39% over control and this might be due to steady and adequate supply of nutrients by the enhanced biochemical activity of microorganisms coupled with large photo synthesizing surface would have helped in the production of more tillers and dry matter with enhanced supply of assimilates to sink resulting in higher yield.

Zhang *et al*. (2013) reported that use of environmental friendly organic manure like green manure was one of the best remedies for improving soil fertility and increase soil water use efficiency in dry land cropping system

Ehsan *et al*. (2014) stated that, the rice grain yield increased 32% to 77% over control due to green manure (Dhaincha) incorporation with different doses of NPK fertilizers application.

Dubey *et al*. (2015) reported that green manures improve soil structure, letting more air into the soil and improving drainage. Organic matter helps sandy soil hold more water and not drain so quickly as a result of increased aggregate stability and porosity and also organic matter reduced rate of runoff and soil erosion.

Espinal *et al*. (2016) conducted an experimental trials which included two GMs (sunn hemp -15N and millet-15N), absence of N organic source (without GM residues in soil) and four N rates, as urea-15N (0, 28.6, 57.2 and 85.8 mg N kg^{-1}). The results showed that both rice grain and straw biomass yields under sunn hemp were greater than that of millet or without the application of GM. The NUE of rice under sunn hemp was greater than that under millet (18.9 and 7.8% under sunn hemp and millet, respectively). The NUE of GMs by rice plants ranged from 14.1% and 16.8% for root and shoot, respectively. The study showed that green manures can play an important role in enhancing soil fertility and N supply to subsequent crops.

Hoque *et al*. (2016) conducted an experiment with treatments - T_1 [No green manure + 100% RDF (RDN)], T_2 (*Sesbania aculeata* + 75% RDN), T_3 (*Sesbania aculeata* + 50% RDN), T_4 (*Sesbania rostrata* + 75% RDN), T_5 (*Sesbania rostrata* + 50% RDN), T_6 (*Vigna radiata* + 75% RDN), T_7 (*Vigna radiata* + 50% RDN), T_8 (*Vigna mungo* + 75% RDN), and T_9 (*Vigna mungo* + 50% RDN). Residual effects of green manures with RDN significantly increased the yield attributes as well as grain and straw yields of wheat. Further, green manures exerted significant residual effects on grain, straw and total N uptake of wheat. Among all the treatments with green manures, the performance of T_4 (*Sesbania rostrata* + 75% RDN) was the best as it produced the highest grain yield (4.28 t ha^{-1}), straw yield (4.74 t ha^{-1}) and total N uptake (108.02 kg ha^{-1}). It was reported that use of green manures slightly increased the organic matter content, total N and available P, K, and S contents of the post-harvest soils.

Pandey and Singh (2016) defined green manuring as a practice of ploughing or turning into the soil un-decomposed green plants or their residue for the purpose of improving physical structure and fertility of a soil.

Kataoka *et al*. (2017) remarked that green manure makes carbon substrates readily available, which helps to restrain microbial development in soil and promote microbial activity, furthermore, green manures based on legumes are significant sources of nitrogen for crop productivity.

Sarwar *et al*. (2017) concluded that dhaincha- (*T. Aman*) rice, had potential effect on soil fertility and nutrient availability as well as the increment of crop production. It was also noted that both organic matter content and total nitrogen (%) were increased due to dhaincha incorporation in soil and the amount of organic matter (%) varied from 1.58% to 2.13% before incorporation and 1.99% to 2.27% after incorporation of dhaincha biomass in soil and remarked that it may be due to the efficient and adequate nutrients supply from dhaincha biomass decomposition and released nutrients for the crop. The study also concluded that due to the incorporation of dhaincha biomass in soil, the grain yield was increased (up to 39%) compared to the control. Among the dhaincha accessions, number 95 showed the best performance in terms of grain yield.

According to Meena *et al*. (2018), due to the symbiotic association with Rhizobium bacteria, legumes contributed to 40% of the world's total nitrogen fixation and can biologically fix 50–80% of the nitrogen plants need.

Sajjad *et al*. (2018) in a study observed that green manuring resulted in 16.8 per cent increase compared to check and the overall performance of cowpea green manuring in wheat was positive and the benefit was ₹10283 ha^{-1}.

Luo *et al*. (2020) reported that the implementation of green manuring had a substantial impact on soil properties and significantly influenced various soil physical properties. This included a reduction in soil bulk density, an increase in soil porosity, and improvements in soil structure characterized by the formation of water-stable aggregates. Additionally, there is a notable enhancement in soil organic matter and observed a positive effect on soil nitrogen content, both in terms of total nitrogen and available nitrogen.

Irin and Biswas (2023) carried out an experiment at Sher-e-Bangla Agricultural University field, 2015 - 2016, which showed that the combined effect of NPK levels and residual effect of green manuring crops had a significant influence on 1000 grain weight, protein content and grain yield of rice and mustard with the highest T. aman yield, mustard yield and grain protein (5.56 t ha^{-1} with F_1 and 5.11 t ha^{-1} with F_2), (1592.3 kg ha^{-1}) and (8.54%) was obtained from T_2. The legume's nutrient contributions may have improved the yields and reduced the need for inorganic N by up to 50% and the increased nitrogen and other nutrient availability to the rice crop due to green manuring assimilation may be the cause of the higher grain yield and protein content.

2.2 Effect of organic manures on growth and yield attributes

Organic manures are highly regarded for their nutrient-rich composition, and it is widely acknowledged that they can significantly enhance crop yields. Beyond their nutrient content, the positive impact of manure on soil quality, organic matter levels, soil structure, and the overall biological activity within the soil is well-established, especially when applied at substantial rates in controlled research trials.

Kumar and Puri (2001) observed that 20.55 and 35.65% more grain and stover of maize with FYM at 15t ha^{-1} over conventional method.

Singh and Agarwal (2001) reported that graded application of nitrogen, FYM @20 tonnes ha^{-1} and recommended fertilizer rate significantly improved plant height, dry matter accumulation, effective tillers, grain, straw and biological yield.

Devi (2002) observed that sawdust, rice husk, wheat husk, cowdung, pig dung, poultry manure and goat dung, when applied at 400 kg ha^{-1} to the soil on which green gram and mungbean were grown, increased the plant growth and rhizobium nodulation.

Amujoyegbe and Alofe (2003) concluded that the effect of poultry manure and inorganic fertilizer on yield and yield components varied from the control. The crude protein, percentage of crude fibre, total nitrogen and carbohydrate contents of the grain varied between the cultivars and were significantly increased with application of poultry manure.

Lakpale *et al*. (2003) reported that application of 2.5t ha^{-1} considerably improved the soil nutritional status, net income, branches per plant, pods per plant, seeds per pod and 100 seed weight.

In a study conducted by Mukherjee *et al*. (2006), two separate sets of experiments were carried out, one in a lateritic soil zone and another in an alluvial soil zone in West Bengal, India, spanning from 1998 - 2000. In the initial experiment conducted in the lateritic soil zone, the highest seed yield of ricebean (1.47 t ha^{-1}) was achieved when the crop received a combination of 20 kg N, 80 kg P_2O_5, and 40 kg K_2O ha^{-1}. In the second experiment conducted in the alluvial soil zone, ricebean outperformed blackgram, with ricebean yielding 1.26 t ha^{-1} compared to blackgram's 1.02 t ha^{-1}. Interestingly, the highest seed yield for both ricebean (1.51 t ha^{-1}) and blackgram (1.14 t ha^{-1}) was recorded when the crops received 50% of the recommended nutrient doses applied through chemical fertilizers, along with the remaining 50% supplied through poultry manure.

In a field experiment conducted by Amanullah *et al*. in 2007, six different sources of organic manure were evaluated, including farmyard manure (25 t ha^{-1}), poultry manure (10 t ha^{-1}), composed poultry manure (5 t ha^{-1}), FYM (12.5 t ha^{-1}), FYM combined with composed poultry manure (5 t ha^{-1}), along with a control group with the objective of the study was to assess the yield and quality of fodder cowpea. The results of the experiment revealed that the combined use of poultry manure, either alone or in combination with FYM, resulted in the highest yield and quality of cowpea fodder among all the tested organic manure sources and this suggests that the combination of poultry manure, either with or without FYM, was the most effective treatment for enhancing both the yield and nutritional quality of cowpea fodder in the study.

In a study conducted by Ibeawuchi *et al*. (2007), an experiment was carried out to investigate the impact of gradually substituting inorganic fertilizer with organic fertilizer on maize (*Zea mays*) production. The findings indicated that treatments involving a combination of NPK (nitrogen, phosphorus, and potassium) fertilizer and poultry manure (PM) at rates of 8 tha^{-1} and 6 t ha^{-1} were more effective in promoting maize production. These treatments resulted in significantly improved grain yields, dry matter production, and the overall fertility of the maize crops.

Boyhan and Hill (2008) discovered that organic fertilizer sources necessitated higher fertilizer requirements compared to conventional fertilizers. This is likely attributed to the lower availability of nutrients in organic compounds, owing to their slow mineralization rates.

Hati *et al*. (2008) conducted a field experiment on long term effects of inorganic fertilizer, manure and lime application on organic carbon content and physical properties of an acid alifisol under an annual soybean wheat crop rotation. Application of balanced fertilizer along with manure (NPKM) or lime

(NPKL) improved soil aggregation, soil water retention, micro porosity and available water capacity and reduced bulk density, exchangeable aluminium of the soil in 0-30 depth over control.

Madukwe *et al*. (2008) carried an experiment in Imo State University, Nigeria to investigate effects of organic manure (poultry and cow dung) on five cowpea varieties (IT93K-452-1, IT89KD-288, Vital 7, IT848-2246-4 and Ife brown) on the soil chemical properties and nodulation of roots of the cowpeas. The results revealed that organic manure significantly influenced the nodulation of the cowpea varieties as poultry manure gave the highest number of nodules (15.9) which was significantly different from the values (12.2 and 10.3) observed from cow dung-treated plots and untreated plots respectively. The yield of cowpea was also improved with the application of poultry manure with a mean yield of 744.7 kg ha^{-1}, which was significantly different from values (571.9 kg ha^{-1} and 505 kg ha^{-1}) observed for untreated plots and cow dung treated plots respectively.

Organic manures *viz*., FYM, poultry manure help in the improvement of soil structure, aeration and water holding capacity of soil. Further, it stimulates the activity of microorganisms that makes the plant to get the macro andmicro-nutrients through enhanced biological processes, increase nutrient solubility, alter soil salinity, sodicity and pH (Alabadan *et al*. 2009).

In the study conducted by Adeoye *et al*. (2011), the research aimed to assess the impact of cattle and poultry manure on the growth and yield of the TVx3236 cowpea variety. The findings of the study indicated that the plot treated with poultry manure yielded the highest cowpea production, with a recorded yield of 854 kg ha^{-1}. This suggests that poultry manure was particularly effective in enhancing the growth and yield of the TVx3236 cowpea variety in their experiment.

Asada *et al*. (2012) concluded from a long term experiment that application of pig manure changes the soil redox conditions by improving the soil structure, depending on the water content of soil pores present in soil.

Anuja and Vijayalakshmi (2014) conducted an experiment which indicated that plant height, was favourably enhanced by the treatment of FYM @ 25 t ha^{-1}+ neem cake @ 5 t ha^{-1}+ panchagavya 3%, whereas number of branches per plant, was favourably enhanced by the treatment FYM @ 25 t ha^{-1} + vermicompost @ 5 t ha^{-1} + panchagavya 3%. The yield per ha showed that FYM @ 25 t ha^{-1} + vermicompost @5 t ha^{-1} + panchagavya 3% recorded highest yield of 6.75 t ha^{-1} in season I and 6.22 t ha^{-1} in season II as compared to 3.64 t ha^{-1} and 3.59 t ha^{-1} in the control during season I and season II, respectively.

Omotoso and Olusegun (2014) investigated the effects of NPK 15-15-15 fertilizer and pig manure on nutrient dynamics and cowpea production of six treatments in RBD. The results showed that 8t ha^{-1} PM 60 kg NPK produced significantly more nodules per $plant^{-1}$, dry matter, number of pods, number of seeds per pod^{-1} and 100 seed weight, respectively.

Shukla and Tej (2014) conducted an experiment in Tehri Garhwal Uttarakhand, observed that increasing levels of organic manures the plant growth in terms of plant height, yield attributing characters- number of pods $plant^{-1}$, number of grains pod^{-1}, pod length (cm) and 1000 grain weight (g), ultimately increased yield of ricebean. The highest value of plant height, yield characters and yield (1215 kg ha^{-1}) was recorded in 100% RDF (20 kg N and 60 kg P_2O_5 ha^{-1}) which was at par with 50% RDF + 205 tonnes vermicompost and vermicompost @7.5 tonnes ha^{-1}. B:C ratio was recorded highest with 100% RDF.

Akinmutimi and Amaechi (2015) evaluated comparisons of chicken manure, pig manure and NPK fertilizer for okra growth, yield and nutrient content. The results obtained from the study showed that okra plant height, stem girth and number of leaves increased significantly when 10 t ha^{-1} of pig manure was used compared to other treatments.

Chinthapalli *et al*. (2015) carried out an experiment to determine effect of organic fertilizer (cow dung) and inorganic fertilizers like urea and potassium chloride on the growth, biomass and biochemical parameters of two legumes of pea (*Pisum sativum*) and faba bean (*Vicia faba*). Cow dung (15 t ha^{-1}) and inorganic fertilizer were applied at rate of urea (120 kg ha^{-1}) and potassium chloride (125 kg ha^{-1}) were used, where the application of cow dung at 15 t ha^{-1} showed significant growth over the inorganic fertilizer urea and potassium chloride in terms of germination percentage, fresh weight and dry weight, plant height, shoot length and root length as well as number of leaves in both the legume plants.

Joshi *et al*. (2016) carried out an experiment on loamy sand soil to evaluate the effect of organic manures (farmyard manure, vermicompost, poultry manure, neem cake and castor cake) on soil and quality parameters of cowpea during summer season. RDF (20:40:0 NPK kg ha^{-1}) recorded significantly higher chlorophyll content of leaves at 60 DAS and crude protein content in green seed over rest of the treatments. Higher OC content after harvest of the crop was reported under treatment poultry manure 2 t ha^{-1}. Significantly higher values of available nutrients (N, P_2O_5 and K_2O) in the soil after harvest of the crop was observed under the treatment, vermicompost 2 t ha^{-1}, FYM 2.5 t $ha^{-1}$and poultry manure 2 t ha^{-1}, respectively. RDF also recorded maximum value of net realization with BCR value followed by treatment poultry manure 2 t ha^{-1}.

Issac and Mathew (2016) carried out to study the influence of different sources of nutrients on seed production in vegetable cowpea during 2010-11 in RBD, with twelve combinations of nutrient sources. Results showed significant variation in seed yield potential in the crop with highest seed yield (435.97 kg ha^{-1}) were recorded in the treatment, where recommended NPK dose for the seed crop was applied along with vermicompost at 50% nitrogen substitution. Germination percentage and 100-seed weight was significantly higher in treatments receiving a combination of vermicompost and poultry manure.

Angin *et al*. (2017) reported that use of organic fertilizers increases soil organic matter, improves microbial activity, and provides both macro- and micronutrients required for the plant in a more efficient way.

Kanwar *et al*. (2017) carried out a field experiment to study the effect of organic and inorganic nutrition on symbiotic efficiency and yield of vegetable cowpea [Vigna unguiculata L. Walp.].The treatments consisted of four levels of organic manure (Control, FYM @ 10 t ha-1,vermicompost @ 5 t ha-1and poultry manure @ 5t ha^{-1}) and five levels of inorganic nutrients (Control, elemental sulphur @ 20 kg ha^{-1}, elemental sulphur @ 20 kg ha^{-1}+ ammonium molybdate @ 1.0 kg ha^{-1}, elemental sulphur @ 20 kg ha^{-1}+ ammonium molybdate @ 1.0 kg ha^{-1} + ferrous sulphate@ 50 kg ha^{-1}, elemental sulphur @ 20 kg ha-1+ ammonium molybdate @ 1.0 kg ha^{-1} + ferrous sulphate @ 50 kg ha^{-1} + zinc sulphate @ 25 kg ha^{-1}) were applied to the vegetable cowpea var. RCV-7. The experiment revealed that the application of vermicompost @ 5 t ha^{-1} and combined application of S + Mo + Fe were found significantly superior in increasing the number of total and effective nodule, leghemoglobin content in root nodules, chlorophyll content in leaves, green pod yield per ha^{-1}over control.

Lyngdoh *et al*. (2017) conducted an experiment which consisted of two organic manures (FYM and vermicompost), two liquid organic supplements (Fish amino Acid (FAA) and Panchagavya) and biofertilizers [Rhizobium and PSB]. The result revealed that treatment T_{14} (Vermicompost + fish amino acid + panchagavya + biofertilizers) was found to be best in length of pods (36.84 cm), width of pods (0.69 cm), days of germination (3.3), number of pods per plant (37.70), number of seeds per pod (14.10), pod weight (17.63), pod yield (254.03 q ha^{-1}) followed by T_{13} (Vermicompost + Panchagavya +

Biofertilizers) with length of pods (36.19 cm), width of pods (0.66 cm), days of germination (3.7), number of pods per plant (37.17), number of seeds per pod (13.93), pod weight (17.10), pod yield (240 q ha^{-1}).

Mahata *et al*. (2018) conducted an experiment during early summer at Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal to study the direct and left over effect of organics on Buckwheat and ricebean-fodder cropping system. It consisted of 14 treatments carried out in RBD and the results demonstrated that application of vermicompost, poultry manure, mustard cake and farm yard manure improved seed yield of buckwheat by 0.51 and 0.53 t ha^{-1} RDF. Among the sole application of organic manures, the application of poultry manure at 5t ha^{-1} proved its superiority in terms of growth attributes.

Maltas *et al*. (2018) observed that organic fertilizers contribute to improved soil structure, offer a diverse array of plant nutrients, and introduce beneficial microorganisms into the soil and remarked that the widespread utilization of organic fertilizers in agricultural systems was driven by their positive effects on soil structure and crop yields.

Koireng *et al*. (2018) carried out an experiment to determine the residual effects of organic manure and micro nutrients on growth and yield parameters of green gram (*Vigna radiata*) in potato-green gram sequence and reported Treatment receiving 50% of T_1 + well decomposed FYM @ 10t ha^{-1} produced significantly taller plants (55.33 cm), better leaf area index (2.33), leaf area duration (43.28), dry matter production (389.80 g $m-^{2}$) and also significantly maximum number of nodules/plant (34.12). It may be due to the fact that more nutrient availability under INM treatments resulted into increased conversion of carbohydrates into protein which in turn elaborated into protoplasm and cell wall material increased the size of the cell, which expressed morphologically in terms of plant height, leaf area, number of branches and ultimately higher dry matter production. FYM, Neemcake is highly persistent composition material, which requires more time for its decomposition. Thus, organic have not been fully utilized by the potato crop in first crop season and notably benefitted the succeeding green gram crop.

Rahimabadi *et al*. (2018) found significant increase in grain yield of more than 800 kg ha^{-1} with 30 Mg of manure ha^{-1} in rice.

Adeyemo *et al*. (2019) found that 6 Mg ha^{-1} animal manure increased shoot dry biomass by 36% in sandy loam and 86% in clay. The study showed an increase in 1000 grain weight and straw weight with increasing fertilizer application. The research concluded that organic manure such as poultry manure could pose to be a viable tool in the improvement and stabilization of coarse textured, fragile and low in organic matter degraded alfisols.

In an trial conducted by Sachan and Krishna (2021) at Instructional Agriculture Farm Complex, College of Agriculture, Fisheries and Forestry, Koronivia Campus, Fiji National University, Fiji to study the influence of organic and inorganic fertilizers on growth and yield of (*Phaseolus vulgaris* L.), it was observed that combination of inorganic and organic fertilizers significantly increase the growth and green pod yield of French bean rather than inorganic fertilizers or organic manure alone for growth and yield of French bean. The combination of 100% NPK (200 kg ha^{-1}) along with poultry manure @ 5t ha^{-1} was found most effective for enhancing growth and yield.

2.3 Effect of Inorganic fertilizers on growth and yield attributes

Chemical fertilizers are used in modern agriculture to correct known plant nutrient deficiencies; to provide high levels of nutrition, which aid plants in withstanding stress conditions; to maintain optimum soil fertility conditions; and to improve crop quality. In essence, fertilizers are used to make certain that soil fertility is not a limiting factor in crop production.

According to a study conducted by Kumarsen *et al*. (2001), application of the recommended dose of P_2O_5 at a rate of 40 kg ha^{-1} had a notable and significant impact on various aspects of cowpea growth. Specifically, it led to a substantial increase in plant height, green fodder yield, and the production of dry matter compared to the control group. In fact, the experiment revealed that the addition of 40 kg ha^{-1} P_2O_5 resulted in a remarkable 75% increase in fodder yield compared to the control group, highlighting the positive effect of phosphorus fertilizer on cowpea growth and productivity.

Abayomi *et al*. (2008) conducted an experiment to study the effect of compound fertilizer (NPK) on growth and yield of genotypes of cowpea at Teaching and Research Farm, Nigeria and was carried out during 2002-2004. Ten cowpea genotypes were evaluated at different levels ranging from 0-300kg ha^{-1} (NPK). Results showed that application of fertilizer resulted in significant improvement in plant height, leaves per plant. Yield components and grain yield were enhanced significantly by application of 30 kg N, 15 kg P_2O_5, and 15 K_2O kg ha^{-1}.

Singh *et al*. (2008) conducted a two year study on the response of black gram (*Vigna mungo* L. Hepper) cv. JU 2, the optimum level of phosphorus through different sources was determined with or without application of PSB. Significantly highest seed yield was recorded due to application of 40 kg ha^{-1} through DAP with PSB and the increase in seed yield was attributed mainly due to increase in nodulation, plant height, branches per plant and pods per plant respectively.

Nayak *et al*. (2009) reported that among the various ricebean genotypes, RBL-6 performed the best with highest productivity of 776 kg ha^{-1} and N, P, K uptake of 49.1, 6.95 and 29.5 kg ha^{-1} respectively. The application of 40 kg N ha^{-1} recorded maximum seed yield of 889 kg ha^{-1} with harvest index of 23.68% and N, P and K uptake of 52.8, 7.15 and 31.16 kg ha^{-1}.

Singh *et al*. (2011) conducted a study in the wet season of 2006 at the Dry Land Teaching and Research Farm, Sokoto to evaluate the effect of phosphorus on the growth and yield of two cowpea varieties. Treatment consisted of four (4) rates of phosphorus (0, 20, 40, 60 kg ha^{-1}) combined with

(2) varieties of cowpea (KVX303096G and TN5-78) and laid out in a randomized complete block design (RCBD) replicated three (3) times. Results showed significant response to applied P on pods per plant, grain and stover yield and 100-seed weight with highest response to the application of 60 kg P ha^{-1} and concluded that KVX303096G and TN5-78 could both be sown under Sokoto condition to obtain reasonable yield.

Hansing (2014) reported that application of NPK @ 20:50:30 kg ha^{-1} recorded the tallest plant height at 30DAS (58.4cm), which may be concluded due to the fact that chemical fertilizer releases plant nutrient much earlier in comparison to organic manure which was also recorded in 30 DAS LAI.

Ibrahim *et al*. (2014) noted that inorganic fertilizers serve the purpose of supplying immediate nutrients to plants precisely when they require them. This stands in contrast to organic fertilizers, which typically exhibit a slower release capability. The rapid action of inorganic fertilizers allows for a more immediate response to the plant's nutritional needs and can be employed in accordance with the specific requirements of the farm. Additionally, inorganic fertilizers are often more cost-effective compared to commercial organic fertilizers and can be applied in larger quantities, making them a practical choice for agricultural operations.

Nkaa *et al*. (2014) conducted an experiment that consisted of five phosphorus levels (0, 20, 40, 60 and 80 kg ha^{-1}) each of which contained seven replicates. Phosphorus fertilizer significantly enhanced growth and yield characters of the cowpea varieties used; plant height, leaf area, number of leaves and number of branches in all the weeks of measurement were significantly improved. There was also significant effect ($p>0.05$) on seed yield per treatment, weight of 50 seeds, number of nodules, weight of nodules and total aboveground dry matter in all varieties used.

Behara *et al*. (2015) conducted a field experiment was conducted at the instructional farm of All India Co-Ordinate Research Network (AICRN) on

Potential Crops, Orissa during *kharif* to study the response of promising ricebean [*Vigna umbellata* (Thunb.) Ohwi & Ohashi] genotypes to different levels of nitrogen in a sandy loam soil with pH5.46, available nitrogen 230 kg ha^{-1}, available phosphorus 30.8 $kgha^{-1}$ and available potash 180.3 kg ha^{-1}. Twenty four (24) treatment combinations comprising of six (6) varieties in the main plot (RBL 1, RBL 6, RBL 35, Phulbani Local, BRB 5, BRBM102) and four levels of nitrogen (0, 20, 40 and 60 kg N ha^{-1}) in the sub- plot were tested in a split plot design with three(3) replications. Highest seed yield (790.08 kg ha^{-1}) was obtained from the variety BRBM 102 followed by Phulbani Local (702.08 kg ha^{-1}). Application of successive dose of nitrogen up to 40 kg ha^{-1} produced maximum seed yield of 865.06 kg $ha^{-1}$and stover yield of 2231.61kg ha^{-1}. Seed yield increased by 20.76, 39.79 and 49.65% with application of 40 kg N ha^{-1}over 20, 60 and 0 kg N ha^{-1} respectively. Variety BRBM102 recorded maximum yield attributing characters like number of clusters per plant (17.18), pods $plant^{-1}$ (61.38) and test weight (59.35g). Irrespective of varieties, application of 40 kg N ha^{-1} favourably influenced the yield attributing characters.

According to Pinell (2015) Inorganic fertilizers were classified as those fertilizers that are synthesized or mined from non-living materials. They are quick-release fertilizers; that is, the rate at which fertilizers release nutrients for the plant to absorb is relatively fast.

Kundu *et al*. (2015) concluded that with application of phosphorus there was significant increase on green fodder and dry matter yield. Application of phosphorus at 90kg ha^{-1} recorded maximum green fodder (385.20 q ha^{-1}) while 60 kg ha^{-1} gave maximum dry matter yield (51.54 q ha^{-1}). There was no significant difference between two levels of phosphorus for green fodder and dry matter yield, while application of phosphors at 90 kg ha^{-1} showed a positive effect on increase in crude protein.

Kumar *et al*. (2016) carried out a field experiment under AICRP on Forage Crops with the collaboration of Agrostologist of the Ranchi Veterinary College under Birsa Agricultural University, Ranchi during *kharif* season two consecutive years. Growth, yield and quality of rice bean genotypes influenced by phosphorus levels. Bidhan Rice bean produced more plant length (126 cm), green fodder yield (265.55 q ha^{-1}), dry fodder yield (58.42q ha^{-1}), crude protein content (13.11 %) and crude protein yield (7.66 q ha^{-1}) over the tested genotype of rice bean JRBJ-05-4.

Daramy *et al*. (2016) was conducted a field study in Department of Crop and Soil Sciences, Kwame Nkrumah University of Science and Technology, Ghana to evaluate the effect of nitrogen and phosphorus fertilizer rates on the crude protein content, nutrient concentration and nodulation of cowpea cultivar. The N fertilizer rates were 0, 10, 20, 30 and 40 kg N ha^{-1} applied as urea, while the P rates were 0, 15, 30 and 45 kg P2O5 ha^{-1} as TSP (46% P_2O_5). Number of nodules significantly decreased with an increase in N application rates - 0 kg N ha^{-1} giving the highest nodule number and 30 kg N ha^{-1} the least. Conversely, number of nodules increased significantly with an increase in P rates – it was lowest at 0 kg $P_2O_5ha^{-1}$ and highest at 45 kg $P_2O_5ha^{-1}$. All the other nodulation parameters were not significantly affected by N and P rates. Furthermore, cowpea seed N, seed crude protein and cowpea total plant N contents were significantly affected by N rates-the highest values were obtained at 30 kg N ha^{-1}. Interaction effect of N and P rates was significant for cowpea seed N, crude protein and plant total N and interaction of 30 kg N ha^{-1} and 0 kg P_2O_5 ha^{-1} gave the highest values for seed N, crude protein and plant total N.

Serme *et al*. (2018) conducted a study with four levels each of P and K in 7.5 and 10.0 kg ha^{-1} increments, respectively; Mg-S-Zn-B package and comparable with and without manure treatments. Yield increased due to P application always occurred with curvilinear to plateau or linear responses. The overall mean grain yield increase was 0.35 Mg $ha^{-1}$and 47% due to application of 22.5 kg ha^{-1} P. Manure application resulted in a mean yield increase of 0.1 Mg ha^{-1} in Niger but only with fertilizer P applied, and had no effect in Burkina Faso. Cowpea grain and fodder yields were responsive to fertilizer P up to 22.5 kg ha^{-1} but little affected by other applied nutrients as reported.

Shilpa and Wali (2018) conducted a field experiment was carried out on vertisols during summer at Bijapur district to study the performance of cowpea genotypes (KBC- 2, KM-5, IT-38956-1 and C-152) with different levels of phosphorus (25, 50 and75 P205kg ha^{-1}) under irrigated condition. The results indicated that seed yield (1397 kg ha-1) and harvest index (0.51%) higher with IT-38956-1 owing to higher number of pods per plant (16.78), number of seeds per pod (13.89) seed yield per plant (12.74g) and 100 seed weight (12.92 g) as compared to other genotypes such as (KBC-2, KM-5 and C-152) and among different levels of phosphorus, application of 50 kg P_2O_5 ha^{-1} significantly higher seed yield (1087kg ha^{-1}) than 25 and 75 kg P_2O_5 ha^{-1} due to higher yield contributing characters.

Sachan and Krishna (2021) in a study conducted during April to September at Instructional Agriculture Farm Complex, College of Agriculture, Fisheries and Forestry, Koronivia Campus, Fiji National University, Fiji to study the influence of organic and inorganic fertilizers on growth and yield of beans (*Phaseolus vulgaris* L.), it was observed on the basis of yield and growth performance treatment 100% NPK along with PM @ 5 t ha^{-1} was superior.

2.4 Effect of Integrated Nutrient Management on growth and yield parameters

Organic manures are eco-friendly and cheap sources of nutrients whereas chemical fertilizers being costly cause soil and environmental health hazards. Therefore, now-a-days integrated nutrient management system is followed for sustaining soil fertility as well as improving the crop productivity.

Kumarsen *et al*. (2001) reported that with application of recommended dose of P_2O_5 at 40 kg ha^{-1} led to significant record increase in plant height, green fodder yield and dry matter production of cowpea as compared to control. The experiment resulted that increase of 40 kg $ha^{-1}P_2O_5$ recorded increase on fodder and yield was increased by 75% than control.

Singh *et al*. (2002) revealed that integrated nutrient management means maintaining or regulating soil fertility and plant nutrient uptake to optimal levels to maintain desired crop productivity and, on the other hand, minimize nutrient loss to the environment. This is achieved through effective management all foods nutrient sources for a plant growing in soil include soil minerals and decomposing soil organic matter, mineral and synthetic fertilizers, animal manure and composts, by-products and wastes, crop residues and biological nitrogen fixation (BNF) .

Based on the evaluation of soil quality indicators, Dutta *et al*. (2003) reported that the use of organic fertilizers in combination with chemical fertilizers had a greater positive effect on microbial biomass and thus soil health compared to the addition of organic fertilizers alone. Application of organic fertilizer with chemical fertilizer has been reported to increase plant uptake of N, P and K in sugarcane leaf tissues and yield in comparison to chemical fertilizers.

A field experiment was conducted by Chand *et al*. (2006) continuously for seven years to evaluate the effects of combined applications on organic and chemical fertility development and nutrient uptake in a mint (*Mentha arvensis*) and mustard (*Brassica juncea*) crop sequence. The results showed that integrated supply of plant nutrients with FYM (farmyard manure) and NPK fertilizer and Sesbania green manure played an important role in maintaining soil fertility and crop productivity.

Ibeawuchi *et al*. (2007) concluded that application of inorganic and organic fertilizers increases plant growth mainly because they contain considerable quantities of plant nutrient, including micro nutrients which have high benefits for plant growth.

Izuchukwu *et al*. (2007) concluded that application of poultry manure with NPK increased maize yield and yield component. The results showed a synergistic effect of replacing inorganic with organic on both yield and yield components of Zea mays and soil improvement, and further suggested that farmers should combine NPK with fertilizer and PM for optimal yield, especially using poultry 8.0 t ha^{-1}.

Abayomi *et al.* (2008) conducted an experiment to study the effect of compound fertilizer (NPK) on growth and yield of genotypes of cowpea at Teaching and Research Farm, Nigeria and was carried out during 2002-2004. Ten cowpea genotypes were evaluated at different levels ranging from 0-300 kg ha^{-1} (NPK). Results showed that application of fertilizer resulted in significant improvement in plant height, leaves per plant. Yield components and grain yield were enhanced significantly by application of 30 kg N, 15 kg P_2O_5, 15 K_2O kg ha^{-1}.

Singh *et al*. (2008) conducted a two year study on the response of Black gram (*Vigna mungo* L. Hepper) cv. JU 2, the optimum level of phosphorus through different sources was determined with or without application of PSB. Significantly highest seed yield of 651 kg ha^{-1} was recorded due to application of 40 kg ha^{-1} through DAP with PSB. The increase in seed yield was attributed mainly due to increase in nodulation, plant height, branches per plant and pods per plant respectively.

Masanta and Biswas (2009) remarked that the increased use of fertilizer will undoubtedly increase the production of raw materials significantly, but in the long run it will have a negative impact on soil health, however, in the case of INM approach, careful application of all nutrients can sustainably improve soil fertility and economic yields.

Nayak *et al*. (2009) reported that among the various ricebean genotypes, RBL-6 performed the best with highest productivity of 776 kg ha^{-1} and N, P, K uptake of 49.1, 6.95 and 29.5 kg ha^{-1} respectively. The application of 40 kg N ha^{-1} recorded maximum seed yield of 889 kg ha^{-1} with harvest index of 23.68% and N, P and K uptake of 52.8, 7.15 and 31.16 kg ha^{-1}.

Aspasia *et al.* (2010) reported that combined organic and inorganic fertilizers resulted in higher increase in photosynthetic rate and stomatal conductance compared with those found under inorganic fertilization. Sustainability yield indices (sustainable yield index and agronomic efficiency) also indicated that the maize crop was more stable under combined organic and inorganic fertilization compared with mineral fertilization and it further increased yield and yield component of sweet maize.

Tagoe *et al*. (2010) reported on the impact of utilizing chicken manure and inorganic fertilizers on various grain legumes and observed that chicken manure proved effective in terms of providing total nitrogen as a fertilizer, exhibiting a significant residual effect. The application of chicken manure positively influenced grain yield, grain quality, and straw yield, with improvements noted in response to the rate of chicken manure used.

Arjumand *et al.* (2013) from a study indicated that the application of Farm yard Manure and poultry manure and chemical fertilizer (NPK) had significantly influence on morphological character like plant height, number of branches, number of leaves and number of pods per plant of common bean. The application of growth promoting substance increased the plant height of such effect was due to the increase photosynthetic activities, enhancement in the mobilization of plants and change in the membrane permeability.

Subba *et al*. (2013) reported that integrated nutrient management was a comprehensive production control system that promotes and improves agro-ecosystem health in terms of biodiversity, nutrient bio-cycles, and soil biological and microbiological activity.

Ghosh *et al*. (2014) confirmed that the integration of organic and inorganic sources of plant nutrients has proved superior to individual components with respect to growth, yield and quality of pulses.

Omotoso and Olusegun (2014) investigated on the effects of NPK 15-15-15 fertilizer and pig manure on nutrient dynamics and cowpea production of six treatments in RBD. The results showed that 8t ha^{-1} PM and 60 kg NPK produced significantly more nodules per $plant^{-1}$, dry matter, number of pods, number of seeds per pod^{-1} and 100 seed weight, respectively.

Falodun *et al*. (2015) concluded that integration of organic and inorganic fertilizers provide the necessary nutrients at the right time, aiding optimal distribution of dry matter from the source to the reproductive stage in soybean resulting to increase in seed yield. The right blend of organic and inorganic fertilizers appeared to have improved the yield by enhancing the availability of essential compounds and photosynthates.

Jat *et al*. (2015) declared that the application of organic material along with inorganic fertilizers into the soils leads to increase in productivity of the cropping system enhance the use efficiency of fertilizer input and sustain the soil health for longer period.

Issac and Mathew (2016) carried out to study the influence of different sources of nutrients on seed production in vegetable cowpea during 2010-11 in RBD, with twelve combinations of nutrient sources. Results showed significant variation in seed yield potential in the crop with highest seed yield (435.97 kg ha^{-1}) were recorded in the treatment, where recommended NPK dose for the seed crop was applied along with vermicompost at 50% nitrogen substitution. Germination percentage and 100-seed weight was significantly higher in treatments receiving a combination of vermicompost and poultry manure.

Getachew and Tilahun (2017) reported that integrated use of organic and inorganic fertilizers for tackling soil fertility depletion and sustainably increasing crop yields had a paramount importance.

Yadav *et al*. (2017) observed that the increase in plant height under various inorganic fertilizer levels alone and in combination with organic sources might be due to increasing availability of nutrients to the plants.

Serme *et al*. (2018) conducted a study with four levels each of P and K in 7.5 and 10.0 kg ha^{-1} increments, respectively; Mg-S-Zn-B package and comparable with and without manure treatments. Yield increased due to P application always occurred with curvilinear to plateau or linear responses. The overall mean grain yield increase was 0.35 Mg ha^{-1}and 47% due to application of 22.5 kg ha^{-1} P. Manure application resulted in a mean yield increase of 0.1 Mg ha^{-1} in Niger but only with fertilizer P applied, and had no effect in Burkina Faso. Cowpea grain and fodder yields were responsive to fertilizer P up to 22.5 kg ha^{-1} but little affected by other applied nutrients as reported.

Koireng *et al.* (2018) carried out an experiment to determine the residual effects of organic manure and micro nutrients on growth and yield parameters of green gram (*Vigna radiata*) in potato-green gram sequence and reported that significantly higher seed (952.05 kg ha^{-1}) and stover yield (2638.852 kg ha^{-1}) of green gram were recorded in treatment receiving 50% of (T_1) NPK @ 200 :150 :150 kg ha^{-1} + Well decomposed FYM @ 10 t ha^{-1}, but remained statistically at par (830.51 Kg ha^{-1}, 2522.127 Kg ha^{-1}) with the treatment receiving 50% of T_1 + well powder Neemcake @ 0.5 t ha^{-1} to rabi potato. It may be ascertained to the increased availability of nutrients due to mineralization of organic materials, release of CO_2 increasing fertilizer use efficiency, accumulation of organic carbon and improvement of soil physical properties. The increased green gram seed yield might be due to addition of FYM or neem-cake to preceding *rabi* potato resulting in improvement in soil structure which reduced the soil crust and also serves as a source of energy for soil microflora which resulted in better root nodulation and nitrogen fixation. And significantly, higher stover yield under above treatments might be due to increase in vegetative growth in terms of plant height, number of branches, leaf area.

Smriti and Ram (2018) investigated the impact of different fertilizers—organic, inorganic, and bio—on yield and yield attributing characters on okra crop. The results indicated that the combination of 50% RDF with vermicompost exhibited superior performance, followed by 75% RDF with phosphate solubilizing bacteria. The conclusion drawn from the study suggests that the application of 50% RDF with vermicompost in the 'kashipragati' variety led to enhanced growth, yield, and nutritional quality of okra in the study area.

Jan *et al*. (2019) carried a study to evaluate the effect of integrated nitrogen management on growth performance characteristics of French bean (*Phaseolus vulgaris* L.) var. contendor under temperate conditions of Kashmir valley during kharif season of 2014 at the research farm of SKUAST-K, Shalimar, Srinagar. The results revealed that application of 75% N through urea + 25% N through vermicompost + biofertilizer (Rhizobium) (22.5 kg N + 0.55 t ha^{-1} + 20 g kg^{-1} seed) recorded maximum growth plant height (29.13 cm), plant spread (29.17 cm), maximum number of branches per plant (5.70) and maximum plant biomass (25.70 q ha^{-1}) and yield characters like Maximum seeds per pod (5.50), Maximum 100-seed weight (40.02 g), maximum seed yield (23.96 q ha^{-1}) and stover yield (29.20 q ha^{-1}) . Thus, it was concluded that integrated nitrogen management (INM) improved the growth and yield of French bean.

In the study conducted by Priya *et al*. (2019), it was found that the incorporation of Biofertilizers within Integrated Nutrient Management (INM) proves to be a cost-effective, environmentally friendly, and renewable alternative. This approach offers a non-bulky, economical solution for supplementing plant nutrients, thereby reducing the reliance on chemical fertilizers in sustainable agricultural systems in India.

Parween (2019) during 2018-2019, carried out an experiment on integrating nutrient management into French bean to observe that a combination of organically and inorganically produced fertilizer contributed to both characters and yields. In some treatments vermicompost and biofertilizer have been shown to be better when used with a suitable combination of nutrients. The use of 75 % RDF + 25 % vermicompost along with biofertilizer had been shown to produce a higher yield of 97.43q ha as compared to alternative treatments.

Pandey *et al*. (2019) remarked that the optimal conditions for green gram cultivation involved the application of a combination of 75% NPK, 5 tons of Farm Yard Manure (FYM) ha^{-1}, along with Phosphorus Solubilizing Bacteria (PSB) and Rhizobium. This combination resulted in the highest observed values for various growth parameters, including plant height, number of leaves and pods, number of branches, as well as the yield of root nodules, grain, and straw. Additionally, the application of P_2O_5 at a rate of 80 kg per hectare in combination with PSB also demonstrated significantly enhanced growth and yield attributes in Green gram.

Wahyuningsih *et al*. (2019) demonstrated that the brief application of inorganic fertilizers led to a notable increase in soil fauna feeding activity within 2 days, as compared to the levels observed before the fertilizer application.

Biswas *et al*. (2020) observed that the application of 100% recommended dose of fertilizer (RDF) along with S_{40} Zn_5 $B_{1.5}$ at a rate of ha^{-1} demonstrated significant superiority over other treatments, including 100% RDF, 75% RDF + 25% nitrogen (N) through sludge, 75% RDF + 25% N through vermicompost, and 75% RDF + 25% N through Sesbania, as well as the control, at various stages concerning plant height and dry matter accumulation per hill. The observed increase in plant height is attributed to the ample supply of essential macro and micronutrients, including sulfur (S), zinc (Zn), and boron (B), provided by the chemical fertilizers used in the study.

Shankar *et al*. (2020) found that the highest Dry Matter Accumulation (DMA) was observed in the treatment with 75% recommended dose of nitrogen (RDN) from chemical fertilizers + 25% RDN from poultry manure (T_4). This was closely followed by treatments using 100% RDN (T_5) and 75% RDN + 25% RDN through farmyard manure (FYM) (T_8). Conversely, the control treatment, where no fertilizer was applied, exhibited the lowest DMA. These findings reported the importance of combining both organic and inorganic fertilizers for enhanced crop growth in terms of dry matter accumulation, ultimately contributing to increased productivity in summer rice cultivation.

Longmatula *et al.* (2021) revealed that the application of different levels of fertilizers, organic manures and biofertilizers either alone or in combination significantly increased the growth, yield and quality of French bean as compared to control. It was concluded that integrated use of 50% NPK through inorganic source + 50% vermi-compost produced the higher pod yield with quality produce under Nagaland conditions.

Behera *et al.* (2021) reported that the combined application of fertilizer and farmyard manure (FYM) demonstrated more favorable outcomes compared to the sole use of chemical fertilizer. The integration of FYM with inorganic fertilizer contributed to an additional boost in grain yield. Notably, the application of 50% recommended dose of fertilizer (RDF) in conjunction with FYM alone led to a significant increase in grain yield compared to the control, and this yield was comparable to that achieved with 75% doses of RDF.

Changkiri *et al*. (2023) from an investigation on integrated nutrient management of French bean (*Phaseolus vulgaris* L.) concluded that in Arka Komal, the application of inorganic fertilizers when combined with organic sources of compost/manures resulted in better growth and yield of French bean in acidic soil of subtropical plain zone of Nagaland, India and the application of T_3 (75% NPK through inorganic + 25% N through vermicompost) resulted in best yield while integrated treatment of T_2 (75% NPK through inorganic + 25% N through FYM) is best with highest benefit cost ratio followed by T_3 (75% NPK through inorganic + 25% N through vermicompost).

Mishra (2023) observed that the application of a combination of 75% Poultry Manure and 25% Di-Ammonium Phosphate (DAP) had markedly enhance various growth parameters in green gram, which included a significant increase in plant height, the number of branches per plant, dry weight, nodules per plant, grain yield, straw yield, as well as the number of pods per plant and suggested that the use of this specific mixture has a positive impact on the overall productivity and growth of green gram crops.

2.5 Effect of integrated nutrient management on soil and microbial properties

Microbial biomass carbon (MBC) may be increased due to the provision of additional mineralizable and readily hydrolytic carbon as a consequence of the application of organic matter, resulting in increased microbial activity and consequently higher MBC.

Parham *et al*. (2003) showed that fertilizer application attracts the soil bacterial community resulting in improved soil productivity. In addition, fertilizer application increases the diversity of soil fungi and, when used in conjunction with inorganic fertilizers, reverses the loss of microbial biodiversity associated with the application of inorganic nutrients alone.

Zhu *et al*. (2003) reported that microbial activity reflected on microbiological processes of soil-microorganisms that include bacteria and fungi in different proportions depending on the soil system.

Bending *et al*. (2004) remarked that the size of microbial biomass can be taken as an indicator of soil fertility and indicator of soil quality, which also largely depend on the rate of nutrient flux (Singh *et al*. 2007) and the quality and quantity of organic inputs (Peacock, 2001) determining the community structure observed that the size of the microbial biomass can be considered as an index of soil fertility and indicator of soil quality, which depends primarily on rate of nutrient fluxes (Singh *et al*. 2007), and quality and quantity of organic inputs determining the community structure.

Sun *et al*. (2004) reported that organic amendments, such as compost, green manures, and sewage sludge, tend to increase soil microbial biomass, soil respiration, and the activity of soil enzymes, as well as SOC and plant nutrient concentrations. Changes in the composition of the soil microbial community are also observed following the addition of both organic and inorganic changes.

Fan *et al*. (2005) reported that the integrated supply of inorganic and organic sources of fertilizers had enhanced water use efficiency and soil chemical properties.

Kaur *et al*. (2005) compared the change of chemical and biological properties in soils receiving FYM, poultry manure and sugarcane filter cake alone or in combination with chemical fertilizers for seven years under a cropping sequence of pearl millet and wheat and the showed that all treatments except chemical fertilizer application improved the soil organic C, total N, P and K status. There had also been increase in microbial biomass C and N was observed in soils receiving organic manures only or with the combined application of organic manures and chemical fertilizers compared to soils receiving chemical fertilizers. This study proved that balanced fertilization using both organic and chemical fertilizers is important for maintenance of soil organic matter (OM) content and long-term soil productivity in the tropics where soil OM content is low.

Nayak *et al*. (2007) demonstrated that enhanced dehydrogenase activity with both compost and inorganic fertilizer application under continuous rice growing situations and explained a significant relationship between SMBC.

Ewulo *et al.* (2008) found that application of chicken manure at 10, 25, 40 and 50 Mg/ha increased SOM levels by 0.85, 1.50, 1.72 and 1.95% compared to no control manure.

Garg and Bahl (2008) found an increase in alkaline phosphatase activity with incorporation of inorganic and organic fertilizers. The increase over the years with inorganic nutrients attributed to the increased root biomass input due to improved crop productivity; with FYM, it may be attributed to increased microbial activity and possibly diversity of phosphate-soluble bacteria due to manure inputs over the year.

Alabadan *et al*. (2009) reported that organic manures viz., FYM, poultry manure help in the improvement of soil structure, aeration and water holding capacity of soil. Further, it stimulates the activity of microorganisms that makes the plant to get the macro and micro-nutrients through enhanced biological processes, increase nutrient solubility, alter soil salinity, sodicity and pH.

Aziz *et al*. (2011) reported that applying the recommended dose of inorganic and organic fertilizers along with 10t ha^{-1} FYM improved the soil properties. Dual inoculation with rhizobium + PSB have shown significantly superior results and improved soil physical properties over no-inoculation.

Dhok (2011) reported that the population of soil fungi, bacteria and actinomycetes was favoured under INM modules soybean-wheat and soybean-gram cropping system. The value of N,P and K status of soil was found significantly superior with 50%RDF + FYM at 5 t ha^{-1} over organic or inorganic modules.

Wanjari *et al*. (2013) revealed that application of recommended dose of NPK with FYM or lime further increased and improved the richness of soil microbial fauna in terms of their population, active pools and enzymatic activity of nutrients.

Shirale *et al*. (2014) revealed that the improvement of soil properties concerning to soil pH, EC, OC available NPKS and Zn was prominent with application of FYM 10Mg ha^{-1} + 100% NPK.

Baishya *et al*. (2015) observed that the incorporation of inorganic fertilizers alongside organic manures aids in mineralization, facilitating the swift conversion of organically bound nutrient forms into organic forms. However, it was noted that crops receiving the same organic manure along with varying levels of inorganic fertilizers did not exhibit significant variations in the soil's organic carbon content.

Sannathammappa *et al*. (2015) found that the use of inorganic fertilizers together with soil-applied organic fertilizers increased the available nutrient status of plants and improved the physico-chemical and biological properties of the soil, which directly affect soil fertility.

Wang *et al*. (2015) reported that over a period of 23 year period, sole pig manure and in combination with N, P and K increased SOC by 25% and 30% relative to the treatment without any additional fertilizer or manure.

Anik *et al*. (2017) concluded that poultry manure amendment in combination with chemical fertilizers under rice growing conditions resulted in the most biologically active soils with higher levels of microbial biomass carbon (MBC) and nitrogen (MBN) and it proved that poultry manure was a more efficient organic amendment than cow dung and rice straw for increasing soil fertility. The application of organic residues also increased the pH, and SOC, N, P, and K contents of the soil, further improving soil fertility. Compared with the initial soil, the poultry manure treatment increased the soil pH from an acidic (5.85) to neutral (7.17) state, SOC by 62%, available P by 187%, total N by 112%, and exchangeable K by 77%, though the latter two were similar to other organic amendments. The soil water holding capacity and bulk density increases that were observed following the application of organic residues reflected the microbial biomass improvements as a result of the same treatments, with poultry manure having the greatest effect and rice straw the least effect. The maximum MBC and MBN were found in the poultry manure treated plots at harvest (432 and 31.6 mg kg^{-1}, respectively) and the findings showed that the regular application of organic materials to soils using whatever sources available will increase the microbial dynamics and nutrient pools in the soil, enhancing soil fertility and productivity.

Kumar *et al*. (2017) conducted a study to investigate the effect of integrated nutrient management on soil enzymes, microbial biomass carbon and microbial population under okra cultivation and the results indicated that there was the improvement in soil biological properties and soil enzymes in all plots over the initial value. The biological properties like Microbial Biomass Carbon (MBC) (244.86 µg g^{-1}), bacterial population (8.24 log cfu g^{-1} soil), fungal population (3.89 log cfu g^{-1} soil), soil enzymes like fluorescein di-acetate (FDA) (7.28 µg fluorescein g^{-1} soil h^{-1}), phosphomonoesterase (PME) (50.15 µg p-nitrophenol g^{-1} h^{-1}), deydrogenase (DH) (136.90 µg TPF g^{-1} soil 24 h^{-1}), Arylsulphatase (14.16 µg p-nitrophenol g^{-1} h^{-1}) and Arylesterase activity (113.92 µg p-nitrophenol g^{-1} h^{-1}) was found in the treatment T_3 [at 50% recommended dose of N, P, K + Vermicompost at the rate of 2 t ha^{-1} (mixed with microbial consortium). It was concluded that addition of good quality organic matter along with biofertilizers helped in increasing soil biological properties which has been considered as a good indicator of high-quality soil, as these biofertilizers provide a good amount of nutrients and growth substances which is essential for good growth and development of plants. Therefore, INM practices should be adopted which helped in reduced application of inorganic fertilizers and also maintain the soil production potential for a longer period of time.

Bhatt *et al*. (2019) concluded that with implementation of 100% NPK was applied (15 t FYM h^{-1}) maximum microbial population - bacteria (24.8 and 29.8 cfu x $10^6 g^{-1}$), fungi (25.4 and 25.9 cfu x 10^4 g^{-1}), actinomycetes (40.1 and 41.9 cfu x 10^5 g^{-1}) 10 after rice and wheat crops were recorded while the lowest population was observed when NPK was not applied (control).

Lokose *et al*. (2019) conducted a field trial during 2015-16 and 2016-17 on loamy soil to asses impact of herbicides and nutrient management on soil microbial populations in mazie + cowpea intercropping system. The results revealed that a higher value of the microbial population was observed under the combined application of recommended NPK+FYM and lime compared to mere doses of recommended NPK.

Singh *et al*. (2019) found that the most effective treatment for Green gram involved the application of 75% of RDF along with Phosphorus Solubilizing Bacteria (PSB), 2.5 tons per hectare of vermicompost, and rhizobium. This particular combination resulted in significantly higher levels of nitrogen, phosphorus, and potassium content and uptake by Green gram plants. Additionally, it led to increased availability of nitrogen, phosphorus, and potassium in the soil, indicating the positive impact of this treatment on both nutrient content in the plant and soil.

In the study conducted by Kalaiyarasi (2019), it was noted that the use of 75% RDF along with bio-fertilizers, vermicompost, and castor cake resulted in a substantial increase in the availability of nutrients in the soil. The integration of organic materials, whether in the form of crop residue, organic manure, or amendments, was found to have a notable impact on the bulk density of agricultural soils. Additionally, it influenced soil aggregation, structure, moisture retention capacity, and infiltration rate.

Tiwari *et al*. (2020) reported that the application of fertilizer in combination with organic manure is known to improve various soil physico-chemical properties resulting in enhanced nutrient absorption and uptake.

In a field experiment conducted at Deendayal Research Institute Krishi Vigyan Kendra Chitrakoot UP to assess the residual impact of Integrated Nutrient Management and direct effect of inorganic fertilization on Wheat (*Triticum aestivum*) for yield attributes, yields, nutrient uptake and economics during Rabi season of 2008-09 and 2009-10, including residual effect of 3 different doses of inorganic fertilizers and 3 different manures (FYM, Vermi-compost and Cow Pat Pit) and direct 3 doses of inorganic fertilizers to wheat, Singh and Kushwaha (2020) concluded that residual impact of 50% NPK and FYM @ 10 tha^{-1} and 100 recommended dose of fertilizers to wheat obtained significantly higher values of Gross return (Rs.54372 and 62083 ha^{-1}), Net return (Rs. 42479 and 48213 ha^{-1}) and B:C ratio (4.57 and 4.48) during both years, which may be due to use of balanced dose of NPK to wheat with residual response of organic manures and inorganic N and P and Consequently, higher soil microbial activity with the presence of organic matter, which ensured higher availability of NPK thus it, increased root cation exchange capacity.

Bairwa *et al*. (2021) reported that the project on long term fertilizer application with soybean-wheat cropping sequence since 1972 at Research Farm of Department for Soil Science and Agricultural Chemistry, JNKVV Jabalpur, it was observed that there were significant increase in soil carbon, total N recorded with 100% NPK + FYM. The bacteria, fungi and actinomycetes population counts in the soil were 39.1 x 10^7, 42.7x10^4 and 39.1x105 cfu g^{-1} soil respectively with the application of 100% NPK + FYM over control (11.7 x 10^7, 18.5x10^4 and 13.6x10^5 cfu g^{-1} soil)

Gogoi *et al*. (2021) reported that the application of different organic manures significantly affected the plant height, number of primary branches per plant, number of siliquae per branch, number of seeds siliqua and 1000-

seed weight of toria crop. With the addition of organic manure significantly, the study revealed that there was enhancement of the soil organic carbon, microbial biomass carbon and available NPK in the soil over initial. It was concluded that the qualitative differences between organic manures could be responsible for the difference in crop yield and in soil health. The application of vermicompost to toria crop improved the soil health with respect to carbon and available nutrient status and microbial activities in the soil.

2.6 Effect of INM on nutritional quality and nutrient uptake

Motavalli and Miles (2002) remarked that was an increase in the macro and micro nutrients as a result of manure application which showed positive effects on the growth and productivity of crops.

Rajkhowa *et al*. (2003) reported that there had been significant increase in the yield, nutrient (N and P) uptake and nodulation of green gram under the integrated use of fertilizer and vermicompost.

Bhat *et al*. (2007) reported that the application of FYM-N (20 kg N) + 2.75% fertilizers N (60 kg N) + 40 kg S ha^{-1} resulted in maximum oil content and protein content in mustard.

Omraj *et al*. (2007) reported that application of 1.5t ha^{-1} vermicompost recorded the highest total nutrient uptake by maize – nitrogen (153.56 kg ha^{-1}), phosphorus (32.04 kg ha^{-1}), and potassium (38.71 kg ha^{-1}) and protein content of maize as compared to 1.0, 1.5 t ha^{-1} and control.

Gupta *et al*. (2010) reported that the amino acid profile of cowpea varied based on the genotypes of cowpea. In comparison between the amino acid content in seven genotypes of cowpea where the maximum and minimum content of total essential amino acids were 33.43 g/100 g and 27.50 g /100 g protein respectively.

Adeyemi *et al*. (2012) conducted an experiment in the Eastern Cape region of South Africa to test the effect of manure application on the leaf crude protein content of six cowpea genotypes (Vegetable cowpea, Ivory grey, Okhalweni, Fahari, Fahari dark, and 97 K-1069-8) in a green house. Fresh leaves were collected from each cowpea plant 21 days after planting and ground in liquid nitrogen for protein extraction and quantification. The results reported that Fahari had the highest concentration of crude protein (46.51 mg ml^{-1}) while vegetable cowpea (24.41 mg ml^{-1}) had the lowest without the influence of manure application. However, upon application of manure (goat), Fahari dark had the highest crude protein concentration (53.53 mg ml^{-1}) while vegetable cowpea had the lowest (29.08 mg ml^{-1}). Fahari, 97K-1069-8, Ivory grey, and Okhalweni contained 51.79, 49.03, 44.83, and 38.33 mg/ml crude protein concentrations, respectively. The study demonstrated that genotypes as well as manure application significantly influenced cowpea yields in terms of its leaf crude protein content.

Khandelwal *et al.* (2012) concluded that in seed inoculation, Rhizobium + PSB treatment provided the significant increase in content of nutrients coupled with increased seed and straw yield which enhanced the total uptake of nitrogen and phosphorus and in protein content (26.81%). Protein content is essentially the manifestation of nitrogen content in seed.

Leela *et al*. (2012) reported that 50% recommended N applied through urea + 50% N through FYM + PSB recorded significantly higher number of pod plant-1, test weight , seed yield, oil content and oil yield in soybean. The uptake of nutrients (N,P, K , Ca, Mg, S, Cu, Zn, Fe and Mn) was positive and significant.

Premanantharajah and Prapagar (2013) in an investigation to determine the effect of poultry manure as partial substitute for P and S on the yield and quality of groundnut, it was concluded that combining poultry manure with chemical fertiliser significantly increased the pod yield, the protein content, and the oil content of the kernel. It was found that the treatment combining 25% poultry manure with 75% chemical fertiliser had the highest pod yield and the greatest increase in oil content (45.20%), while the treatment combining

75% poultry manure with 25% chemical fertiliser had the highest protein content (12.50%).

Rani and Sukumari (2013) reported that the maximum total N, P, K, Fe, Zn and Mn uptake by medicinal rice (Njavara) was recorded under INM source rather than sole application of inorganic and organic sources.

Ghosh *et al*. (2014) provide that the uptake of N, P, K, S, Ca and Mg by both straw and grain of rice were significant due to the use of integrated nutrient management. The highest nutrient uptake was recorded from the treatment application of RDF for HYG + cowdung @ 5 t ha^{-1} based on IPNS and the least value was recorded from controlled plot.

Kumar *et al*. (2014) proved that the application of inorganic and organic sources of nutrients combined increased N uptake in grian (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.

Animasaun *et al*. (2015) carried out a study on ten cultivars of cowpea grown for evaluation of their genetic similarity and variability at Botanical garden, University of Ilorin, Nigeria. Data were collected on vegetative, fruiting and seed characters and analysis were conducted to determine variation in nutrient composition of the seeds at harvest. The results showed considerable variations in growth and yield characters evaluated. Cultivars NGB/06/047, IFE BROWN 2012 and IT98K-133-1-1 had optimal growth performance with respect to fruiting and seed yield parameters. Proximate results indicated that crude protein varied from 23.42-26.78%. Ash content ranged between 3.60-4.21%, crude fibre varied from 2.10-2.98%, and carbohydrates 56.10 - 59.59%. Principal components analysis revealed that first principal components (majorly fruiting and seed characters) accounted for 26.63% observed variation, followed by the second component (23.05%) which are mainly vegetative parameters while third (13.82%) consisting of nutritional variations.

Baishya *et al*. (2015) reported that among the several organic sources, the crop receiving 2.5 t poultry manure ha^{-1} along with 75 kg N + 16.5 kg P + 31.3 kg K ha^{-1} improved nutrient uptake and crop profitability (Rs 366.28 ha^{-1} day^{-1}) over the other treatments.

Kansotia *et al*. (2013) reported that the application of 80 kg N + 40 kg P ha^{-1} + vermicompost up to 6 t ha^{-1} resulted in highest oil content and protein content in mustard.

Lolita *et al*. (2015) reported that the combination of 5 Mg organic fertilizer (manure or Crotalaria compost), 50% recommendation fertilizer plus VAM was an efficient fertilization to improve P fertilizer uptake efficiency (PUE), productivity and quality of ricebean crop.

Chauhan *et al*. (2016) reported from an investigation that protein content recorded maximum with treatment of vermicompost + neem cake + mustard cake + biofertilizers (Rhizobium and PSB).

Kichu *et al*. (2016) reported that the highest accumulation of available N, P and K was found in NPK + Poultry litter, NPK litter, NPK + FYM and ½ N + PK + ½ N Forest litter respectively.

Kumar *et al*. (2017) concluded from an experiment that INM increased the nutrient uptake as well as the efficiency of nutrient use and thus integrated nutrient management of chemical and organic sources in rice were found to be more viable for sustaining productivity and improving the efficiency of organic fertilizers.

Yadav and Singh (2018) reported from a study to determine the effect of integrated nutrient management on yield and quality of oat, it was concluded that the integrated use of inorganic fertilizer along with organic sources had positive and significant effect on green foliage and dry matter yield of oat crop. The higher yield of oat fodder could be achieved by adopting integrated nutrient management (75% NPK + FYM @ 10 tonnes ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}). Application of 75% NPK + FYM @ 10 tonnes ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} proved significantly superior to other treatments in respect of crude fibre, crude protein, reducing and non-reducing sugar content. The various INM treatments showed significantly better results in term of over control.

Desai *et al*. (2018) from an experiment conducted to study the effect of integrated nutrient management on growth, herb yield and quality of alfalfa (*Medicago sativa* L.) at the farm field of Krishi Vigyan Kendra, Konehalli, Tiptur, Tumkuru district under Central dry zone (Zone-4) of Karnataka state during *rabi* seasons concluded that the maximum crude protein content of plant was recorded at first (7.14 %) second (7.10 %), with 50 % RDF + 25 % N through vermicompost + Rhizobium + PSB + VAM. The application of 10 t ha^{-1} FYM + 100 % N through FYM recorded least crude protein content of plant during *rabi* season at all the harvests. The increased crude protein content of plant may be attributed to higher level of nitrogen supplied through atmospheric nitrogen fixation and the application of vermicompost, which enhanced the maximum availability of nitrogen to the plant.

Krishnaprabu (2018) revealed that the application of RDF in combination with rhizobium and Phosphorus Solubilizing Bacteria (PSB) through seed inoculation at a rate of 600 g per hectare, along with foliar spraying of 2% DAP and 40 ppm NAA, combined with salicylic acid at 100 ppm at 30 and 45 days after sowing (DAS), resulted in increased green gram yield. It was noted that the integrated nutrient management approach not only enhanced nutrient uptake but also improved the physico-chemical and biological properties of the soil, creating a more favorable environment for crop growth. The system exhibited higher uptake of nitrogen (N), phosphorus (P), and potassium (K) when subjected to the mentioned treatment combinations, and the use of biofertilizer contributed to maintaining soil fertility by preserving available nutrients.

Ram *et al*. (2020) found that the nitrogen (N) content in both grain and straw of summer rice reached its maximum in treatments where 75% of the recommended dose of nitrogen (RDN) was supplemented with 25% nitrogen through vermicompost (T_2). This was closely followed by the treatment involving 75% RDN and 25% RDN through farmyard manure (FYM) (T_3), as well as the treatment with 100% RDN (T_1). In the straw, the N content of treatment T_3 (75% RDN + 25% RDN through FYM) was significantly higher than that of the treatment involving 50% RDN and 50% nitrogen through vermicompost (T_4). Regarding phosphorus (P), the content in both grain and straw under various nutrient management treatments was comparable, except for the control treatment (T_8), which exhibited significantly lower P content compared to the others.

Tiwari *et al*. (2020) observed variations in the nutrient content (%) of grain and straw, as well as their uptake, in response to different Integrated Nutrient Management (INM) practices. The treatment T_{10}, which involved 100% recommended dose of fertilizer (RDF) through inorganic fertilizers (IF) along with 25% recommended dose of nitrogen (RDN) through Neem Cakes, exhibited the highest levels of nitrogen (N), phosphorus (P), and potassium (K) content in both grains and straw. Following closely, T_9 (100% RDF through IF + 25% RDN through Poultry Manure) also showed elevated nutrient content in grains and straw; these findings remained consistent across various INM practices.

The findings of Vigneshvarraj (2020) demonstrated that a combined approach involving the recommended dose of NPK, Zn enriched composted coir pith (ZnECCP) at a rate of 6.25 tons ha^{-1}, Rhizobium at 2.0 kg ha^{-1} applied through both soil and foliar spray of pink pigmented facultative methylotrophs (PPFM) at 1.0 percent twice during pre-flowering and flowering stages significantly improved the growth, yield, and nutrient uptake of green gram.

Dubey *et al*. (2021) reported that application of 50% RDF + FYM @ 2.5t/ha + Vermicompost @ 0.62t/ha + Bio-fertilizers @ 7.5kg ha^{-1} + $ZnSO_4$ @ 10kg ha^{-1} followed by 75% RDF + Vermicompost @ 0.62t ha^{-1} + Biofertilizers@ 7.5kg ha^{-1} gave highest oil content (40.15% and 39.57%), oil yield (933.48 kg ha^{-1} and 906.15kg ha^{-1}), protein content (17.37% and 17.35%) and protein yield (403.85 kg ha^{-1} and 397.315 kg ha^{-1}) respectively.

Kaur and Kumar (2022) in a trial to evaluate the growth, yield and quality of Indian mustard [*Brassica juncea* (L.) Czern. & Coss.] influence by integrated nutrient management concluded that the maximum oil content (39.65%) was obtained with in T_7 (100% RDF + 2 t FYM ha^{-1} + 20 kg S ha^{-1} + 20 kg ZnSO4 ha^{-1} + 1 t vermicompost ha^{-1} + Azotobacter Seed treatment) which were statistically at par recorded in T_6 (100% RDF + 2 t FYM ha^{-1} + 20 kg S ha^{-1} + 20 kg ZnSO4 ha^{-1} (38.38%) which significantly superior to rest of all the treatments. The maximum protein content (20.98%) was obtained with in T_7 (100% RDF + 2 t FYM ha^{-1} + 20 kg S ha^{-1} + 20 kg $ZnSO_4$ ha^{-1} + 1 t vermicompost ha^{-1} + Azotobacter Seed treatment) which were statistically at par recorded in T_6 (100% RDF + 2 t FYM ha^{-1} + 20 kg S ha^{-1} + 20 kg $ZnSO_4$ ha^{-1}) which recorded the value of 20.31% which was significantly superior to rest of all the treatments.

Singh *et al*. (2023) concluded that the rapeseed and mustard crops production, profitability, and quality were all supported by integrated nutrition management; as the integration enhanced and maintained the soil's fertility and production while maintaining ecological balance. The review also concluded that in order to produce high-quality crops with increased output and advantages, the farmers in the areas where rapeseed and mustard are grown are urged to apply biofertilizer using farmyard manure, compost, vermicompost, crop residues, and inorganic fertilisers.

2.7 Residual effect in succeeding crop

Puste *et al*. (2001) concluded that 25% of the recommended nitrogen dose of chemical fertilizers instead of 100 % was replaced by some organic source, which not only gave the highest rice yield, but also the grain yield of pulses was significantly affected by the residual effect of INM and INM also improved the physical and chemical soil properties and hence, increased the total productivity of rice-pulse system.

Akande *et al*. (2003) observed that there was an increase in soil available P of between 112 and 115 % and 144 and 153 % respectively for a two year field trials, after application of rock phosphate with poultry manure in okra crop.

Maiksteniene and Arlauskiene (2004) concluded that the highest wheat yield is attained when wheat is grown after lucerne as a preceding crop, the yield being 18.5% higher than after clover. Higher grain yields are usually associated with lower protein concentration.

Basavarajappa and Prabhakar (2003) conducted an experiment was carried out to assess the response of various tillage practices, organic materials, and nitrogen levels in foxtail millet cultivation during the *Kharif* season. The study involved different combinations of tillage practices, four organic materials, and three nitrogen levels for foxtail millet. In the same experimental layout, a succeeding castor crop was cultivated during the *rabi* season as a sequential crop. The results related to seed yield showed that the highest seed yield, measuring 398 kg ha^{-1}, was achieved in the residual fertility of shallow tillage and ridging treatment. Additionally, *Glyricidia* green manuring (456 kg ha^{-1}) and the application of 60 kg N ha^{-1} (493 kg ha^{-1}) to foxtail millet during the *Kharif* season also resulted in significantly higher seed yields. These findings underscore the importance of specific tillage practices, organic materials, and nitrogen levels in optimizing foxtail millet yields, which can subsequently benefit the succeeding castor crop in the crop rotation,

Sharma *et al*. (2003) reported that application of FYM and mineral nutrients to cowpea significantly increased the grain and straw yields of subsequent wheat crop. The interactive effects were significant for grain and straw yields or wheat available nitrogen and iron for both the years and cobalt during 2000-2001 with highest values under the application of FYM @10 t ha^{-1}

+ mineral nutrient combination. *i.e* - 20. 1.0, 50, 25 and 0.5 kg ha^{-1} (Elemental sulphur, sodium molybdate, ferrous sulphate zinc sulphate and cobalt nitrate).

In a study conducted by Gawai and Pawar (2006) within a sorghum-chickpea cropping system, the researchers found that the combination of 75% Recommended Dose of Fertilizer (RDF) consisting of 90-45-45 NPK (nitrogen, phosphorus, and potassium) per hectare, along with the application of 5 t ha^{-1} of farmyard manure (FYM) and bio-fertilizer, resulted in the maximum plant height, dry matter production, and subsequent crop yield. These parameters were significantly superior to the comparison treatments in both years of the study and the results suggests that this specific combination of fertilization and organic inputs was highly effective in enhancing crop growth and yield in the sorghum-chickpea cropping system.

Roul and Mahapatra (2006) observed that the residual impact of both organic and inorganic nutrient sources had a positive effect on the productivity of the subsequent crop.

In an experiment conducted by Chavan *et al*. (2008) in Akolam, Maharashtra, the researchers investigated soybean yield within a soybean-sunflower cropping sequence while employing integrated nutrient management practices. The study evaluated various treatments including NPK fertilizers at 100% of recommended rates, farmyard manure (FYM) at 5.0 t ha^{-1}, NPK at 150% of recommended rate, and the incorporation of plant residues. The results indicated that the treatments involving NPK fertilizers at 150% of the recommended rate, FYM at 5.0 tha^{-1}, and the inclusion of plant residues resulted in the highest yields of soybean seeds, straw, and biological yield. These findings underscore the positive impact of integrated nutrient management practices on soybean production in the soybean-sunflower cropping sequence.

According to a report by Goulding *et al*. (2008), organic manures not only provide nutrients to the current crop but also have a significant residual effect on the following crop in various sequential cropping systems. Additionally, the efficiency of applied chemical fertilizers was observed to increase when they were used in combination with organic manures. This highlights the valuable role of organic materials in enhancing nutrient availability and crop productivity across different cropping sequences.

Gudadhe (2008) evaluated the effect of integrated nutrient management of summer cotton with recommended fertilizer application on rabi chickpea in Rahur (Maharashtra) cotton-chickpea cropping system and estimated the residual effect of 10 t FYM ha^{-1} RDF-100-50-50 kg NPK ha^{-1} for summer cotton gave significantly higher chickpea values in terms of plant height, number of pods $plant^{-1}$, 100 grain weight, grain weight $plant^{-1}$ and chickpea grain and yield and was found at par with application of 100% RDN through vermicompost and 25% RDF through 75% RDN vermicompost.

Patil *et al*. (2008) reported that the residual effect of application of 5 t FYM ha^{-1} to preceding sorghum resulted in significantly higher growth, yield attributes and yield of chickpea owing to 100% RDF to chickpea and at par with that of 50% RDF showing 50% savings of nutrients.

Vandauwe *et al*. (2008) conducted an experiment on the effect of plant age and rock phosphate on the organic resource quality of grass legume residues in their N and P release dynamics. This showed that legume age was a parameter strongly influenced by the quality of legume residues and thus the dynamics of their N and P release, which could have important consequences for the recovery and losses of N and P assimilation and finally the sustainability of the crop system.

Shanwad *et al*. (2010) conducted a study at Raichur to determine the effect of integrated management of maize-Bengal gram cropping system. The results showed that application of FYM @7.5 t ha^{-1} + 100 RDF (100-50-25 kg N-P-K ha^{-1}) to maize resulted in a significantly higher yield of Bengal gram and was equivalent to vermicompost @ 2.5 t ha^{-1} + 100% RDF (100-50-25 kg N-P-K ha^{-1}).

Porpavai *et al*. (2011) conducted a field experiment with ten rice based cropping systems during 2002-2006 at Thanjavur (Tamil Nadu) and found that inclusion of pulses (black gram and green gram) in the cropping system improved the organic carbon and available nitrogen status of the soil.

Sohu *et al*. (2015) found that the use of organic additions of FYM and poultry manure with inorganic NPK sources showed positive effects on subsequent chickpea growth, yield and yield parameters in a rice-chickpea cropping system.

Balasubramanian *et al*. (2016), concluded that among the various integrated nutrient management practices, the residual effect of applying 75% Recommended Dose of Nitrogen (RDN) through fertilizer combined with 25% nitrogen through vermicompost (75% Cd + 25% Wh) to rice (T_5) resulted in superior growth attributes (such as plant height, Leaf Area Index - LAI, and Dry Matter Production - DMP) in blackgram. This treatment's performance was comparable to that of applying 75% RDN along with 25% nitrogen through vermicompost (100% Cd) to rice (T_4). This effect was attributed to the synergistic and cumulative carry-over effect of water hyacinth-based vermicompost, which not only supplied significant quantities of micronutrients and major nutrients but also contained growth-promoting substances. These factors likely contributed to the improved growth characteristics of blackgram when cultivated as a residual crop in the rice-fallow system.

In an experiment conducted by Hoque *et al*. (2016), various treatments were applied, including T_1 (No green manure + 100% Recommended Dose of Nitrogen - RDN), T_2 (*Sesbania aculeata* + 75% RDN), T_3 (*Sesbania aculeata* + 50% RDN), T_4 (*Sesbania rostrata* + 75% RDN), T_5 (*Sesbania rostrata* + 50% RDN), T_6 (*Vigna radiata* + 75% RDN), T_7 (*Vigna radiata* + 50% RDN), T_8 (*Vigna mungo* + 75% RDN), and T_9 (*Vigna mungo* + 50% RDN). The study found that the residual effects of green manures combined with RDN (Recommended Dose of Nitrogen) significantly increased various yield attributes, as well as the grain and straw yields of wheat. Additionally, green manures had a substantial residual impact on the grain, straw, and total nitrogen uptake by wheat plants. Among all the treatments involving green manures, T_4 (*Sesbania rostrata* + 75% RDN) performed the best, producing the highest grain yield (4.28 t ha^{-1}), straw yield (4.74 t ha^{-1}), and total nitrogen uptake (108.02 kg ha^{-1}). Furthermore, the use of green manures led to a slight increase in the organic matter content and the levels of total nitrogen, available phosphorus, potassium, and sulfur in the soil after the harvest. These findings highlight the positive residual effects of green manure application on wheat production and soil properties.

Bora *et al*. (2018) reported from a field experiment conducted during *rabi*, 2009-10 at Assam Agricultural University, Jorhat revealed that productivity of linseed grown after rice could be enhanced following conventional tillage practice, recommended dose of fertilizers (40-20-10 kg N, P_2O_5, K_2O ha^{-1}) and maintaining cutting height of rice stubble at 40 cm above the ground level.

Latha *et al*. (2019) conducted a field trial and the results of the work showed that with 50% RDN 25% N - FYM 25% N recommended dose of neem cake microbial consortium (*Azospirillum* PSB @ 2.5 kg ha^{-1}) significantly higher grain and straw yield was recorded more than 100% of RDN. In addition, they reported that plant height, dry matter, yield characteristics, grain yield, paddy yield, test weight and yield index of young crops (black gram, maize, sorghum, sunflower and mustard) were highest in all fields receiving combined organic matter at 50%. RDN *Azospirillum* and PSB @ 2.5 kg ha^{-1} were applied to previous rice. Application of INM to the previous rice crop increased the yield of all rabies crops by 25-30% compared to 100% RDN alone.

Senthivalavan and Ravichandran (2019) studied that the residual effect of different nutrient management practises imposed to preceding rice crop on the yield, NPK uptake and economics of black gram grown in rice-fallow-blackgram cropping sequence consecutively for two years. Among the various nutrient management practises imposed to rice, STCR based IPNS (144:64:60 kg NPK ha^{-1} along with 12.5 t ha^{-1} FYM and bio-fertilizers viz. *Azospirillium* and PSB as soil treatment) registered more residual effect by recording the highest yield, NPK uptake in seed and haulm and the net profitability (Net return of ₹15,480; ₹ 16,015 and benefit-cost ratio of 3.74, 3.88) respectively.

In an experiment conducted by Singh and Kushwaha (2020) to study the residual impact of Integrated Nutrient Management on wheat (*Triticum aestivum*), it was noted that the application of 100% NPK through fertilizer to wheat and the residual effect of FYM at 10 t ha^{-1} + 50% NPK to the *Kharif* crop (T_{10}) resulted in significantly higher values for various yield attributing characteristics. These characteristics included the number of spikes per plant (2.3 and 2.4), spike length (10.3 and 10.4 cm), spikelet per spike (20.7 and 20.6), seeds per spike (60.20 and 60.33), seed weight per spike (2.42 and 2.24 g), seed weight per plant (5.37 and 5.38 g), and seed test weight (40.53 and 40.54 g) during the years 2008-09 and 2009-10. The higher values of these yield attributes could be attributed to the balanced supply of NPK nutrients and the significant accumulation of nitrogen (N) and organic content through the application of FYM. This combination likely contributed to enhanced primary vegetative growth and other growth parameters in wheat, ultimately leading to higher yields.

In a field experiment conducted at Deendayal Research Institute Krishi Vigyan Kendra in Chitrakoot, Uttar Pradesh, Singh and Kushwaha (2020) investigated the residual impact of Integrated Nutrient Management and the direct effects of inorganic fertilization on wheat (*Triticum aestivum*), where the findings indicated that the residual impact of applying 50% of nitrogen, phosphorus, and potassium (NPK) along with farmyard manure (FYM) at a rate of 10 t ha^{-1}, as well as the direct application of 100% recommended dose of fertilizers to wheat, resulted in significantly higher values for Gross return (Rs.54372 and 62083 per hectare), Net return (Rs. 42479 and 48213 per hectare), and Benefit-Cost ratio (4.57 and 4.48) over both years and noted tghat the balanced use of fertilizers and the incorporation of macro and micronutrients through organic manures, applied in the preceding kharif crop, were found to enhance root and shoot development. The adequate supply of nitrogen was particularly noted for promoting the physiological processes of growth and development in the wheat crop, ultimately leading to higher values of yield-contributing characteristics.

Ninama *et al*. (2022) conducted an experiment at Anand Agricultural University, Anand, Gujarat, to investigate the impact of integrated nutrient management on the growth and yield parameters of Rustica tobacco (*Nicotiana rustica* L.) and its residual effect on subsequent summer green gram (*Vigna radiata* L.). The study concluded that the simultaneous application of organic and inorganic fertilizers, specifically using 75% recommended dose of fertilizer (RDF) combined with 25% nitrogen from poultry manure, resulted in a direct enhancement of both crop growth and productivity in Rustica tobacco. Furthermore, the research revealed that the application of organic and inorganic fertilizers during the cultivation of Rustica tobacco had a notable influence on the growth and yield parameters of the succeeding summer green gram crop and suggested that the integrated nutrient management approach not only benefits the primary crop, Rustica tobacco, but also positively affected the performance of the subsequent crop, summer green gram.

2.8 Effect of poultry manure

According to Boateng *et al*. (2006) from his study on the effect of poultry manure on growth and yield of maize, West African reported that poultry manure significantly increased grain yield.

Sathe (2007) conducted an investigation on the Effect of different sources of nitrogen on growth and yield of French Bean (*Phaseolus vulgaris* L.) cv. Arka Komal" was conducted at Department of Horticulture, College of Agriculture, Latur during 2007-2008. The study revealed that certain growth attributes, such as plant height (55.96 cm) and the number of branches (12.66), were highest with the treatment involving 50% N from urea and 50% N from poultry manure (T_4). The maximum number of compound leaves (13.00) was recorded with the treatment using 50% N from poultry manure alone. Regarding yield attributes, the highest yield (0.140 kg) per plant and yield (119.70 qt) per hectare were achieved with the combination of 50% N from urea and 50% N from poultry manure.

Garg and Bahl (2008) reported that the utilization of poultry manure (PM) had a significant impact on various aspects of maize growth and yield. This impact was evident in parameters such as plant height, row count per cob, number of grains per row, the weight of 1000 grains, grain yield, biological yield, and harvest index. The highest values for each of these parameters were observed when 12 tonnes per hectare of poultry manure were applied. The author also mentioned earlier that poultry manure typically contains approximately 2.04% nitrogen, 2.06% phosphorus, and 1.86% potassium.

Farhad *et al*. (2009), according to the data, Poultry Manure comprised of approximately 3.03% nitrogen, 2.63% phosphorus, and 1.4% potash. The data presented indicated that the plot where 12 t ha^{-1} of poultry manure was utilized had the highest grain yield with a significant value of 5.11 t ha^{-1}, while the next highest yield was recorded from the plot using 10 t ha^{-1} PM, which was statistically equivalent to the setup that used 8 t ha^{-1} PM, and produced grain yields of 4.16 and 3.60 t ha^{-1}, respectively.

Ismaeil *et al*. (2012) conducted a field experiment was conducted at the Experimental Farm of the Faculty of Agriculture, University of Khartoum, Shambat during the period (February – May 2007) to study the effect of different rates of chicken manure on growth and forage yield of sorghum (*Sorghum bicolor* (L.), Moench). The results indicated significant differences among treatments in most growth attributes during the growing period. Chicken manure was found to increase these growth attributes, as well as forage yield. Specifically, the application of 5 tons/ha of poultry manure resulted in higher fresh and dry forage yields at harvest compared to the other treatments.

In a study conducted by Okonmah (2012) in the Asaba agro-ecological zone of Nigeria, it was noted that the utilization of poultry manure at a rate of 12 kg ha^{-1} resulted in the highest and best outcomes for maize crop. Parameters such as plant height, leaf area, number of leaves, plant girth, and yield components exhibited their highest values under the application of poultry manure in comaprsion with the other treattments.

A field experiment conducted by Okoroafor *et al*. (2013) supported the positive impact of poultry droppings on the growth and yield of maize., where among various treatments, the application of poultry droppings stood out, demonstrating superior results compared to other methods and suggested that the use of poultry manure, particularly at the specified rate, can be effective in enhancing maize growth and yield in the given agricultural context.

Jasim and Mhanna (2014) demonstrated that the use of poultry manure increased the plant height, 100 seed weight and finally the seed yield of beans compared to control or not using poultry manure.

Turkmen and Kutuk (2017) reported that the combined application of poultry manure with chemical fertilizers, while reducing the reliance on chemical fertilizers, enhances soil fertility, facilitates nutrient uptake, and boosts bean seed yield. Additionally, Boateng *et al*. (2006) also noted that poultry manure improves nutrient uptake in plants by increasing organic matter content and enhancing soil structure.

Nafi'ah and Vitalaya (2017) remarked that utilization of organic chicken manure as a standalone fertilizer may not directly supply nutrients to plants due to its gradual nutrient release characteristics and recommended the simultaneous use of organic chicken manure and inorganic fertilizer, specifically NPK fertilizer. It was concluded that combined approach was deemed crucial in the study for enhancing the growth and yield of wheat plants and summarized that the application of both NPK fertilizer and organic chicken manure emerges as a significant factor in endeavors to boost wheat plant development and productivity.

Addis (2019) remarked that poultry manure, being an excellent natural fertilizer, is abundant in essential nutrients including nitrogen, phosphorus, potassium, and others. Unlike chemical fertilizers, it also enriches the soil with organic matter, which has several benefits such as enhancing soil quality, improving nutrient retention, promoting aeration, increasing soil moisture retention, and facilitating better water infiltration.

Aziz *et al*. (2020) carried out a field experiment in the College of Agriculture, University of Sargodha, Sargodha, Punjab, Pakistan, to evaluate the effect of poultry manure on the growth and yield of forage sorghum with four treatments (0 t ha^{-1}, 1t ha^{-1}, 2.5 t ha^{-1} and 4 t ha^{-1}) with three replications were used in Randomized Complete Block Design (RCBD). The results indicated significant differences among treatments in various growth parameters throughout the growing period. Maximum plant height (130 cm), number of leaves per plant (11), stem diameter (49 cm), fresh weight of forage (20 t ha^{-1}), dry weight of forage (5.5 t ha^{-1}), nitrogen content in plants (2.25%), phosphorus content in plants (18%), and potassium content in plants (17%) were observed when 4 t ha^{-1} of poultry manure was applied. It was concluded that increasing the dosage of poultry manure led to enhanced growth and higher nutrient concentrations in the plants, specifically at the rate of 4 t ha^{-1}, which improved the growth and yield of forage sorghum (*Sorghum bicolor* L.).

According to findings Gezahegn and Martini (2020), focused on the impact of residual organic manure and supplementary inorganic fertilizers on the performance of subsequent maize crops and soil chemical properties. It was concluded that incorporating poultry manure to replace 50% of inorganic fertilizer effectively reduced the dependence on chemical fertilizers while maintaining crop productivity. The combination of fertilizers containing 50% NPK and 100% poultry manure, as well as fertilizers with pure 100% NPK, resulted in the highest pod and seed yields per plant. In contrast, the control and 100% poultry manure treatments showed the lowest number of pods per plant and seed yield per plant, emphasizing poultry waste as a valuable source of crop nutrients.

Danmaigoro (2020) found that the application of poultry manure had a positive impact on the vegetative growth of sesame, resulting to an increase in the quantity of capsules produced, improved seed formation, and enhanced seed filling, ultimately resulting in a higher seed yield.

Shaaibu and Rabiu (2023) conducted a pot experiment at the screen house aimed to assess the impact of different treatments, specifically nitrogen-phosphorus-potassium (NPK) at a ratio of 15:15:15 and varying rates of poultry manure (PM) (0g, 3g, 6g, and 12g), on the growth and yield of soybean (TGx1835-10E). The study indicated that the combined application of NPK and poultry manure at different rates resulted in superior outcomes compared to using PM or NPK alone, as well as the control group with increased plant height, number of leaves, number of branches, leaf area, chlorophyll content, shoot dry weight, harvest index, and economic yield of soybean. The results suggested that the combination of NPK and poultry manure at the specified rates positively influenced the overall growth and productivity of the soybean crop.

Sachan and Krishna (2021) concluded that the combination of 100% NPK along with PM @ 5 t ha^{-1} was found most effective for enhancing growth and yield. This treatment recorded maximum values of all yield attributing characters such as pod length (12.76 cm), pod diameter (0.93 cm), number of pods plant^{-1} (41.51) followed by T_2-100% NPK + FYM @ 12 t ha^{-1}, T_3: 50% NPK + PM @ 5 t ha^{-1}, T_4: 50 % NPK+ FYM @ 25 t ha^{-1}, T_5: PM @ 5 t ha^{-1} and T6: FYM @ 25 t ha^{-1}. This also recorded maximum values of all yield attributing characters such as pod length (12.76 cm), pod diameter (0.93 cm), number of pods plant^{-1} (41.51) followed by T_2, T_3, T_4, T_5 and T_6. The conclusion indicated that the treatment involving 100% NPK along with 5 tons of poultry manure per hectare yielded superior results in terms of both yield and growth performance. Furthermore, the findings suggested that the optimal dose of organic and inorganic fertilizers for achieving maximum growth and yield benefits is a combination of 100% NPK at a rate of 200 kg per hectare along with 5 tons of poultry manure per hectare.

Subedi *et al*. (2022) concluded that among the five treatments experimented, it was found that the poultry manure treatment at a rate of 2.620 kg per plot was the most effective and led to a significant increase in various plant attributes, including plant height, leaf count, branch count, pod count, and overall yield. On the contrary, the use of mustard oil cake did not produce the desired results in terms of yield and associated characteristics. The treatment utilizing poultry manure resulted in the highest yield at 8.438 tonnes ha^{-1}, whereas the treatment involving mustard oil cake yielded the lowest at 2.906 tonnes ha^{-1}.

2.9. Effect of integrated nutrient management on economics

Mosa *et al*. (2003) reported that the net and gross return and B:C ratio worked out at the end of the maize-groundnut sequence during the two crop cycles indicated that an improvement in profitability of INM treatments, particularly, of those wherever organic manures were applied in addition to the recommended NPK to the preceding crop in sequence.

Nayak *et al*. (2009) reported among the ricebean genotypes, RBL-6 performed the best with a productivity of 776 kg ha^{-1} with net profit of ₹. 3,929 ha^{-1}, while application of 40 kg N ha^{-1} recorded maximum seed yield of 889 kg ha^{-1}, harvest index 23.68% respectively with net return of ₹5,124 ha^{-1}.

Acharya and Mondal (2010) from an experiment on rice-cabbage-green gram cropping system reported higher rice equivalent yield (REY) of 32.33 t ha^{-1} under 75% RDF + 25% N through FYM to all the crops than RDF alone which produced REY of 26.80 t ha^{-1}. The higher returns (₹1,43,463 ha^{-1}) and B:C ratio (2.92) were obtained when crops in sequence were fertilized.

Singh *et al*. (2011) during an experiment on rice-pea cropping system on an acid upland soil of Jharkhand concluded that the system productivity was increased by 2 - 4times under INM treatments over the existing farmer's practices. Higher system productivity (9412 kg ha^{-1}) was obtained with combined application of 5t FYM + 250 kg lime + 20 kg S + 1 kg B ha^{-1} along with 50% RDF than obtained with 100% RDF only (6832 kg ha^{-1}). It was also observed that cost of cultivation was marginally increased in case of INM, but due to higher grain and straw yields, the net income (₹32,823 ha^{-1}) and B:C ratio (2.73) were also higher under the integrated use of inorganic and organic sources of nutrients that received with 100% RDF (₹28,823 ha^{-1}) and B:C ratio (2.43).

Ghosh *et al*. (2014) concluded that combined application of cowdung @ 5 t ha^{-1} with recommended chemicals fertilizers based on the IPNS was more economic compared to other treatments because maximum B:C ratio was calculated from the treatments. The overall results suggested that integrated nutrient management could be sued as an alternate option of chemical fertilization to achieve maximum cost of returns for rice cv. NERICA 10 cultivation.

Kumar *et al*. (2014) reported that maximum gross return (₹ 39,098 ha^{-1}), net return (₹. 27, 281 ha^{-1}), B:C ratio (2.29), production efficiency, and economic efficiency were also realized with the application of lime at 0.6 t ha^{-1}. Among the ricebean cultivars, RBS-53 produced significantly higher growth, yield attributes, grain yield, straw yield, biological yield, and harvest index. Similarly, yield and protein content were higher in RBS-53. Maximum gross return, net return, B:C ratio, production efficiency, and economic efficiency were observed for RBS-53.

Leela Rani *et al*. (2015) carried an assessment of integrated nutrient management practices on the growth, yield, and economic aspects of the green chili variety Pusa Jwala. The findings revealed that the application of 150 kg per hectare of nitrogen, in combination with 10 tons of farmyard manure (FYM) and 0.5 tons of neem cake, resulted in a notably higher benefit-cost ratio of 2.5:1 which also led to an increased in the value of net income.

Tyagi *et al*. (2015) concluded that application of 100% RDF along with 1.0 ton of vermicompost ha^{-1} and rhizobium resulted in the highest gross return of Rs 62,125 ha^{-1}. The maximum net return of Rs 39,741 ha^{-1} was observed with the application of 100% RDF, 2 tons of Farm Yard Manure (FYM) ha^{-1}, and Rhizobium. Furthermore, the highest B: C of 1.97 was achieved with the application of 100% RDF along with rhizobium.

Sorokhaibam *et al*. (2016) conducted field experiment on rice-rapeseed and reported that the application of lime @500 kg CaCO3 ha^{-1} before planting rice continuously for two cropping seasons had residual effect on seed and stover yields succeeding rapeseed resulting in improvement of system productivity in terms of rice equivalent yield (REY) by 7.2% respectively over no liming.

Imade *et al*. (2017) reported that B:C ratio (1.39) was highest with the application of 75% recommended dose of nitrogen (RDN) through chemical fertilizer + 25% recommended dose of nitrogen (RDN) through biocompost because of lower cost of cultivation.

Joshi *et al.* (2016) concluded from experiment that treatment T_2, RDF (20-40-0 kg NPK ha^{-1}) recorded the maximum value of net realization ₹1,09,440 with BCR value followed by treatment T_7 i.e. ₹. 1,28,674 (PM 2 t ha^{-1}) with BCR 3.46. Higher BCR in treatment T_2 (3.81) resulted due to higher green pod and stover yield.

In the study conducted by Kavita *et al*. (2018) it was concluded that application of 25% nitrogen through FYM, 25% nitrogen through vermicompost, and the addition of rhizobium and PSB at a rate of 5 ml/l resulted in the highest gross monetary returns (Rs 39,332 ha^{-1}), net monetary returns (Rs 15,392 ha^{-1}), and a beneficial benefit-cost ratio of 1.64 in green gram cultivation.

Sajjad *et al*. (2018) in a study observed that green manuring resulted in 16.8 per cent increase compared to check and the overall performance of cowpea green manuring in wheat was positive and the benefit was ₹10283 ha^{-1}

Shilpa and Wali (2018) concluded from a study on performance of different genotypes in cowpea that maximum gross returns (₹42,690 ha^{-1}), net returns (₹28,493 $ha^{-1)}$ and BC ratio (3.01) was realized with genotype IT-38956-1 compared to other genotypes. The application of 50 kg P_2O_5 ha^{-1} gave the higher gross returns, net returns and B:C ratio but differences as were non-significant.

Singh *et al*. (2018) reported that green gram crop yielded the highest gross returns of Rs 72,371.00 per hectare, net returns of Rs 50,873.00 per hectare, and a favorable benefit-cost ratio of 2.37 under the treatment involving the application of 60 kg P_2O_5 per hectare along with Phosphorus Solubilizing Bacteria (PSB).

Mahata *et al*. (2018) concluded an experiment and revealed that maximum gross return of ₹91,500 and ₹97,920 were achieved T_{14} (vermicompost @ 2.5t ha^{-1} + mustard cake @ 2.5 t ha + poultry manure @ 2.5 t ha^{-1} + FYM @ 4 t ha^{-1}) which was followed by T_{12} (vermicompost @ 2.5 t ha^{-1} + mustard cake @ 5 t ha^{-1}). Higher gross return was simply reported due to higher yield in crop sequence during 2012 and 2013. The highest B:C ratio was in T_2 (2.33 and 2.59 during 2012 and 2013) followed by T_{10} (100% RDF) followed by T_{10} (2.07and 2.33 during 2012 and 2013).

Singh *et al*. (2019) concluded that the most effective approach for achieving higher net returns and a favorable benefit-cost ratio in green gram cultivation was the simultaneous application of 75% RDF with PSB@ 2.5 tons per hectare of vermicompost, and thizobium. This combination proved to be the optimal choice, yielding a net return of Rs 28,905 per hectare and a benefit-cost ratio of 0.79.

Senthivalavan and Ravichandran (2019) studied that the residual effect of different nutrient management practises imposed to preceding rice crop on the yield, NPK uptake and economics of black gram grown in rice-fallow-blackgram cropping sequence consecutively for two years. Among the various nutrient management practises imposed to rice, STCR based IPNS (144:64:60 kg NPK ha^{-1} along with 12.5 t ha^{-1} FYM and bio-fertilizers viz. Azospirillium and PSB as soil treatment) registered more residual effect by recording the highest yield, NPK uptake in seed and haulm and the net profitability (Net return of ₹15,480; 16,015 and benefit-cost ratio of 3.74; 3.88) respectively.

In a field experiment conducted at Deendayal Research Institute Krishi Vigyan Kendra in Chitrakoot, Uttar Pradesh, Singh and Kushwaha (2020) investigated the residual impact of Integrated Nutrient Management and the direct effects of inorganic fertilization on wheat (*Triticum aestivum*), where the findings indicated that the residual impact of applying 50% of nitrogen, phosphorus, and potassium (NPK) along with farmyard manure (FYM) at a rate of 10 t ha^{-1}, as well as the direct application of 100% recommended dose of fertilizers to wheat, resulted in significantly higher values for Gross return (Rs.54372 and 62083 per hectare), Net return (Rs. 42479 and 48213 per hectare), and Benefit-Cost ratio (4.57 and 4.48) over both years and noted tghat the balanced use of fertilizers and the incorporation of macro and micronutrients through organic manures, applied in the preceding kharif crop, were found to enhance root and shoot development. The adequate supply of nitrogen was particularly noted for promoting the physiological processes of growth and development in the wheat crop, ultimately leading to higher values of yield-contributing characteristics.

CHAPTER III

MATERIALS AND METHODS

MATERIALS AND METHODS

A study titled "Effect of nutrient management on ricebean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi] – linseed (*Linum usitatissimum* L.) cropping system" was conducted at the experimental farm of the School of Agricultural Sciences, Nagaland University, Medziphema campus, Nagaland. For more detailed information on the methods and materials employed during this investigation, is provided in the current chapter.

3.1 General information

3.1.1. Location

The experimental farm is situated in the foothills of Nagaland with geographical location of 25^{o}45'43''N latitude and 95^{o}53'04''N longitude at an elevation of 310 meters above sea level.

3.1.2 Climatic and weather condition during investigation period.

The experimental farm is situated in a humid and subtropical climate region, characterized by an average annual rainfall ranging from 2000 to 2500 mm. The mean temperature typically falls within the range of 21-32°C during the summer, and even in winter, it seldom drops below 8°C due to the presence of high atmospheric humidity.

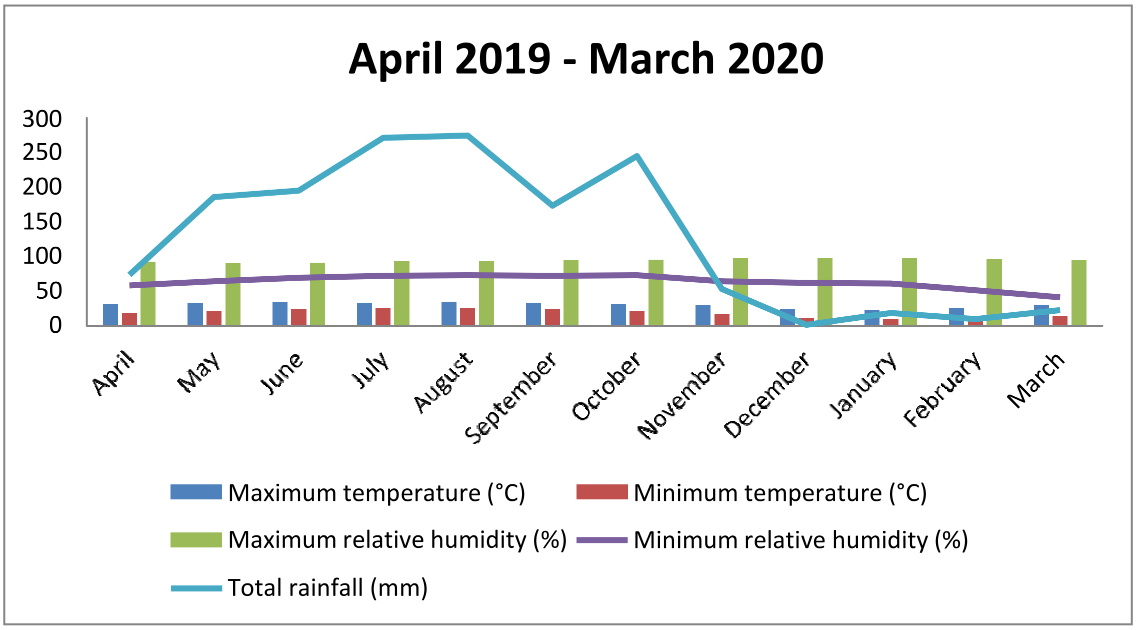
The detailed information on meteorology during the investigation have been presented and illustrated. The maximum temperature was recorded during month of were recorded from Agro Meteorology Observatory , Indian Council of Agricultural Research, ICAR Complex for NEH Region, Nagaland Centre, Jharnapani, Nagaland.

Table 3.1 (a) Meteorological data during the period of investigation

Month	Temperature		Relative humidity		Total rainfall (mm)
	Maximum temperature (°C)	Minimum temperature (°C)	Maximum relative humidity (%)	Minimum relative humidity (%)	
April (2019)	30.8	18.5	92	58	73.3
May	32.2	21.7	90	64	185.8
June	33.5	24.0	91	69	195.0
July	33.0	24.8	93	72	271.3
August	34.1	24.9	93	73	274.5
September	32.7	23.9	94	72	173.4
October	30.3	21.7	95	73	244.8
November	28.8	16.3	97	64	52.9
December	23.7	10.4	97	62	0.9
January (2020)	22.4	9.6	97	61	18.5
February	24.8	11.1	96	51	9.7
March	30.1	14.1	94	41	22.5
April	30.7	17.1	90	52	153.9
May	31.1	21.1	90	64	134.2
June	32.5	23.8	92	72	266.2
July	32.4	24.5	94	74	199.9
August	33.7	25.0	93	70	80.3
September	32.8	24.3	95	73	157.6
October	31.3	23.0	95	74	175.7
November	27.9	15.6	97	59	35.2
December	24.5	9.8	97	52	0
January (2021)	24.0	8.9	96	50	3.4
February	27.1	9.7	95	40	2.3
March	31.1	14.9	93	41	43.5
April	33.1	17.9	87	34	59.6

Source: ICAR research Complex for NEH region.

Monthly metrological data during cropping season 2019-2020



Monthly metrological data during cropping season 2020-2021

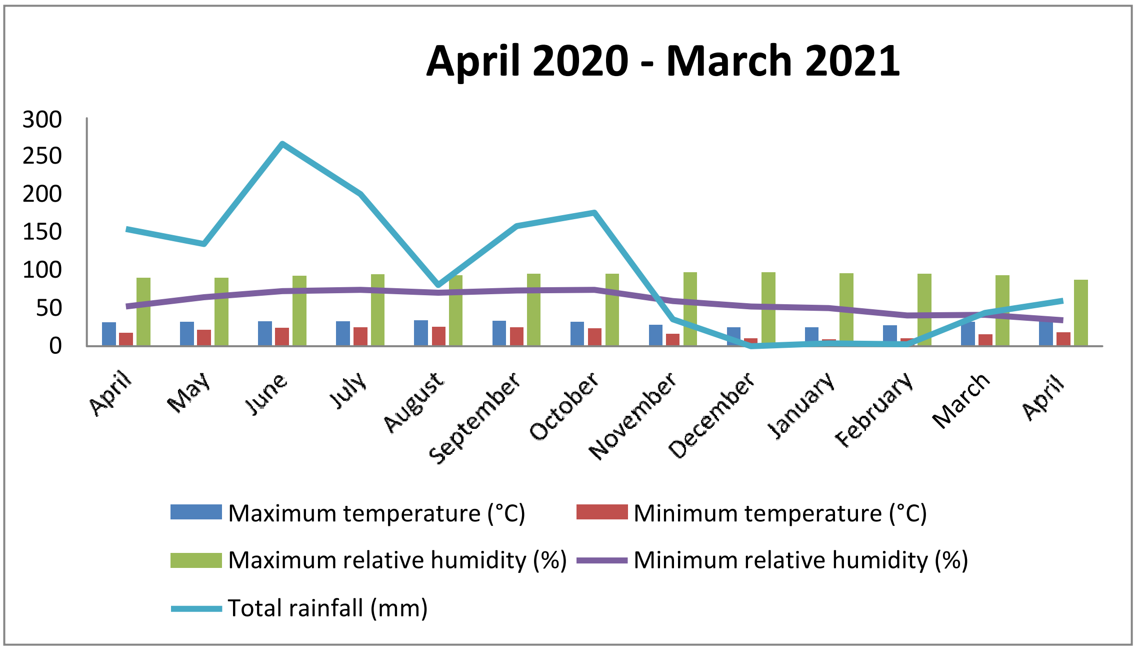


Fig: 3.1: Metrological data during the period of investigation

3.1.3 Soil condition

The soil of the area of experimentation was found to be clayey loam in texture. The soil is acidic in nature with pH fluctuating at around 4.3 with relatively high organic matter content. The physiological, chemical and biological status of the soil after a proper analysis is given in the table no 3.2.

Table 3.2 Initial soil fertility status of the experimental field

a. Physical & and chemical properties

Characteristics	Methods adopted	Content 2019	Content 2020
Soil pH	Digital pH meter (Single electrode meter)	4.3	4.6
Organic carbon (%)	Titrimetric determination (Walkley and Black method, 1934)	1.37	1.47
Available Nitrogen (kg ha^{-1})	Alkaline potassium permanganate method (Subbiah and Asija, 1956)	277.53	293.78
Available Phosphorous (kg ha^{-1})	Bray's I method (Bray and Kurtz, 1945)	25.1	36.02
Available potassium (kg ha^{-1})	Neutral normal ammonium acetate method (Hanway and Heidal, 1952)	141.2	152.63
Soil texture	International pipette method (Vance *et al*., 1987)	Sandy Loam	Sandy Loam

b. Biological properties

Particulars	Methods adopted	Value
Bacteria (10^6 x Cfu g^{-1})	Serial dilution agar plating method	33.5
Actinomycetes (10^5 x Cfu g^{-1})		1.65
Fungi (10^3 x Cfu g^{-1})		20.3
Dehydrogenase enzyme activity (µ`g $TPFg^{-1}$ h^{-1})	2-3-5-triphenyl tetrazolium chloride reduction technique (Casida, 1977)	16.3
Soil Microbial biomass	Fumigation-extraction method	310.4

carbon (µg g^{-1})	(Vance *et al*., 1987)	
Acid phosphatase activity (µg PNP g^{-1} h^{-1})	p-nitrophenyl phosphate method (Tabatabai and Bremner, 1969)	37.2

Table 3.3 Nutrient content in organic manure

Manure type	Nitrogen (N %)	Phosphorus (P %)	Potassium (K %)
Poultry	4.5	2.46	2.02
FYM	0.5	0.2	0.5
Pig	0.6	0.4	0.3

Source : Anonymous 2023 (a) & (b)

3.1 EXPERIMENTAL DETAILS

3.2.1 VARIETY

Rice bean: Bidhan-1 is renowned for its notable resistance to major pests and diseases, along with its consistent excellence in both green and dry matter yields. It is recognized for its quality attributes and its resilience against insect pests and diseases, whether in the field or during storage. Additionally, Bidhan-1 possesses desirable characteristics such as drought tolerance, cold tolerance, low fertilizer requirements, and adaptability to various soil types.

Linseed: Ruchi (LCK-5021) is a variety developed at AICRP Centre Kanpur (CSAU) and officially released from CVRC (Central Variety Release Committee), New Delhi, in the year 2010. This variety is suitable for cultivation in several states, including Uttar Pradesh (excluding Bundelkhand), Bihar, Jharkhand, West Bengal, Assam, and the NEH (North-Eastern Hill) region. It is known for its dual-purpose nature. It exhibits a seed yield of approximately 12-15 quintals per hectare and a fiber yield of 10-11 quintals per hectare. The variety matures in about 130-135 days from sowing. Additionally, it has an oil content of around 39.84%. Notably, Ruchi has demonstrated tolerance *to Alternaria blight* in All India Coordinated Trials, making it a desirable choice for cultivation in various regions.

3.2.2 Design and details of experimentation

The experimental field was laid out in Randomized Block Design (RBD) consisting of three sources of manure which were further divided into nine treatments. A total of 27 plots were made and the different treatments were randomly allocated within for main crop ricebean crop and followed by linseed as the residual crop and the trial was repeated twice with three equal blocks.

The layout of the experimental field is given in Fig

1.	Experimental design	: RBD
2.	Variety	: Bidhan-1
3.	Number of factors	2
4.	Number of treatments	9
5.	Number of replication	3
6.	Number of plots	27
7.	Gross plot size	: 16.2 m^2 (4.5 x 3.6 m^2)
8.	Net plot size	: 3.6 x 3.0 m^2
9.	Spacing	: 45cm x 30 cm
10.	Seed rate	: 35 kg ha^{-1}
11.	Sequential crop	: Linseed (*Linum usitatissimum* L.)
12.	Variety	: Ruchi
13.	Spacing	: 30 x 10 cm

The treatment consisted of:

Sources (3)	: GM (*Sesbania*) + PM (0.7 t / ha)
	GM (*Sesbania*) + PGM (0.7 t / ha)
	GM (*Sesbania*) + FYM (4 t / ha)
RDF	: 3(100% RDF, 75% RDF, 50% RDF)

Green Manuring (GM); Poultry manure (PM); Pig manure (PGM); FYM (Faym yard manure); Recommended Dose of Fertilizer (RDF)

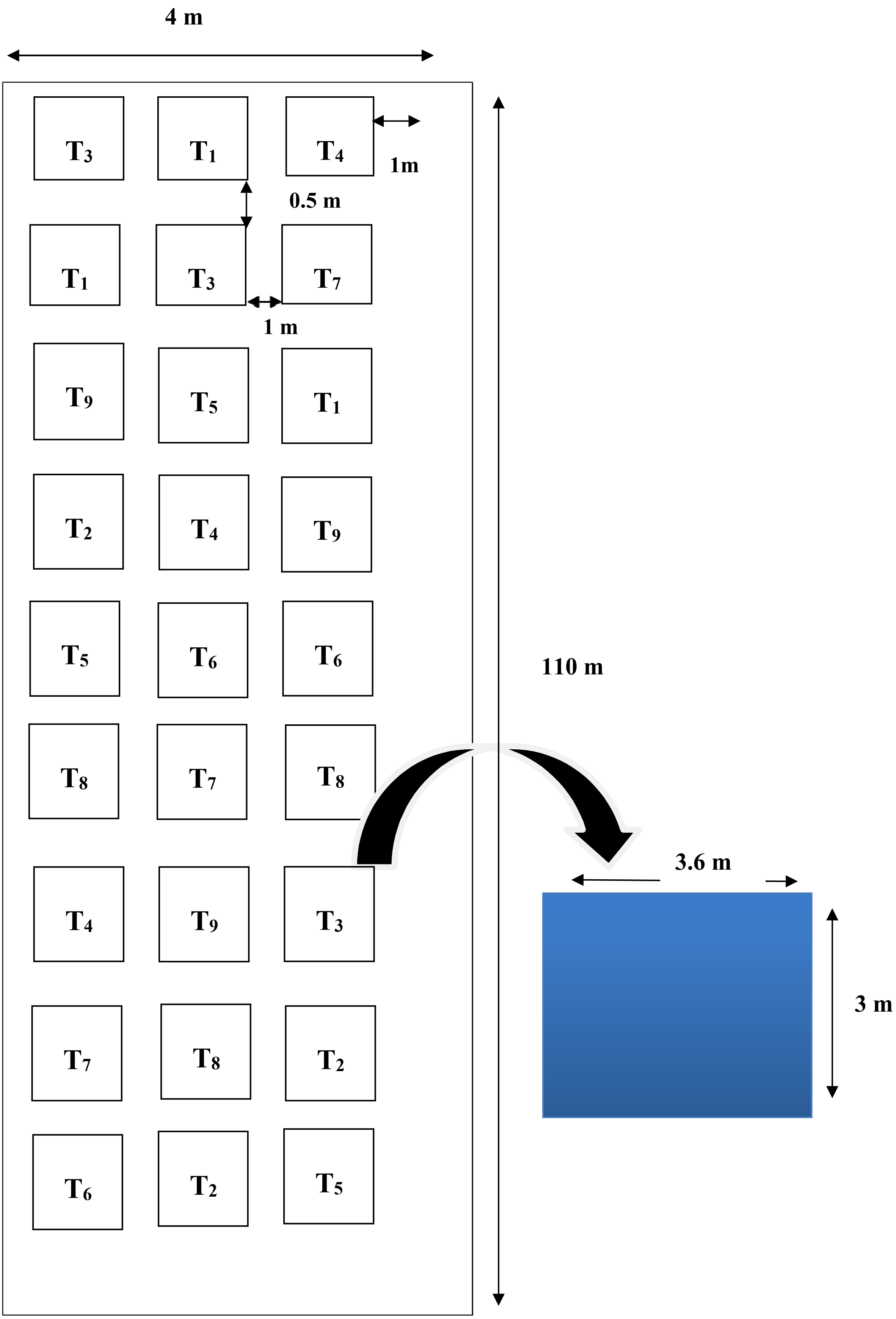


Fig 3.2: Field layout of the experiment

3.2.3 Treatment combinations

The experiment was carried out in the following treatment combinations

Symbol	Treatment combinations
T1	GM (*Sesbania*) + PM (0.7 t / ha) + 100 % RDF
T2	GM (*Sesbania*) + PM (0.7 t / ha) + 75 % RDF
T3	GM (*Sesbania*) + PM (0.7 t / ha) + 50 % RDF
T4	GM (*Sesbania*) + PGM (0.7 t / ha) + 100 % RDF
T5	GM (*Sesbania*) + PGM (0.7 t / ha) + 75% RDF
T6	GM (*Sesbania*) + PGM (0.7 t / ha) + 50 % RDF
T7	GM (*Sesbania*) + FYM (4 t / ha) + 100 % RDF
T8	GM (*Sesbania*) + FYM (4 t / ha) + 75 % RDF
T9	GM (*Sesbania*) + FYM (4 t / ha) + 50 % RDF

General recommendation = 20:40:20 NPK kg ha^{-1}

3.3 Cultivation details

3.3.1 Selection and preparation of field

A well-drained bench terraced plot of land was selected for carrying out the experimental trial. The land preparation consisted of using cultivator for ploughing, then followed by harrowing and rotavator was used for breaking the clods during the 2nd week of march and 3rd week of May for 2019-2020 and 2020-2021 and finally levelled for layout preparation.

3.3.2 Application of manures and fertilizers

Green manuring was carried out in a consistent manner by broadcasting the green manure seeds on the 22nd March in 2019 and 10th of April in 2020. Subsequently, a rotavator was used to incorporate the green manure into the soil on the 12th and 14th of May, for both the 2019-2020 and 2020-2021 cropping seasons. For the subsequent crop, linseed, it was exclusively grown using the residues from the previous ricebean crop.

Different levels of inorganic fertilizers in the form of urea, SSP and MOP (100%, 75% and 50%) was also applied on the day before sowing of the crop, all these were applied as basal dose in the open furrows.

3.3.2 Seed and sowing

Sowing of the ricebean seeds, furrows were made and followed by line sowing of the seeds were done maintaining a depth of 4-5 cm with a spacing of 45 cm between rows and 15 cm distance between plants and sowing was done on 23rd (2019) with a seed rate of 35kg ha^{-1}. While in the second year, sowing was carried out on 25th May (2020).

In the succeeding crop, no fertilizers or additives were added, and linseed was raised on residual fertility of the different sources of organic and inorganic nutrients. The land was prepared to necessary tilth with the help of spade without disturbing the plot bunds and the seeds were sown on 17th November (2019) and 19th November (2020) in line maintaining a depth of 4-5cm in the soil.

3.3.4 Intercultural operation

Cultural practices such as hand weeding were performed as necessary at DAS. Thinning was conducted about one month after sowing to ensure an ideal plant density in all the plots, eliminating any surplus seedlings and filling gaps as needed. Additionally, earthing up was carried out to retain soil moisture and offer support to the growing plants. Hand weeding using local hoes and khurpi tools was also undertaken at 45 days after sowing.

3.3.5 Plant protection measures

Timely monitoring of the field was carried out; hand picking was carried out to control the insects in the experimental plots.

3.3.5 Harvesting and threshing

The harvesting of the crops were carried out in four to five batches, while hand picking of the plots were also carried out in subsequent plot wise.

In the final harvest, the plants were cut with help of sickles, tied into bundles, sundried, threshed and cleaned manually.

Harvesting of linseed was done on 18th April 2020 after the capsules attained maturity and was carried manually by pulling out the plants with the roots and then sun dried. Threshing was done separately for the harvest of individual plots and seeds were cleaned, dried and weighed accordingly.

Table 3.4 Agronomic calendar of the practises adopted during the experiment

Sl no.	Operation	Date	
		2019-2020	**2020-2021**
Rice-bean			
1.	Soil sample collection	March 20	9 April
2.	Primary tillage	March 20	9 April
3.	Secondary tillage	March 22	10 April
4.	Green manure sowing	March 22	10 April
5.	Green manure incorporation	12 May	14 May
6.	Layout and levelling	13 May	15 May
7.	Organic Manure application	13 May	15 May
8.	Fertilizer application	22 May	24 May
9.	Sowing	23 May	25 May
10.	Irrigation	24 May	26 May
11.	Gap filling & thinning	15 June	18 June
12.	30DAS	22 June	23 June
13.	60 DAS	21 July	22 July
14.	90DAS	23 August	24 August
15.	Harvesting	14 November	16 November
16.	Drying	15 November	17 November
Linseed			
1.	Land preparation	16 November	18 November
2.	Soil sample collection	16 November	17 November
3.	Sowing	17 November	19 November
4.	Earthing up	18 December	20 December
5.	Thinning	28 December	30 December
6.	Harvesting	7 April	10 April
7.	Drying and storage of seeds	8 April	12 April

3.4 Experimental observations to be recorded

3.4.1 Meterological observations

The metrological observations on relative humidity (%), temperature (maximum and minimum in ^{o}C), bright sunshine hours, rainfall (mm) and number of rainy days were recorded for the research period during 2019-2020 and 2020-2021.

3.4.2 Growth attributes

For keeping record of the growth attributes, five plants were selected randomly in each plot and tagged.

3.4.2.1Plant height (cm)

Five plants from each plot were tagged and with the help of a linear scale plant height was measured from the ground level to the tip of the plant at 30.60,90 DAS and at harvest and the average plant height was calculated from each of the treatments respectively.

3.4.2.2Number of branches plant^{-1}

The numbers of branches were counted from the tagged plants at 30, 60 and 90DAS where the averages were recorded from each treatment.

3.4.2.3Number of nodules plant^{-1}

The number of nodules plant^{-1} were counted from the randomly selected plants from each treatment at 30,50 and 70 DAS where the roots were then gently washed and separated and counted.

3.4.2.4 Leaf area index (LAI)

Five leaves were collected from each plot at 30, 60 and 90 DAS and was calculated by the formula

$$\text{LAI} = \frac{\text{Leaf area(cm)}}{\text{ground area (cm)}}$$

3.4.2.5 Dry matter (g plant^{-1})

Samples from respective plots were collected at 30, 60, 90 and at harvest and sundried over two days and over dried at 60-70^{0}C for further drying. After the completion, weight of the samples of each plot were recorded separately and noted.

3.4.2.6Crop Growth Rate (CGR)

The oven dried weight of five plants from each plots were recorded and calculated by the following formula expressed in g m^{-2} day^{-1}.

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

where, $W_1$and W_2 are the dry weight of the plants at time t_1 and t_2, S is the land area (m^2) respectively.

3.4.2.7Relative Growth Rate (RGR)

The weight of the oven dried of the plants from each plot was taken and formula was used to calculate relative growth rate is given as follows expressed in g g^{-1} day^{-1}.

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

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

3.4.2.8Net Assimilation Rate (NAR)

The increase in dry weight of plant per unit leaf area unit time was calculated by the following formula (Gregory, 1917).

$$NAR = \frac{(w2 - w1)(logeL2 - logeL1)}{(t_2 - t_1)\,(L2 - L1)}$$

Where, L_1 and W_1 are the leaf area and dry weight of the plant at time t_1, while L_2 and W_2 are the leaf area and dry weight of the plant at time t_2.

3.4.3 Yield and yield attributes

3.4.3.1 Number of pods plant^{-1}

During the harvest, the number of pods from the selected five plants were counted and recorded and the average was taken to get the number of plods plant^{-1}.

3.4.3.2 Number of seeds pod^{-1}

The numbers of seeds from the five recorded pods were counted and average value was taken to obtain the number of seeds pod^{-1}.

3.4.3.3 Length of pods (cm)

Length of the pods was recorded from the randomly tagged plants from each plot and the average was recorded for statistical analysis.

3.4.3.4 Test weight (g)

From the threshed plants, 1000 seed samples were taken randomly, counted and weighed to get the test weight (g).

3.4.3.5 Seed yield (kg ha^{-1})

The harvested plants from the plots were threshed separately, and weight per plot was recorded and yield was maintained in kg ha^{-1}.

$$\text{Seed yield (kg ha}^{-1}) = \frac{\text{Weight of the seed plot}^{-1}}{\text{Size of the plot}} \text{x}10000$$

3.4.3.6 Stover yield (kg ha^{-1})

The harvested plants from ploys were threshed individually, and weight of the stover was recorded and recorded and maintained in kg ha^{-1}.

$$\text{Stover yield (kg ha}^{-1}) = \frac{\text{Weight of the stover plot}^{-1}}{\text{Size of the plot}} \text{x}10{,}000$$

3.4.3.7 Harvest index (%)

It is the ratio of economic yield to the biological obtained and it was determined by the following formula

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

Where, Economic yield = seed yield

Biological yield = seed yield + stover yield

3.4.3.8 Protein content (%)

The protein content in the plants were estimated by multiplying the nitrogen percentage from Kjeldahl method with the help of the following formula

$$\text{Protein (\%)} = \text{Nitrogen \%} \times 6.25$$

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

The protein yield was calculated by multiplying the protein content with dry matter of the respective treatments.

$$\text{Protein yield (kg ha}^{-1}) = \frac{\text{protein content (\%)}}{100} \text{ x yield(kg ha}^{-1})$$

3.5 Determination of chemical characteristics of the soil

The physicochemical and biological analysis of soil samples were carried out for both initial and final samples (samples collected after harvest) following standard procedures. The soil samples were collected with help of an auger, samples were then dried, ground and analysed.

3.5.1 Soil pH

Soil samples were dissolved in water in the ratio of 2:1 and the pH was determined by Digital pH meter (Jackson, 1976).

3.5.2 Electrical conductivity (EC)

The electrical conductivity (EC) was determined using the conductivity bridge (Richards, 1954) in 1:2 soil-water suspensions at 25^{o}C.

3.5.2 Organic carbon (%)

Organic carbon was estimated by Walkley and Black's rapid titration method and was expressed in terms of percentage.

3.5.3 Available nitrogen (kg ha^{-1})

The available N status was determined by strictly following the method suggested by Subbiah and Asijia (1956). The distillation of soil with alkaline potassium permanganate solution was carried out and the ammonia liberated in the process is determined and was calculated in terms of kg ha^{-1}.

3.5.4 Available phosphorus (kg ha^{-1})

Available phosphorus was extracted with 0.03N NHF in 0.025N HCl. The procedure is primarily meant for soils which are moderately to strongly acidic with pH around 5.5 or less (Brady and Kurtz, 1945) and expressed in terms of kg ha^{-1}.

3.5.5 Available potassium (kg ha^{-1})

Available potassium was extracted from 5 g of soil by shaking with 25 ml of Neutral ammonium acetate (pH=7) solution for half an hour and the extract was filtered immediately through a dry filter paper (Whatman no. 1) and then the potassium concentration in the extract was determined by Flame photometer (Hanway & Heidal, 1952) and expressed in terms of kg ha^{-1}.

3.6 Plant Analysis

3.6.1 Sample preparation

Plant samples were randomly collected from each plot at the harvest stage. The seeds and stover were dried initially under the sun and further dried at approximately 60°C. Subsequently, they were ground and sieved to facilitate the determination of NPK uptake. The seed and stover samples were ground separately into powder and placed in labeled bags for chemical NPK analysis.

3.6.2 Digestion of plant samples

The powdered samples were pre-digested separately in HNO_3. The pre-digested samples were digested with di acid (HNO_3:$HClO_4$) mixture till clear solution was observed, cooled and diluted in HCl. The content was made up to a known volume using distilled water. A known quantity was used for further analysis of NPK**.**

3.6.3Nitrogen Uptake

The seeds and stover samples were digested with concentrated sulphuric acid in presence of digestion mixture. Nitrogen plant samples was determined by modified Kjeldhal method as described by Black (1965).

3.6.4 Phosphorus Uptake

The phosphorus was determined by wet digestion method. The plant samples were digested by di-acid mixture i.e. (HNO_3:HCl4 : 3:1) (Baruah and Barthakur, 1999). Total phosphorus in plant samples were determined by Vanadomolybdate yellow color method as outlined by Jackson (1973).

3.6.5 Potassium Uptake

For the total potassium the samples were digested by di-acid mixture (Baruah and Barthakur, 1999) and were determined by Flame photometry as described by Hanway and Heidal (1952).

3.6.6 Total Nutrient Uptake

Nutrient uptake is the amount of nutrient taken by the crop. The seed and stover samples were grounded separately to the powder and analysed for NPK content (%) and NPK uptake (kg ha^{-1}). The uptake of nutrient was computed as follows:

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

Total nutrient uptake N, P, K Uptake by the crop = NPK uptake by the seed + NPK uptake by the stove

3.7 Determination of biological parameters of soil

3.7.1 Microbial population

3.7.1.1 Sample preparation for Microbial population analysis (CFU g^{-1} soil)

The soil samples were collected from each plots and air dried, further for microbial analysis through serial dilation procedure as follows. Four test tubes consisting of 9ml of sterile diluted water were taken; one test tube containing 9 ml of sterile distilled water was taken and 1g of soil was added in the test tube. Thereafter, the soil was mixed thoroughly with sterile distilled water and then, 1 ml of microbial suspension was added to another tube containing 9 ml of sterile distil water. This same step was repeated for the other test tubes. In this way, the microbial suspension was diluted 10 fold. Finally, 100µl of diluted suspension and poured into the surface of nutrient agar plate and spread. The bacteria can thus be isolated and counted by C.F.U i.e. Colony forming Unit. The same procedure was carried out for actinomycetes and fungi respectively. The dishes were then rotated gently to disperse the inoculums uniformly over the surface of the medium. The inoculated dishes were incubated at 30± 1 ˚C for 24 hr.

3.7.1.2 Bacteria (10^6 x Cfu g^{-1})

Nutrient agar medium was used for enumeration of bacteria.

3.7.1.3 Fungi (10^3 x Cfu g^{-1})

Potato dextrose Agar medium was used for enumeration of fungi.

3.7.1.4 Actinomycetes (10^5 x Cfu g^{-1})

Kenknight medium medium was used for enumeration of acitnomycetes.

3.7.2 Enzyme activity

3.7.2.1 Phosphatase activity (µg p-nitrophenol g^{-1}soil h^{-1})

The phosphatase activity involves spectrophotometric estimation of p-nitrophenyl released when known amount of soil is incubated with buffered sodium p-nitrophenyl phosphate solution and toluene (Tabatabai and Bremner, 1969). A stable yellow colour develops and the intensity is measured with the help of a spectrophotometer.

3.7.2.2 Dehydrogenase activity (µg TPF g^{-1} soil h^{-1})

Dehydrogenase activity was assayed by the 2-3-5-triphenyltetrazolium chloride reduction technique (Casida, 1977). Five grams of fresh soil was placed in a test tube and carefully mixed with 0.1g $CaCO_3$ and 1ml fresh 1% of 2-3-5-triphenyl tertrazolium chloride solution. The tubes were plugged with a rubber stopper and incubated at 30˚C for 24 hr. the resulting slurry was transferred on Whatman no.1 filter paper, and triphenylformazan was extracted with successive aliquots of concentrated CH_3OH. The volume of filtrate was made up to 50ml by adding CH_3OH. The extinction of the pink colour was read spectrophotometrically at 485 nm, using CH_3OH as a control.

3.7.2.3 Soil Microbial biomass carbon (µg g^{-1} soil)

The microbial biomass carbon of soil was determined by using the fumigation-extraction method by (Vance *et al*., 1987). The fresh soil sample were placed in 50 ml beakers and kept in a vacuum desiccator for fumigation with chloroform for 24 hours. The fumigated soil samples were treated with K_2SO_4 and placed in the shaker for few minutes. The extracts were filtered and digested using H_2SO_4 and then titrated against ferrous ammonium sulphate. The microbial biomass carbon was calculated as the difference between the values obtained from fumigated and non-fumigated soil samples.

3.8 Residual effect of nutrient management after harvest of ricebean crop on the succeeding crop linseed

3.8.1 Yield attributes

3.8.1.1 Number of pods $plant^{-1}$

During the harvest, the number of pods from the selected five plants were counted and recorded and the average was taken to get the number of plods $plant^{-1}$.

3.8.1.2 Number of seeds pod^{-1}

The number of seeds from the five recorded pods were counted and average value was taken to obtain the number of seeds pod^{-1}.

3.8.1.3 Length of pods (cm)

Length of the pods was recorded from the randomly tagged plants from each plot and the average was recorded for statistical analysis.

3.8.1.4 Test weight (g)

From the threshed plants, 1000 seed samples were taken randomly, counted and weighed to get the test weight (g).

3.8.1.5 Seed yield (kg ha^{-1})

The harvested plants from the plots were threshed separately, and weight per plot was recorded and yield was maintained in kg ha^{-1}.

$$\text{Seed yield (kg ha}^{-1}) = \frac{\text{Weight of the seed plot}^{-1}}{\text{Size of the plot}} \text{x10000}$$

3.8.1.6 Stover yield (kg ha^{-1})

The harvested plants from ploys were threshed individually, and weight of the stover was recorded and recorded and maintained in kg ha^{-1}.

$$\text{Stover yield (kg ha}^{-1}) = \frac{\text{Weight of the stover plot}^{-1}}{\text{Size of the plot}} \text{x10,000}$$

3.8.1.7 Total Nutrient Uptake

Nutrient uptake is the amount of nutrient taken by the crop. The seed and stover samples were grounded separately to the powder and analyzed for NPK content (%) and NPK uptake (kg ha^{-1}). The uptake of nutrient was computed as follows:

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

Total nutrient uptake N, P, K Uptake by the plant = NPK uptake by the seed + NPK uptake by the stover.

3.8.2 Chemical parameters of soil

3.8.2.1 Soil pH

Soil samples were dissolved in water in the ratio of 2:1 and the pH was determined by Digital pH meter (Jackson, 1973).

3.8.2.2 Soil electrical conductivity (dS m^{-1})

The electrical conductivity (EC) was determined using the conductivity bridge (Richards, 1954) in 1:2 soil-water suspensions at 25^{o}C.

3.8.2.3 Organic carbon (%)

Organic carbon was estimated by Walkley and Black's rapid titration method (Walkley and Black, 1934) and was expressed in terms of percentage

3.8.2.4 Available nitrogen (kg ha^{-1})

The available N status was determined by the method suggested by Subbiah and Asijia (1956). The distillation of soil with alkaline potassium permanganate solution was carried out and the ammonia liberated in the process is determined and was calculated in terms of kg ha^{-1}.

3.8.2.5 Available phosphorus (kg ha^{-1})

Available phosphorus was extracted with 0.03N NHF in 0.025N HCl. The procedure is primarily meant for soils which are moderately to strongly acidic with pH around 5.5 or less (Brady and Kurtz, 1945) and expressed in terms of kg ha^{-1}.

3.8.2.6 Available potassium (kg ha^{-1})

Available potassium was extracted from 5 g of soil by shaking with 25 ml of Neutral ammonium acetate (pH=7) solution for half an hour and the extract was filtered immediately through a dry filter paper (Whatman no. 1) and then the potassium concentration in the extract was determined by Flame photometer (Hanway & Heidal, 1952) and expressed in terms of kg ha^{-1}.

3.9 ECONOMIC ANALYSIS

Economic analysis of all the treatments was enumerated as per the existing market prices.

3.9.1 Cost of cultivation (₹ ha^{-1})

The cost of cultivation of each treatment was calculated on per hectare basis by considering the cost incurred in different operations and items separately for each treatments.

3.9.2 Gross return (₹ ha^{-1})

The gross return for each treatment was estimated by multiplying the values of economic yield with the prevailing support prices ha^{-1} of the output.

Gross return (₹ ha^{-1}) = Yield x selling price

3.9.3 Net return (₹ ha^{-1})

Net return was estimated by subtracting the total cost of cultivation from the gross income respectively for each treatment.

$$\text{Net return}(₹\ ha^{-1}) = \text{Gross return} - \text{Total cost of cultivation}$$

3.9.4 Benefit: Cost ratio

Benefit cost ration was calculated by the following formula

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

3.10 STATISTICAL ANAYLSIS

The various data recorded during the course of experiment were statistically analysed by following the "Randomized Block Design'' as described by Gomez and Gomez (1976). 'F' test was used to determine significant difference between two means and critical difference (CD) was calculated for comparison in those cases where 'F' was significant at 5 percent level of significance. The treatments were then compared among themselves by calculating critical difference (CD) as follows:

$CD_{0.05}$ = SEm± x t0.05 for error degrees of freedom

The standard error mean (SEm ±) was calculated by using the formula

SEm± = square root of error mean square

Number of replication

Where SEm± = standard error mean

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

CHAPTER IV

RESULTS AND DISCUSSIONS

RESULTS AND DISCUSSIONS

A field study titled "Effect of nutrient management on ricebean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi] – linseed (*Linum usitatissimum* L.) cropping system" was conducted to investigate various aspects including growth, yield parameters, quality, nutrient uptake, soil nutrient status, and economic considerations. This study was conducted during the 2019-2021 period and aimed to achieve the following objectives:

1. To find out the effect of nutrient management on growth, yield and quality of ricebean-linseed cropping system.
2. To assess the effect of nutrient management on nutrient concentration, their uptake and soil fertility status under ricebean-linseed cropping system.
3. To find out the economics of the treatments under study.

The data collected during the investigation underwent statistical analysis, and this chapter presents the findings of the experimental data including tables, graphs, and references that are pertinent to the conducted experiment. These results are extensively discussed to draw meaningful conclusions, both in terms of their scientific relevance and practical applicability. The discussion is grounded in established principles and supported by existing evidence.

Climatic condition

The fluctuating climatic conditions observed in the meteorological data presented in Table 3.1(a) from 2019 to 2021 likely played a significant role in influencing crop performance in the field. Notably, there was an evident increase in temperature and relative humidity, accompanied by an irregular rainfall pattern during this period. The rise in temperature and a higher amountof rainfall in comparison to the subsequent years, 2020 and 2021, could have exerted direct or indirect impacts on the growth and yield of crops.

The heightened temperatures experienced during this timeframe might haveinduced heat stress on the crops, potentially affecting various physiological processes critical for optimal growth. Additionally, the elevated relative humidity levels could have created conditions conducive to the development of fungal diseases, posing a threat to crop health.

The irregular rainfall pattern observed in the meteorological data may have led to challenges such as drought stress or waterlogged conditions, depending on the timing and distribution of rainfall events (Salem, 2004). Extended periods of water scarcity may have adversely affected crop yields due to inadequate moisture for proper growth and development. Conversely, excessive rainfall could have resulted in waterlogged soils, negatively impacting root health and nutrient uptake.

Comparing these weather conditions with the subsequent years, 2020 and 2021, where there was a decrease in temperature and possibly less rainfall, it becomes apparent that the variations in climatic factors may have contributed to differing crop performances over the examined period. The data from Table 3.1(a) serves as a crucial foundation for understanding the intricate relationship between weather dynamics and crop responses, allowing for a comprehensive analysis of the direct and indirect effects on the field's agricultural productivity during the specified years.

4.1 Growth attributes of rice bean

Enhancing the growth characteristics of crops is essential for increasing overall yield. The study found that combinations of NPK fertilizers with organic manures had a notably positive impact on growth characteristics when compared to other treatments.

4.1.1 Plant height (cm)

Plant height, is the primary yield factor in fodder crops which reflects how different nutrient intake affects plant metabolism and vigour.

Pertaining to the data, plant height of rice bean was observed at 30, 60, 90 days after sowing and at harvest, Plant height parameter at various growth stages as affected by nutrients showed significant response as presented in the table 4.1 and illustrated in the figure 4.1.

The results revealed that there was significant influence of nutrient management on plant height at 30 DAS. It was observed that T_1 [GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF] recorded highest plant height in both the years with the value of 41.86 cm in 2019 and 48.79 cm in year 2020. Similarly, in the pooled data the maximum plant height was observed in the treatment T_1, where poultry manure (0.7 t ha^{-1}) along with 100 % RDF was applied (45.33 cm) whereas the lowest plant height was observed where poultry manure T_6 [PGM (0.7 t ha^{-1}) + 50 % RDF] was applied (32.91cm), simultaneously T_6 recorded the least plant height in both the years with the value of 32.74cm in 2019 and 33.08 cm in year 2020. Similarly, the higher nitrogen content in poultry manure promotes faster vegetative growth in green bean plants, as evidenced by the increased number of leaves observed in the study conducted by Yafizham and Sumarsono (2020). Additionally, incorporating additional green material, like dhaincha, into the soil increased the organic matter content, which subsequently enhanced the availability of essential nutrients to the plants and this overall improvement in nutrient availability contributed to better growth and yield (Thakuria and Thakuria, 2018). The practice of green manuring offers numerous benefits for enhancing rice production, as confirmed by several researchers (Deshpande and Devasenapathy, 2010; Kumari *et al*., 2010).

A close analysis of the data at 60DAS, similar trend was observed where it was indicated that highest value of plant height was recorded highest in T_1 with the value of 75.02 cm in 2019 and 81.30 cm in 2020 while pooled data was achieved the value of 78.16 cm and the lowest plant height (57.44cm) was achieved in application of pig manure @ 0.7 t ha^{-1} with 50 % RDF (T_6), which might due to the addition of biological and organic manure to the soil along with chemical fertilisers has a significant impact and increased plant height, clearly demonstrating the need for doing so.

Subedi *et al*. (2022) reported that cowpea plants exhibited improved growth in terms of plant height when cultivated in soil enriched with chicken manure. This observation suggests that the chicken manure was readily accessible to the plants and in excellent condition for efficient absorption by the plant roots and consequently, this favourable condition resulted in significant plant growth. A group of researchers corroborated these findings in their report, highlighting the potential of organic manures, particularly poultry manure, to enhance the plant height of cowpea when compared to other sources of manure (Singh *et al*., 2011).

It was revealed in table 4.1 that during 2019, highest value of plant height at 90DAS (118.34cm), was recorded with the under T_1 [GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF] 90 DAS and respectively, while the least was recorded at T_6 (103.23cm). In 2020, T_1 exhibited highest plant height value of 133.68 cm and similar trend in pooled average data of 126.01 cm. The findings are consistent with those of Babalad (1999), who found that the application of organic manure and inorganic fertilisers to soybean plants enhanced plant height, the number of trifoliate leaves per plant, and the number of branches per plant and precise findings were reported by Babhulkar (2000) in soybean.

During the time of harvest, the maximum highest plant height was exhibited at T_1 under the value of 167.93 cm in 2019 and 174.70 cm in the year 2020 while T_6 recorded least plant height was exhibited at T_1 under the value of 121.89cm in 2019 and 124.83cm in 2020. The pooled data also revealed that a significant difference with the maximum plant height recorded in T_1 (171.32 cm) and the minimum under treatment T_6 (123.36 cm) at all the growth stages during both years of investigation. The fact that application of green manuring (*Sesbania*) with PM (0.7 t ha^{-1}) with 100% RDF enhanced the plant height to its maximum in all development phases may be related to the plants' increased nutrient availability and improved fertiliser utilisation which might have largely contribute to the overall increase of plant height.

Similarly, Kawikhonliu (2002) also observed notable increase in plant height, reaching 179.52 cm with the utilization of poultry manure, whereas the lowest plant height was recorded when vermicompost was used, measuring 168.23 cm. This significant response in plant height can be attributed to the fact that poultry manure contains significantly higher levels of nitrogen, phosphorus, and potassium compared to other animal manures which enhances the plant growth associated with poultry manure application as a result of its capacity to provide more abundant nutrients throughout the entire growth period, as suggested by Farhad *et al*. (2009). The cause of the increase in plant height with full dose of RDF may be due to nutrients assistance in photosynthetic activity, cell and internodal elongation, and maintenance of higher auxin levels, all of which lead to taller plants in comparison to other treatments and these findings were also supported by Jeet *et al*. (2012). Similar findings was also reported by Msaakpa (2016), where poultry manure is believed to superiorly increase the height of cowpea plants signifying its ability to quickly release nutrient elements required for vigour and growth of the plant, apart from its high nitrogen fixing ability and supported by Ewulo (2005). Another contributing factor to the substantial rise in plant height observed in the poultry manure-treated group may be attributed to the enhanced availability of nutrients released during the mineralization process of poultry manure. Additionally, poultry manure tends to have a higher nutrient content compared to other nutrient sources, and these findings align closely with the research by Diwale *et al*. (2020). Likewise, Ananda *et al*. (2006) also documented that the use of poultry manure resulted in a significant positive impact, leading to increased crop yields when compared to alternatives such as vermicomposting, farmyard manure (FYM), and goat manure.

Table 4.1: Effect of nutrient management on plant height at different growth stages

Treatment	30DAS (cm)			60DAS (cm)			90 DAS (cm)			Harvest (cm)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	41.86	48.79	45.33	75.02	81.30	78.16	118.34	133.68	126.01	167.93	174.70	171.32
T_2	41.49	43.66	42.57	69.06	76.54	72.80	116.84	130.37	123.60	164.40	168.51	166.45
T_3	38.81	43.03	40.92	68.25	73.09	70.67	113.33	126.56	119.94	164.11	168.24	166.18
T_4	34.91	37.19	36.05	58.55	66.49	62.52	105.35	108.72	107.04	135.85	140.71	138.28
T_5	34.45	36.35	35.40	57.69	66.03	61.86	104.55	107.74	106.15	129.04	130.88	129.96
T_6	32.74	33.08	32.91	54.05	60.83	57.44	103.23	105.63	104.43	121.89	124.83	123.36
T_7	37.87	42.83	40.35	64.71	68.10	66.41	112.34	120.87	116.61	164.25	174.77	169.51
T_8	37.25	41.97	39.61	62.88	66.78	64.83	109.52	113.07	111.29	152.37	166.36	159.37
T_9	35.82	40.13	37.97	61.92	66.53	64.23	109.38	110.20	109.79	156.92	151.47	154.20
SEm ±	1.66	2.35	1.44	3.30	2.77	2.15	3.06	5.38	3.10	10.00	11.85	7.75
CD (P=0.05)	4.97	7.04	4.14	9.89	8.30	6.20	9.18	16.14	8.92	29.97	35.53	22.33

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

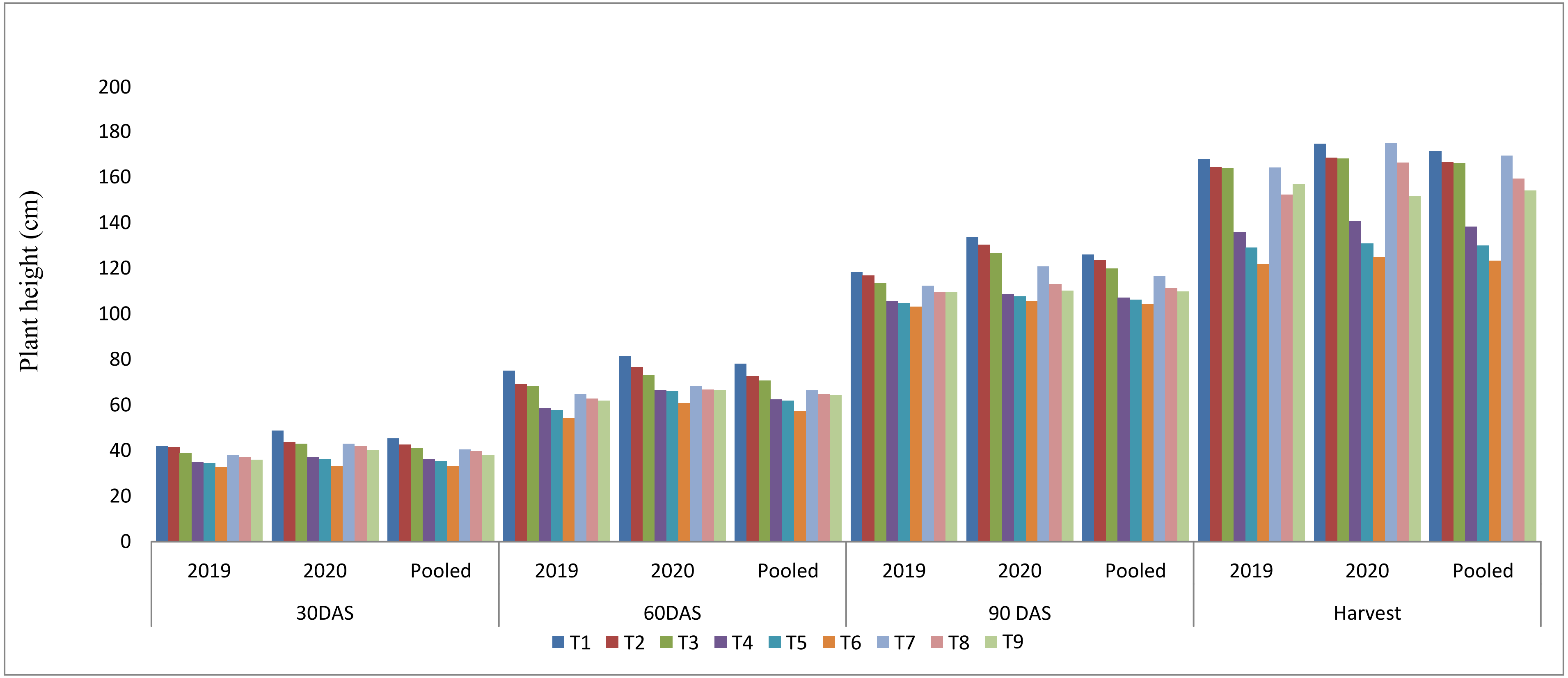


Fig 4.1: Effect of nutrient management on plant height (cm) at different growth stages in ricebean

4.1.2 Number of branches plant^{-1}

The data recorded on the effect of nutrient management on number of branches plant^{-1} of rice bean is illustrated in table 4.2 and figure 4.2.

As portrayed from the data in 30 DAS, there was significant variation in the number of branches plant^{-1} between the treatments attributing to various nutrients supplied by the organic manures and fertilizers. The maximum number of branches plant^{-1} was obtained in the treatment where rice bean had received PM @ 0.7 t ha^{-1} along with 100 % RDF in both the years *i.e.* 6.53 in 2019 and 6.73 in 2020 and the pooled data also reflected significant effect on number of branches plant^{-1} where the maximum was recorded in the treatment PM (0.7 t ha^{-1}) + 100 % RDF (T_1) with the number of branches plant^{-1} *i.e.* 6.63 followed by application of poultry manure which was comparable with the treatment T_2 (6.17), while the lowest number of branches plant^{-1} of 5.38 was recorded in the treatment pig manure @ 0.7 t ha^{-1} along with 50 % RDF (T_6) in pooled data. In summary, poultry manure can boost branching in legumes by providing essential nutrients, promoting overall plant growth and health, improving soil conditions, and enhancing microbial activity and these results in legume plants with more branches, which can lead to increased yields and better overall performance.

More or less, similar trend was observed at 60 DAS in table 4.2, where the number of branches plant^{-1} in both 2019 and 2020 years and pooled data exhibited showed significant higher number of branches plant^{-1} with value of 8.28 and 8.51 branches plant^{-1}. The application of PM (0.7 t ha^{-1}) + 100 % RDF with the values of application of T_1 recorded maximum pooled number of branches plant^{-1} with 8.39 which was precise with the treatment of poultry manure at T_2 (PM @ 0.7 t ha^{-1} + 75 % RDF) and T_3 (PM @ 0.7 t ha^{-1} + 50 % RDF) with the value of 8.33 and 8.32. It was previously understood that poultry manure had the most elevated levels of nitrogen, phosphorus, and potassium nutrients compared to other types of animal manures. This heightened nutrient content could also be attributed to improved nutrient accessibility, which promoted the outward growth of rice beans by stimulating cell division in the meristematic area.

At 90 DAS, there was significant response of the manures on number of branches plant^{-1} during 2019 and 2020 and similar trend was observed in the case of pooled data. The result presented in table 4.2 revealed that T_1, application of poultry manure (0.7 t ha^{-1}) along 100 % RDF resulted in significantly higher branches plant^{-1} in both the years i.e. 2019 (9.43) and 2020 (9.74). Similarly, poultry manure application recorded significantly highest number of branches plant^{-1} in pooled data with the value of 9.59 in the same treatment and lowest in with application pig manure with value of 8.27 in T_6 treatment. Incorporating more green materials like dhaincha into the soil brought about an increase in the presence of organic matter. Consequently, this enhancement contributed to greater quantities of vital nutrients accessible to plants, ultimately resulting in improved growth and crop yield (Thakuria and Thakuria, 2018). Several researchers have verified that the utilization of green manuring provides numerous advantages for improving rice production (Deshpande and Devasenapathy, 2010; Kumari *et al*., 2010).

These findings were also supported by Edward and Daniel (1992) reported from their observation that combining poultry manure with chemical fertilizer supplemented all the necessary nutrients for the crop and resulted in a positive increase in crop productivity was made by an unidentified source.

Table 4.2: Effect of nutrient management on number of branches at different growth stages in ricebean

Treatment	30DAS			60DAS			90 DAS		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	6.53	6.73	6.63	8.28	8.51	8.39	9.43	9.74	9.59
T_2	6.00	6.35	6.17	8.23	8.43	8.33	9.30	9.63	9.47
T_3	6.13	6.01	6.07	8.23	8.40	8.32	9.27	9.47	9.37
T_4	5.57	6.00	5.78	7.67	7.97	7.82	8.70	8.77	8.73
T_5	5.47	5.83	5.65	7.39	7.52	7.45	8.47	8.68	8.58
T_6	4.97	5.79	5.38	7.11	7.26	7.19	8.10	8.44	8.27
T_7	5.80	6.03	5.92	8.15	8.21	8.18	9.19	9.34	9.27
T_8	5.67	6.07	5.87	8.07	8.19	8.13	9.13	9.17	9.15
T_9	5.60	6.04	5.82	7.83	8.10	7.97	8.87	8.87	8.87
SEm ±	0.27	0.13	0.15	0.19	0.25	0.16	0.22	0.23	0.16
CD (P=0.05)	0.81	0.38	0.43	0.58	0.76	0.46	0.67	0.70	0.46

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

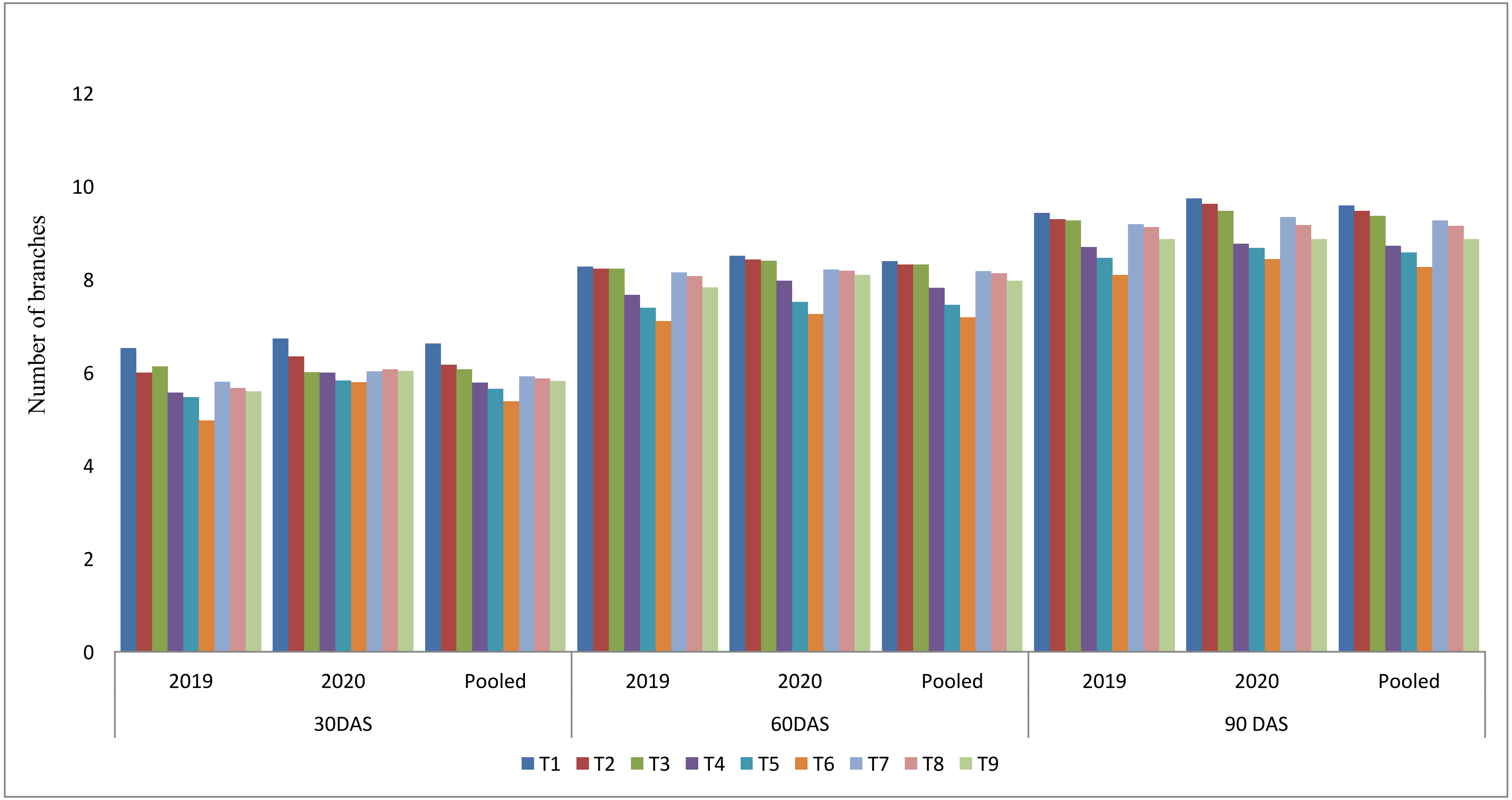


Fig 4.2: Effect of nutrient management on number of branches at different growth stages in ricebean

4.1.3 Number of nodules plant^{-1}

The number of nodules plant^{-1}were influenced significantly by the different combination of organic and inorganic fertilizers.

At the initial stage, *i.e.* 30DAS, there was no significant response to the effect of nutrient management on number of nodules plant^{-1} of ricebean in table 4.3 and figure 4.3.

However in 2019, significant response was observed with the application of poultry manure, where the highest number of nodules plant^{-1} at 50 DAS was exhibited in T_1 (20.63) over pig manure (17.20) and FYM (19.93) while T_2 and T_3 were at par (20.47 each). Similarly in 2020, it was observed that treatment T_1 recorded the maximum nodules plant^{-1} (26.33) and minimum was recorded in T_6 (15.47), pooled data also revealed that there was a significant effect on number of nodules plant^{-1} due to the different organic manures. The treatment where poultry manure was (T_1, T_2 and T_3) administered exhibited the highest number of nodules plant^{-1} (23.48) and the lowest number of nodules plant^{-1} (15.67) was observed in the treatment were pig manure (T_6) was applied. It is known that poultry manure contributes to increased nodule formation in legumes by supplying nitrogen and other nutrients, improving soil fertility, stimulating beneficial microbial activity, and enhancing the overall health and growth of legume plants which ultimately leads to improved nitrogen fixation and better legume yields.

At 70 DAS, there was also a significant response of the organic manures on the number of nodules plant^{-1}during the year 2019 and 2020 and identical pattern was observed in the case of pooled data respectively. The results presented in the table revealed that application of poultry manure @ 0.7 t ha^{-1} with 100 % RDF (T_1) indicated significantly higher nodules plant^{-1} in both the year i.e. 2019 (36.07) and 2020 (38.20), and simultaneously, T_1 also recorded number of nodules plant^{-1} in pooled data with the value of 37.13 and lowest in T_6 (29.87) followed by T_5 (29.90). The residual impact of green manure could also be a contributing factor to the enhanced soil fertility in ricebean. The increase in ricebean nodules from 50 to 70 days after sowing is likely a result of the plant's growth and development, increased nitrogen demand, and favourable environmental conditions that support the establishment and proliferation of rhizobia in the root nodules. This symbiotic relationship between the plant and the bacteria is crucial for nitrogen fixation, which benefits the plant's nutrient uptake and overall growth.

As shown in table 4.3 and figure 4.3, the addition of poultry manure with RDF had significant increasing effect on the number of nodules relative to the other treatments, these finding were similar to those reported by Panda *et al*. (2012) who revealed that poultry manure improve the effectiveness of rhizobium in cowpea and consequently, the highest number of nodules (196) was obtained in the pot that had poultry manure at 2 t ha^{-1}. The noted phenomenon can be explained by the fact that poultry manure, in addition to nitrogen and other elements, contains significant quantities of organic phosphates. These organic phosphates undergo mineralization, enriching the soil with available phosphorus. This increase in phosphorus availability, in turn, promotes enhanced nodulation of legumes and these findings were supported by the results of Osodeke (2002); Amba *et al*. (2013). Therefore the nodules produced by the plant that had poultry manure @ 0.4 t ha^{-1} with 100 RDF were significantly higher than the other treatments. The increase in availability of N in soil with the application of organic manures might be due to the increase in root nodulation, releasing higher amounts of N compounds by root nodules at early stages of crop growth (Nagar *et al*. 2016). The inclusion of additional green material, such as dhaincha, into the soil resulted in the introduction of higher amounts of organic matter. This, in turn, led to an augmentation of essential nutrients available to plants, ultimately leading to an improvement in growth and yield (Thakuria and Thakuria, 2018). The practice of green manuring offers numerous benefits for enhancing rice production, as

Table 4.3: Effect of nutrient management on number of nodules at different growth stages in ricebean

Treatment	30DAS			50DAS			70 DAS		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	7.50	7.97	7.73	20.63	26.33	23.48	36.07	38.20	37.13
T_2	7.24	7.83	7.54	20.47	26.00	23.23	35.13	37.37	36.25
T_3	7.13	7.82	7.48	20.47	24.60	22.53	33.93	35.87	34.90
T_4	6.73	7.37	7.05	17.20	21.33	19.27	29.07	31.47	30.27
T_5	6.50	6.70	6.60	15.87	16.00	15.93	28.40	31.40	29.90
T_6	6.47	6.57	6.52	15.47	15.87	15.67	27.73	32.00	29.87
T_7	7.10	7.80	7.45	19.93	25.33	22.63	33.53	34.47	34.00
T_8	7.07	7.77	7.42	19.30	22.07	20.68	32.47	34.53	33.50
T_9	6.80	7.43	7.12	18.41	21.07	19.74	31.93	33.67	32.80
SEm ±	0.47	0.55	0.36	0.82	2.47	1.30	1.45	1.53	1.06
CD (P=0.05)	NS	NS	NS	2.45	7.41	3.75	4.36	4.60	3.04

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

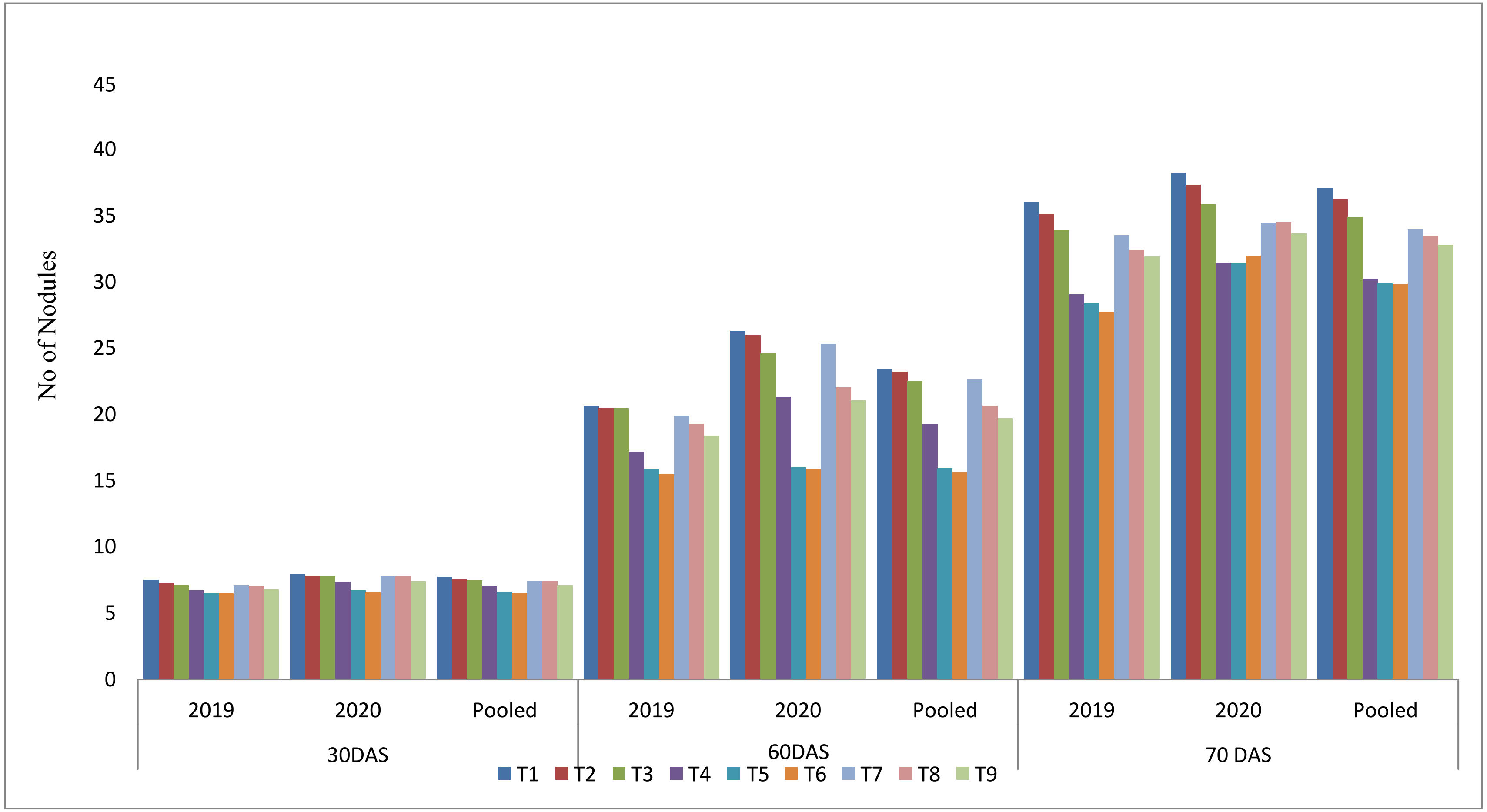


Fig 4.3: Effect of nutrient management on number of nodules at different growth stages of ricebean

confirmed by several researchers (Deshpande and Devasenapathy, 2010; Kumari *et al*., 2010).

This underscores the significance of combining organic manures with inorganic fertilizers, as it substantially boosts the availability of nutrients. This combination has led to a positive impact on various growth parameters (Sachan and Krishna, 2021). Poultry manure, which was readily accessible to the plant, had a higher C: N ratio. This meant that it provided an abundant supply of available nutrients to the soil, with comparatively less retention in the roots and more translocation to the above-ground parts of the plant for the synthesis of protoplasmic proteins and other compounds. The introduction of organic manures in the form of poultry manure likely improved the physical condition of the soil and enhanced nutrient availability, resulting in better plant growth. The increased growth characteristics can be attributed to the greater availability of nitrogen, which improved plant growth. After being absorbed by the plant, nitrogen is converted into amino acids, the building blocks of proteins. This process may have accelerated meristematic activity, leading to improved growth characteristics and these results are in conformity with the results of Sathe (2007), Choudhari *et al*. (2001) and Band *et al*. (2007) in French bean.

4.1.4 Leaf area index (LAI)

Leaf Area Index (LAI) is a measurement that quantifies the leaf surface area per unit of ground area in a vegetation canopy and is typically used to assess the vigor and productivity of crops or natural vegetation.

The data on LAI at different stages of ricebean crop as affected by nutrient management is presented in table 4.4 and illustrated in figure 4.4. A perusal data the present study revealed that at 30 DAS, LAI was significantly superior in 2019 with the application of poultry manure @ 0.7 t ha^{-1} along with 100 % RDF in T_1 (0.537) caused maximum LAI while the minimum value was recorded in T_6 (0.463) identical to the second year with the value 0.535 and in the pooled data was 0.536 from application of poultry manure @ 0.7 t ha^{-1}

along with 100 % RDF in treatment T_1. One probable reason may be that with application of poultry manure to soil, it can positively affect LAI by providing essential nutrients, promoting plant growth, and enhancing the overall health and density of the vegetation canopy. This in turn, can have a significant impact on crop productivity and ecosystem functioning.

It is evident from the data that increasing the levels of poultry manure and RDF had a significant effect on the LAI at the different stages of the crop. In 2019, T_1 recorded significantly maximum LAI at 60 DAS (0.972) and the lowest was recorded in T_6 (0.920) and at par with T_5 (0.922) and similarly, in 2020, T_1 recorded significantly maximum LAI with the value of 0.966 followed by T2 (0.964), T3 (0.954) while at par with T_7 (0.952) and T_8 (0.953) and pooled data maximum in T_1 (0.969).

Upon careful examination of the data, it was evident that at 90 days after sowing (DAS), the Leaf Area Index (LAI) was significantly higher in the year 2019 when poultry manure was applied at a rate of 0.7 tons per hectare along with 100% Recommended Dose of Fertilizers (RDF) in T_1. In this treatment, the LAI reached its maximum value at 1.519, while the minimum LAI was observed in T_6 at 1.471. Interestingly, these findings were consistent with the second year of the study, where the LAI value was 1.521. When pooling the data from both years, the LAI averaged at 1.519, indicating that the application of poultry manure at 0.7 t ha^{-1} along with 100% RDF in T_1 consistently yielded the highest LAI.

This could be because chemical fertilizers supply nutrients to crops more rapidly, while organic manures contribute to improving the soil's physical properties over time. These improved soil conditions facilitate better plant growth and the capture of solar energy during photosynthesis.

Table 4.4: Effect of nutrient management on LAI at different growth stages in ricebean

Treatment	30DAS			60DAS			70 DAS		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	0.537	0.535	0.536	0.972	0.966	0.969	1.518	1.521	1.519
T_2	0.526	0.532	0.529	0.968	0.964	0.966	1.510	1.515	1.513
T_3	0.524	0.528	0.526	0.958	0.954	0.956	1.510	1.512	1.511
T_4	0.466	0.473	0.469	0.935	0.929	0.932	1.493	1.495	1.494
T_5	0.469	0.473	0.471	0.922	0.926	0.924	1.489	1.492	1.491
T_6	0.463	0.464	0.463	0.920	0.923	0.922	1.477	1.465	1.471
T_7	0.511	0.512	0.511	0.956	0.952	0.954	1.503	1.503	1.503
T_8	0.499	0.507	0.503	0.951	0.953	0.952	1.501	1.501	1.501
T_9	0.469	0.481	0.475	0.939	0.930	0.935	1.497	1.498	1.497
SEm ±	0.004	0.004	0.003	0.003	0.005	0.003	0.003	0.007	0.004
CD (P=0.05)	0.013	0.013	0.009	0.008	0.016	0.009	0.008	0.021	0.011

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

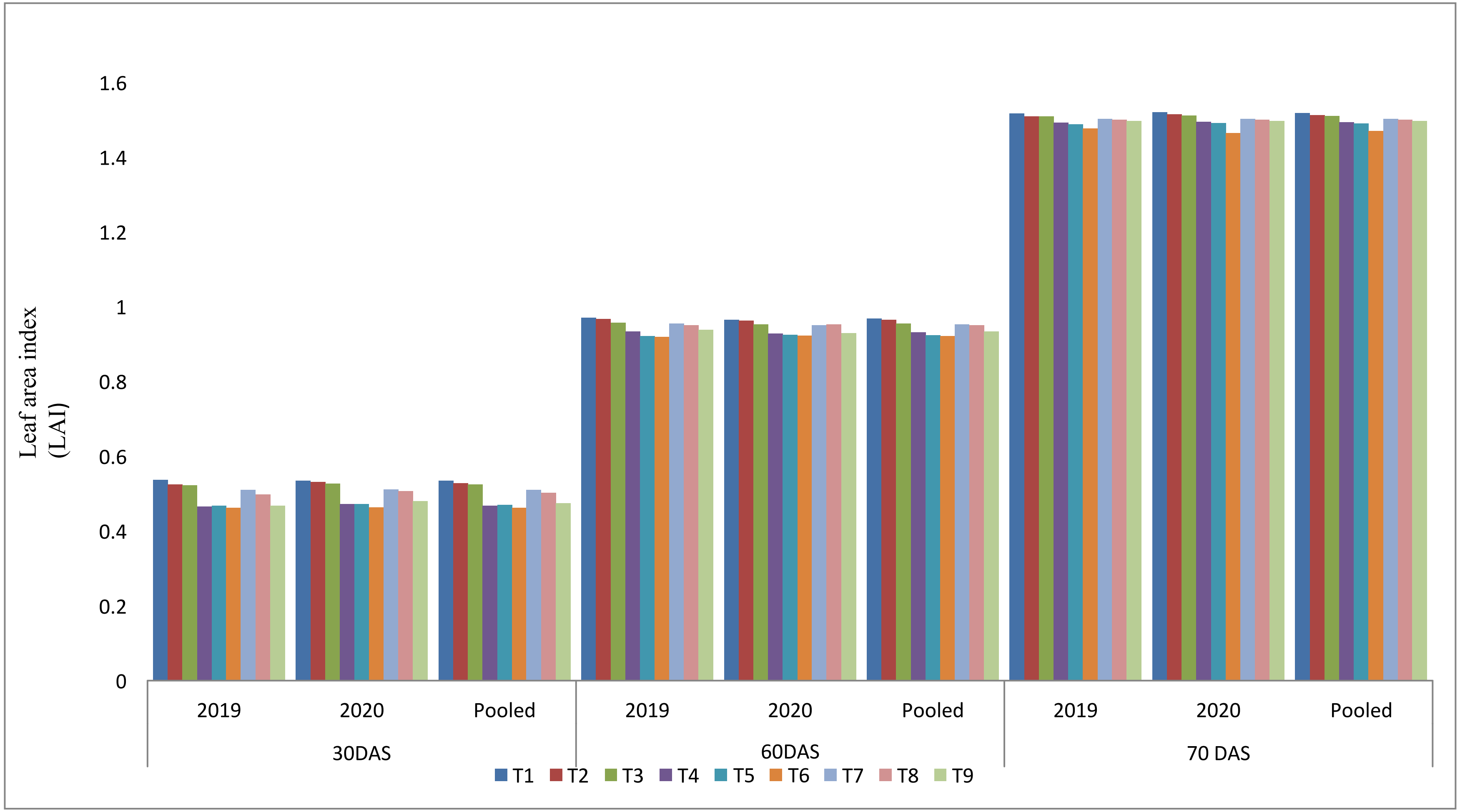


Fig 4.4: Effect of nutrient management on LAI at different growth stages in ricebean

4.1.5. Dry matter (g plant^{-1})

As per the experimental findings, the effect of nutrient management on dry matter (g plant^{-1}) at different stages of rice bean is presented in table 4.5 and figure 4.5.

Analysing the data in table, the present study revealed that at 30 DAS dry matter production was significantly superior with the application of poultry manure @ 0.7 t ha^{-1} along with 100 % RDF in T_1 (5.85 g plant^{-1}) caused maximum dry matter identical to the second year (6.16 g plant^{-1}) and in the pooled data *i.e* 6.00 g plant^{-1}. Similar trend was observed at 60 DAS also where the application of poultry manure gave the maximum dry matter in 2019 and 2020 under T_1 with the value of 21.28 and 26.17 g plant^{-1} and in pooled data of 23.73g plant^{-1}, this reason could be attributed to the fact that among all the types of animal manures, poultry manure had the highest concentrations of nitrogen, phosphorus, and potassium in comparison to the other treatments.

At 90 DAS, application of GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF (T_1) in showed positive responses, where during the first year, poultry manure recorded the highest dry matter accumulation with the value of 42.88 g plant^{-1} which was at par with T_2, poultry manure @ 0.7 t ha^{-1} along with 75 % RDF (42.62 g plant^{-1}) and at close proximity with T_3 (41.54 g plant^{-1}). In the second year similarly, T_1 recorded the highest dry matter accumulation of 44.14 g plant^{-1}, while T_2 (43.40 g plant^{-1}), T_3 (43.08 g plant^{-1}) and T_7 (43.07 g plant^{-1}) exhibited par results and the pooled data of poultry manure accumulated highest dry matter in T_1 (43.51 g plant^{-1}) which was comparable with T_2 (43.06g plant^{-1}) and the least amount of dry matter accumulation of dry matter was observed where pig manure was applied in all the growth stages.

A reference to the data in table 4.5 indicated that application of poultry manure greatly boosted the dry matter accumulation at all the stages till harvest in both the years. The pooled value was 137.13g plant^{-1}, in 2019 poultry manure exhibited maximum dry matter accumulation with the value of 135.19g plant^{-1}

which was under T_1 treatment, while T_2 (134.87 g plant^{-1}) and T_3 (138.00g plant^{-1}) exhibited par observations and in 2020, T_1 displayed highest dry matter accumulation (137.13g plant^{-1}) while T_7 (133.40g plant^{-1}) and T_8 (133.07g plant^{-1}) exhibited par results which we comparably lower compared to application of poultry nature.

The increased availability of higher nutrients and beneficial macro nutrients facilitated early root development, which was essential for improved growth and ultimately led to higher accumulation of dry matter in plants. Poultry manure, in particular, exhibited exceptional dry matter accumulation at all stages of crop growth, similar findings was reported by Kawikhonliu (2022). The rise in soybean plant height and the increased accumulation of dry matter at harvest can likely be attributed to the greater availability of nutrients from organic sources. This availability led to increased synthesis of nucleic acids and amino acids, as well as amide substances in the growing regions and meristematic tissue. Consequently, this enhancement in nutrient availability promoted cell division, thus contributing to the overall improvement in various growth attributes within these treatments. These results related to plant height and dry matters are in agreement with the findings of Kannan *et al*. (2013) in soybean and Pramanick *et al*. (2013) in green gram.

These findings are in agreement with the findings of Kawikhonliu (2022) who reported that combining poultry manure with chemical fertilizer significantly influenced the dry matter yield. The enhanced dry matter accumulation might be due to the integrated effects of poultry manure and chemical fertilizer in improving the major and micronutrients availability, as well as improving soil physical, chemical and biological properties.

Table 4.5: Effect of nutrient management on dry matter (g plant^{-1}) at different growth stages in ricebean

Treatment	30DAS (g plant^{-1})			60DAS (g plant^{-1})			90 DAS (g plant^{-1})			Harvest (g plant^{-1})		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	5.85	6.16	6.00	21.28	26.17	23.73	42.88	44.14	43.51	135.19	139.07	137.13
T_2	5.77	5.97	5.87	20.90	24.23	22.57	42.62	43.50	43.06	134.87	138.23	136.55
T_3	5.68	5.81	5.74	20.49	23.96	22.22	41.54	43.08	42.31	134.55	138.00	136.27
T_4	5.22	5.59	5.40	16.93	16.38	16.66	35.67	38.52	37.10	115.83	129.45	122.64
T_5	5.09	5.37	5.23	13.26	15.97	14.61	35.44	37.81	36.62	113.30	124.10	118.70
T_6	4.97	5.14	5.05	14.84	15.61	15.23	31.01	35.92	33.47	113.23	121.46	117.35
T_7	5.44	5.80	5.62	18.95	21.79	20.37	40.86	43.07	41.96	128.43	136.70	132.57
T_8	5.38	5.72	5.55	17.83	21.61	19.72	37.59	42.26	39.93	128.43	137.70	133.07
T_9	5.33	5.61	5.47	17.05	18.66	17.85	35.99	40.11	38.05	127.57	130.47	129.02
SEm ±	0.19	0.17	0.13	1.12	2.37	1.31	1.72	1.72	1.21	5.33	3.31	3.14
CD (P=0.05)	0.56	0.52	0.37	3.35	7.12	3.78	5.16	5.15	3.50	15.97	9.94	9.04

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

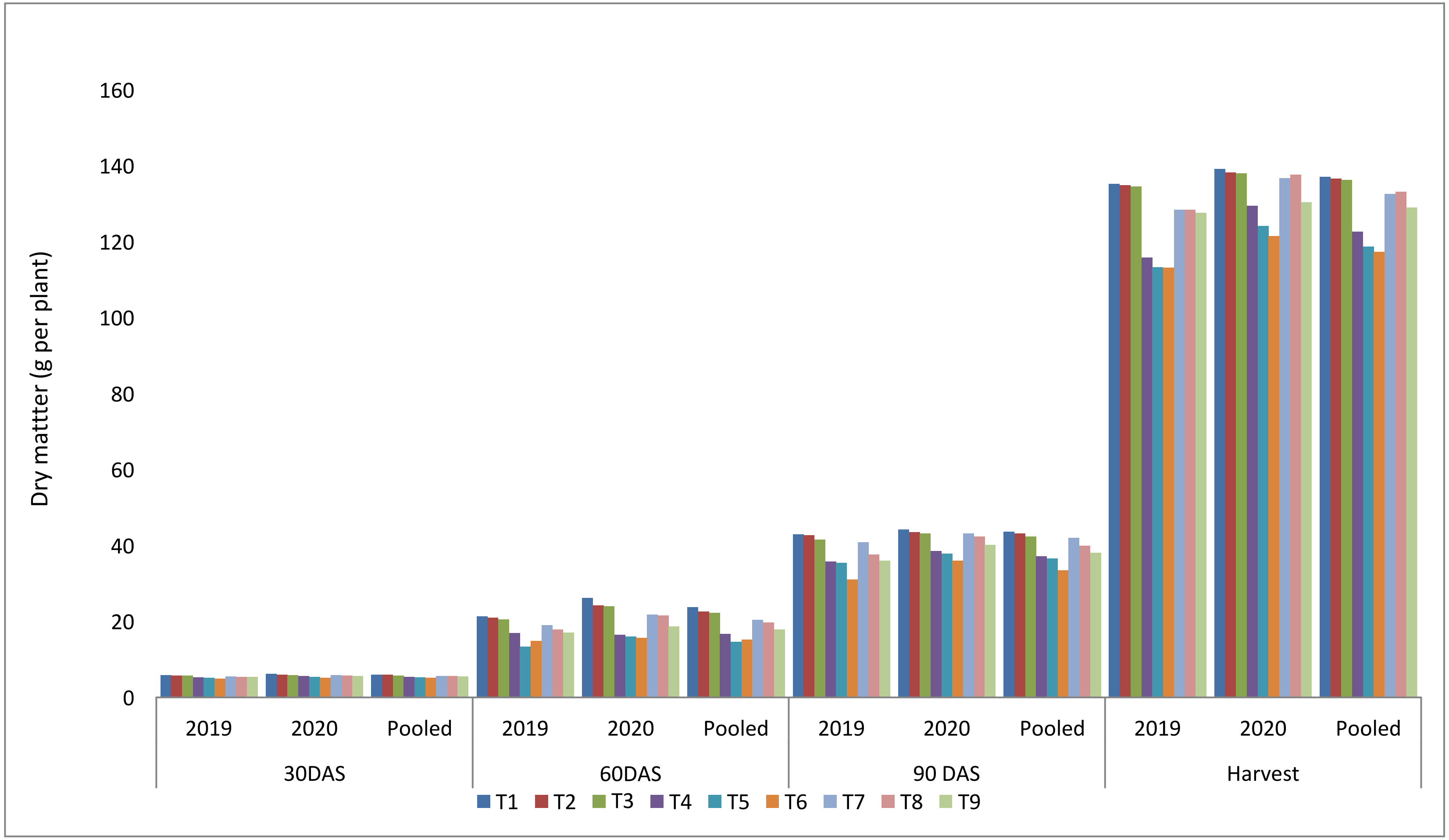


Fig 4.5: Effect of nutrient management on dry matter (g plant^{-1}) at different growth stages in ricebean

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

The experimental results regarding the impact of nutrient management on the mean crop growth rate (CGR) at various stages of ricebean growth are detailed in table 4.6 and visualized in figure 4.6 (a).

In the CGR from 30-60 DAS, the highest value was observed in T_1, which involved the use of poultry manure (0.7 t ha^{-1}) and 100% RDF in both 2019 (3.42 g m^{-2} day^{-1}) and 2020 (3.84 g m^{-2} day^{-1}). Similarly, when considering the combined data (pooled data), T_1 showed the maximum CGR at 3.63 g m^{-2} day^{-1}. Conversely, the lowest CGR values were reported in T_5, with 1.63 g m^{-2} day^{-1} in 2019, 2.12 g m^{-2} day^{-1} in 2020, with an average of 1.88 g m^{-2} day^{-1} in the pooled data.

However, a reference on the data presented in 60-90 DAS, revealed that the treatments did not different significantly in terms of crop growth rate during the two years and pooled value. The data obtained in Table no 4.6 suggest that may be interpreted with caution and hence there is a lack of available information on the mentioned field of work, indicating the necessity for additional research.

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

The data obtained in Table no 4.6 (b) revealed that the treatments did not different significantly in terms of relative growth rate during the two years and pooled value.

4.1.8 Net Assimilation Rate (NAR)

There was no significant response to the effect of nutrient management on the net assimilation rate in both the years as well as in pooled value in table 4.6(c).

Table 4.6: Effect of nutrient management on CGR, RGR and NAR at different growth stages in ricebean

Treatment	Crop growth rate (g m^{-2} day^{-1})						Relative growth rate (g g^{-1} day^{-1})						Net assimilation rate (g cm^{-2} day^{-1})					
	30 DAS-60DAS			60-90DAS			30 DAS-60DAS			60-90DAS			30-60DAS			60-90DAS		
	2019	2020	Pooled	2019	2019	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	3.42	3.84	3.63	4.25	4.75	4.50	0.046	0.048	0.047	0.023	0.031	0.027	184.0	221.5	202.7	249.6	257.2	253.4
T_2	3.03	3.65	3.34	4.16	4.65	4.41	0.044	0.046	0.045	0.024	0.020	0.022	184.5	217.0	200.8	237.3	244.0	240.6
T_3	2.96	3.63	3.30	4.03	4.52	4.27	0.043	0.045	0.044	0.024	0.020	0.022	174.2	206.4	190.3	234.6	247.0	240.8
T_4	2.34	2.16	2.25	3.95	4.43	4.19	0.039	0.037	0.038	0.026	0.030	0.028	171.3	149.1	160.2	220.1	220.8	220.5
T_5	1.63	2.12	1.88	3.72	3.87	3.79	0.036	0.032	0.034	0.033	0.029	0.031	112.9	143.0	127.9	216.1	218.9	217.5
T_6	1.65	2.35	2.00	3.23	3.93	3.58	0.036	0.039	0.038	0.025	0.027	0.026	101.2	144.6	122.9	215.5	214.8	215.1
T_7	2.70	3.20	2.95	3.91	4.62	4.27	0.042	0.044	0.043	0.026	0.023	0.024	182.3	196.4	189.4	232.1	241.0	236.6
T_8	2.49	3.18	2.83	3.95	4.46	4.21	0.040	0.044	0.042	0.025	0.022	0.024	176.6	171.5	174.1	222.2	232.0	227.1
T_9	2.48	2.81	2.64	3.55	4.46	4.01	0.040	0.042	0.041	0.024	0.026	0.025	172.3	173.8	173.1	221.4	227.5	224.5
SEm ±	0.17	0.41	0.22	0.21	0.30	0.18	0.002	0.004	0.002	0.002	0.004	0.002	20.9	32.2	19.2	30.5	25.0	19.7
CD (P=0.05)	0.52	1.23	0.64	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

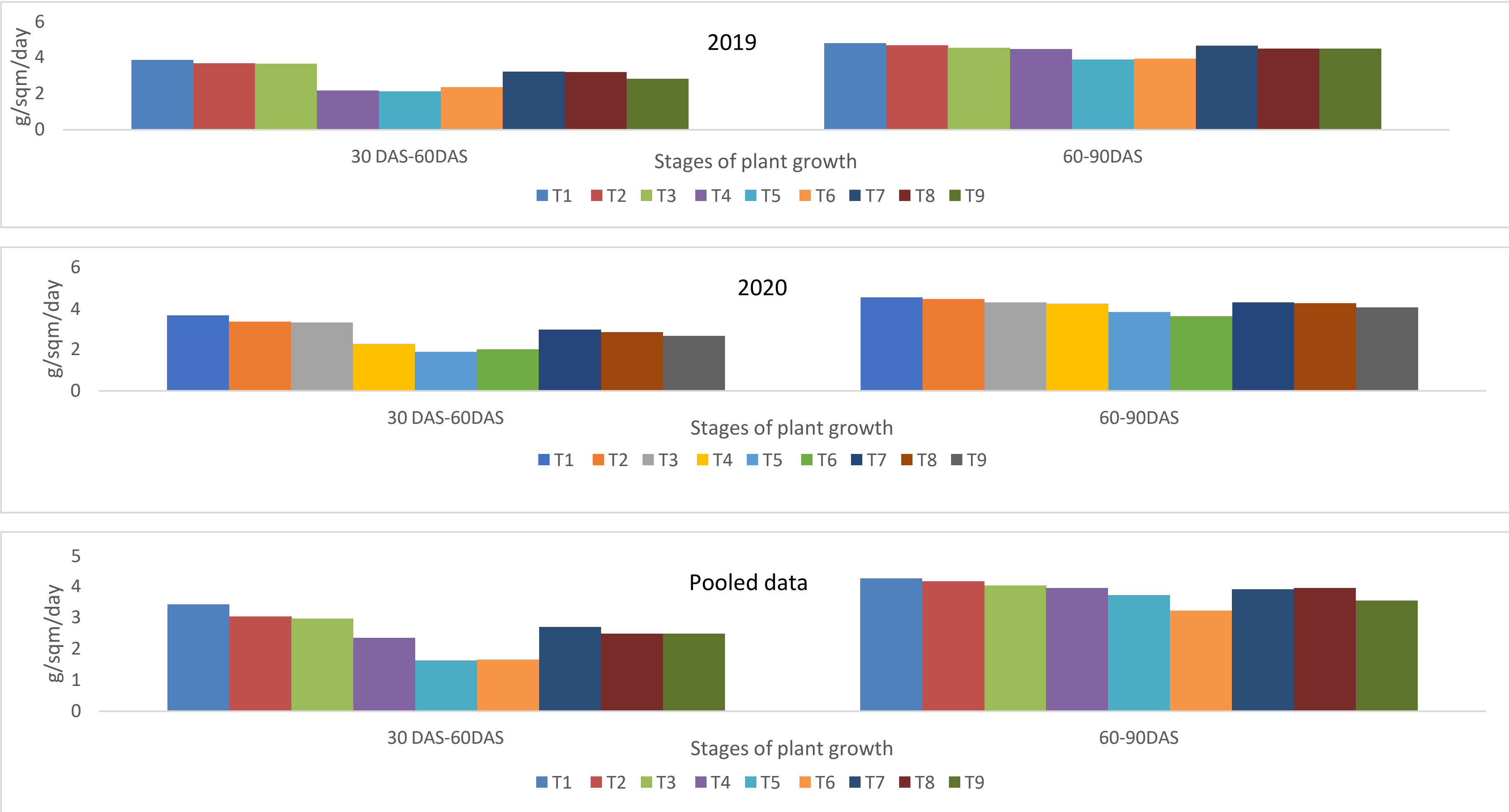


Fig 4.6 (a): Effect of nutrient management on crop growth rate at different growth stages in ricebean

Fig 4.6(b): Effect of nutrient management on relative growth rate at different growth stages in ricebean

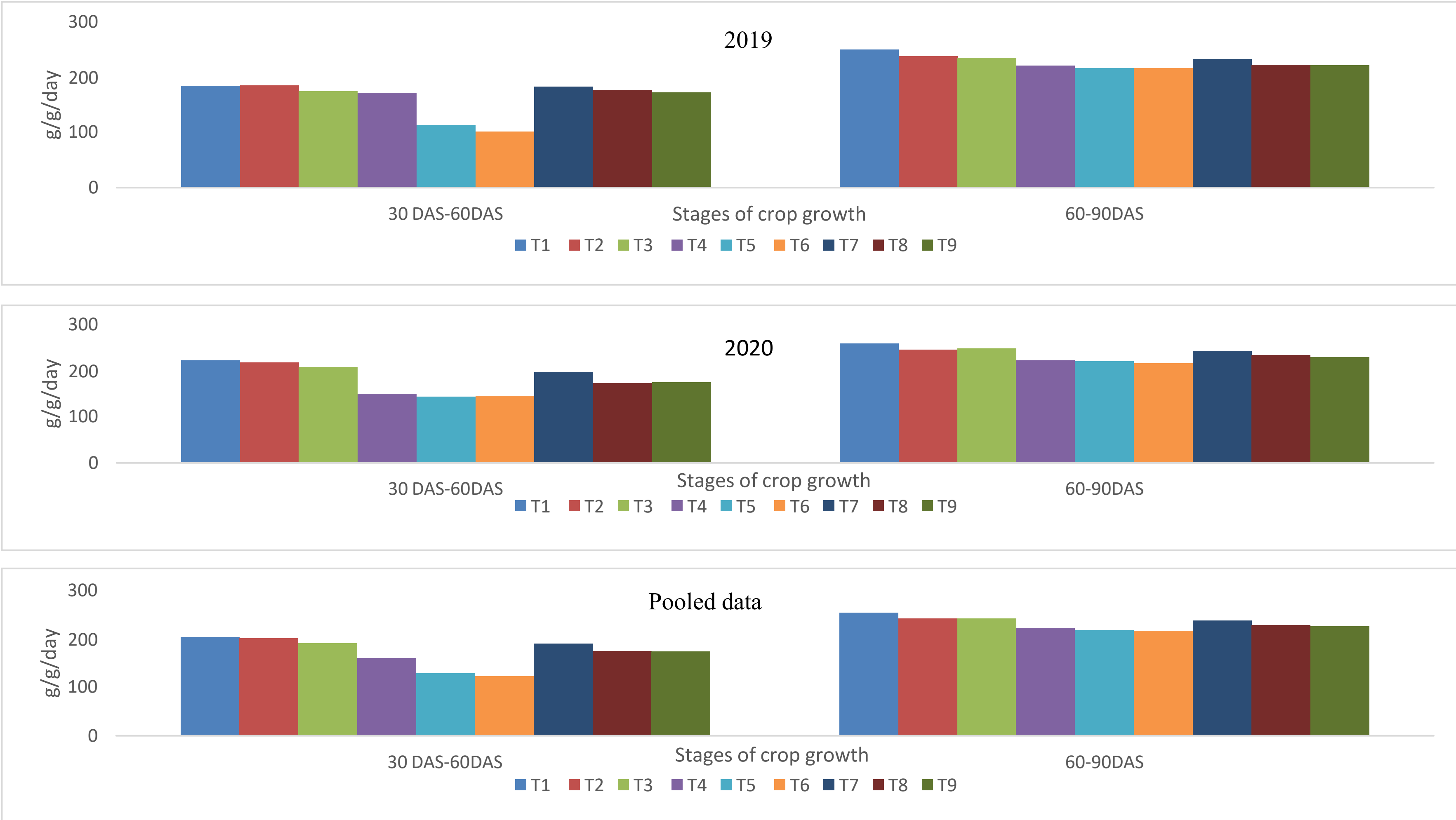


Fig 4.6(c): Effect of nutrient management on at net assimilation rate different growth stages in ricebean

4.1.9 Physiological attributes

4.1.9.1Days to 50% flowering

Application of organic manures along with fertilizers did not respond significantly when it comes to days 50% flowering during both the years as well as in pooled value as presented in table 4.7.

4.1.9.2Days to maturity

The data in table 4.7 and figure 4.7 show information regarding the number of days it takes for ricebean plants to reach full maturity.

Among the different treatment combinations, T_1 stands out as having the longest time to reach maturity. This variation in maturation time among the combined treatments can be attributed to several factors. Firstly, it may result from the influence of both organic and inorganic sources, leading to varietal differences and genetic characteristics in ricebean. Additionally, favorable environmental conditions and the presence of appropriate nutrient concentrations may have contributed to this variation. These conditions likely enabled the crop to absorb nutrients more effectively, enhancing metabolic activities within the plant. This, in turn, could have led to increased cell enlargement and elongation, potentially accelerating the rate of photosynthesis and promoting early flowering in the plant.

4.2 YIELD ATTRIBUTES OF RICE BEAN

The findings of growth attributes namely-number of pods plant^{-1}, number of seeds pod^{-1}, seed yield (kg ha^{-1}) and stover yield (kg ha^{-1}) are being presented and were observed to have significant variation between the treatment at different intervals, these factors may have contributed to increased biomass accumulation and efficient translocation and distribution of photosynthates from source to sink. These processes likely played a crucial role in achieving the maximum values for the mentioned yield attributes.

Table 4.7: Effect of nutrient management on days to 50 % flowering and days to maturity

Treatment	Days to 50% flowering			Dasy to maturity		
	2019	2020	Pooled	2019	2020	Pooled
T_1	116.43	118.54	117.49	159.67	163.44	161.56
T_2	115.67	118.30	116.98	153.33	163.44	158.39
T_3	114.17	116.63	115.40	152.33	160.67	156.50
T_4	112.83	114.90	113.87	152.33	156.22	154.28
T_5	111.07	115.44	113.26	153.67	152.44	153.06
T_6	110.83	112.44	111.64	150.00	149.56	149.78
T_7	113.80	113.00	113.40	145.00	149.22	147.11
T_8	113.40	114.78	114.09	145.07	155.00	150.03
T_9	112.73	115.73	114.23	152.63	154.11	153.37
SEm ±	3.94	2.78	2.41	2.72	2.95	2.00
CD (P=0.05)	NS	NS	NS	8.15	8.83	5.77

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

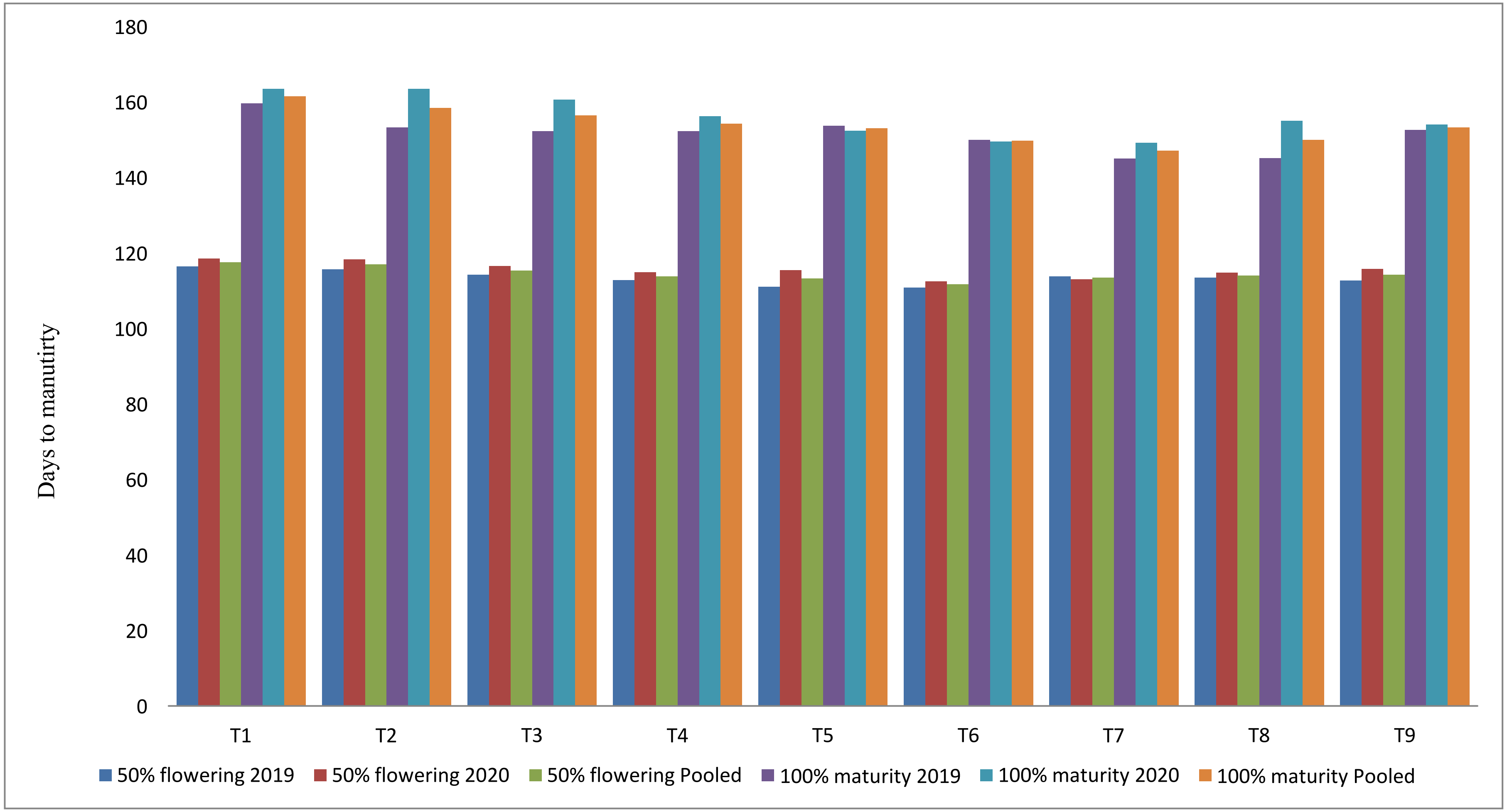


Fig 4.7: Effect of nutrient management on days to 50 % flowering days and days to maturity

4.2.1 Number of pods plant^{-1}

Data of the experimental finding of the effect of nutrient management on number of pods plant^{-1} presented in the table 4.8 and illustrated in figure 4.8, revealed that both the years and pooled data application of poultry manure significantly increased the number of pods plant^{-1}.

The value was found to be maximum in T_1 [poultry manure (0.7 t ha^{-1}) + 100 % RDF] 13.00 pods plant^{-1} during 2019, 15.33 pods plant^{-1} during 2020 and 14.17 pods plant^{-1} for pooled data while the minimum was reported inT_6 with the value of 8.40 and 11.40 in 2019 and 2020 with pooled data further elucidated as 9.90 number of pods plant^{-1}. The possible explanation for this phenomenon could be the rapid mineralization of poultry manure compared to other animal manures like cattle or pig dung. This faster mineralization process could have provided the plant with a higher and more readily available nutritional status, which is essential for stimulating growth, meristematic activity, and physiological processes in the plant.

Consequently, this enhanced nutrient availability may have contributed to increased synthesis and assimilation of nutrients, ultimately leading to a higher number of pods. A critical examination of the data indicated that in the case of pooled data T_2 (13.80) and T_3 (13.45) were statistically at par while T_8 (11.96) and T_9 (11.77) of number of pods plant^{-1}, the incorporation of a larger quantity of poultry manure alongside recommended chemical fertilizer doses may have played a role in providing a well-balanced supply of nutrients to the ricebean crop. This balanced nutrition likely contributed to the plant's increased ability to produce a higher number of pods, indicating greater pod-bearing capacity and this effect might have been more pronounced when compared to other organic manure dosage levels. This outcome can also be attributed to the fact that poultry manure is recognized as a valuable organic source of major, secondary, and micronutrients. Its application enhances the availability of these micronutrients, which are directly related to crop yield and their concentration within the crop. Likewise, Subedi *et al*. (2022) concluded that poultry manure demonstrated superior performance in terms of yield-related factors, including the number of flowers per plant, the number of pods per plant, and the total pod yield, when compared to alternative treatments like goat manure, farmyard manure (FYM), mustard cake, and recommended dose of fertilizer (RDF). Consequently, it was established that poultry manure emerged as the most effective organic fertilizer for enhancing the growth and yield of the Malepatan-1 variety of cowpea.

The increase in the number of pods can likely be attributed to the combination of green manuring incorporation with poultry manure and recommended chemical fertilizer doses (RDF). This combination appears to have promoted enhanced plant growth and development by enabling efficient resource utilization by the plant. The comprehensive supply of essential nutrients from both poultry manure and RDF in T_1 contributed to this positive effect on pod production, these result are in complete agreement with the findings of Omotoso and Olusegun (2014); Jan *et al*. (2019).

4.2.2 Number of seeds pod^{-1}

On the data related to number of seeds pod^{-1}, presented in table 4.9 and figure 4.8, it is apparent that there were significant variations amongst the number of seeds pod^{-1} with respect to the given treatments.

The combined application of green manuring (*Sesbania*) with PM (0.7 t ha^{-1}) and 100 % RDF (T_1) gave the result of the highest number of seeds pod^{-1} of 8.87 in 2019 and 9.61 in 2020 with a pooled data of 9.24 seeds pod^{-1} from both years. Significantly, the lowest number of seeds pod^{-1} was observed in application of pig manure @ 0.7 t ha^{-1} with 50 % RDF (T_6) with the value of 6.97 in 2019 and 7.13 in 2020 with pooled value of 7.05, the residual effect of green manure may also have contributed to the improved soil fertility in ricebean by adding organic matter, nitrogen, P and K to the soil resulting as source of energy for soil micro flora which may have resulted in better root

Table 4.8: Effect of nutrient management on number of pods $plant^{-1}$ and seeds pod^{-1} in ricebean

Treatment	Number of pods $plant^{-1}$			Number of seeds pod^{-1}		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1	13.00	15.33	14.17	8.87	9.61	9.24
T_2	12.83	14.77	13.80	8.67	9.50	9.08
T_3	12.23	14.67	13.45	8.57	9.57	9.07
T_4	10.17	12.23	11.20	8.07	8.27	8.17
T_5	9.17	12.10	10.63	8.03	8.37	8.20
T_6	8.40	11.40	9.90	6.97	7.13	7.05
T_7	11.25	13.90	12.58	8.33	8.53	8.43
T_8	10.39	13.53	11.96	8.47	8.65	8.56
T_9	10.47	13.06	11.77	8.13	8.47	8.30
SEm ±	0.99	0.67	0.60	0.26	0.46	0.27
CD (P=0.05)	2.96	2.02	1.72	0.79	1.39	0.77

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

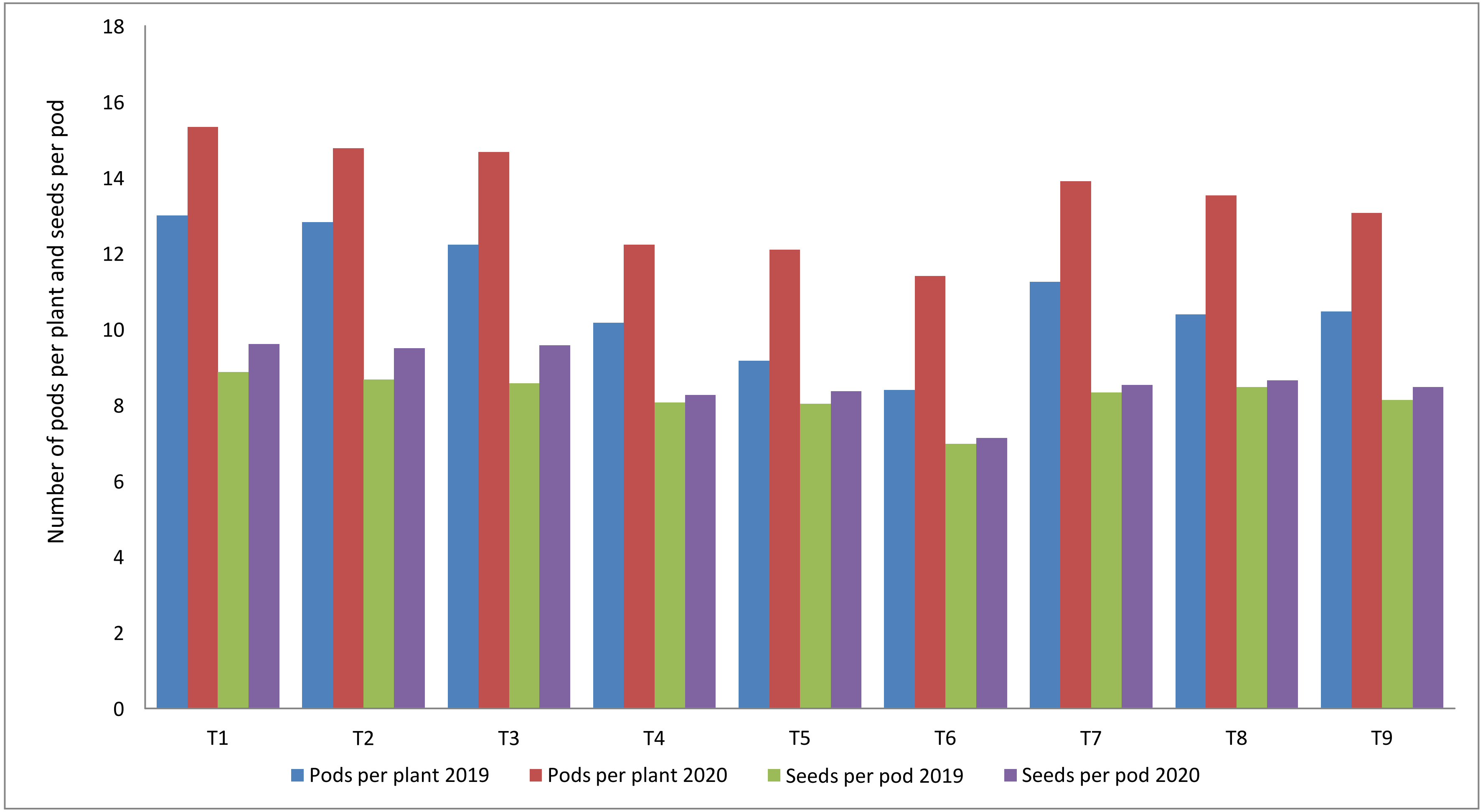


Fig 4.8: Effect of nutrient management on number of pods $plant^{-1}$ and seeds pod^{-1} in ricebean

nodulation and nitrogen fixation respectively. The response of poultry manure with 100% RDF in number of seeds pod^{-1} could be due overall enhancement of the overall growth of rice bean thereby creating a larger source and sink. This could be due to poultry manure is one of the potential organic sources of major, secondary, and micronutrients, its application enhances the availability of these micronutrients, which are a function of yield and concentration in the crop.

These results align with the research conducted by Jasim and Mhanna (2014), where they also noted an increase in broad bean yield. They attributed this increase to the role of organic matter in supplying plants with essential nutrients, which boosted the growth of vegetative parts and subsequently enhanced the photosynthesis process. This surplus energy from photosynthesis was then utilized for building plant components, reducing competition among plant parts, and minimizing abortion, ultimately resulting in a higher number of seeds per pod, and is consistent with Anju and Vijayalakshmi's (2013) findings on common beans.

The results of the investigation cited above are also in conformity with Sitinjak and Purba (2018) who reported that more the number of branching in green bean plants the more the number of pods and seeds were produced where plants' adequate supply of nutrients and other nutrients from laying chicken manure caused the height of branches in the application of up to 11.5 tons ha^{-1} of chicken manure.

4.2.3 Pod length (cm)

The data pertaining to the effect of nutrient management on pod length (cm) of rice bean are presented in table 4.9 and illustrated in figure 4.9.

The application of T_1 had a significant impact on the length of pods (cm), with the highest values being 8.90 cm in 2019, 9.51 cm in 2020, and an average of 9.20 cm when the two years were pooled together. It is known that poultry manure contributes to increased nodule formation in legumes by supplying nitrogen and other nutrients, improving soil fertility, stimulating beneficial microbial activity, and enhancing the overall health and growth of legume plants which ultimately leads to improved nitrogen fixation and better legume yields.

One major factor contributing to this notable increase in pod length could be attributed to the combined use of organic and inorganic substances, along with the prior application of green manures. These factors likely played a crucial role in enhancing the yield-related characteristics. Furthermore, this effect can also be explained by the role of nutrients in stimulating the growth of branches, biological processes, and various growth parameters. This, in turn, resulted in taller plants and increased enzyme activity, which encouraged the development of more vegetative branches and longer pods on the plants. The findings from the mentioned study align with the research conducted by Sitinjak and Purba (2018), where it was observed that green bean plants tend to produce a higher number of pods and seeds when they have more branches. This increase in branching and subsequently, pod and seed production, is often associated with sufficient nutrient availability. They found that the application of up to 11.5 tons ha^{-1} of chicken manure provided an ample source of nutrients, leading to increased branch height in the plants.

4.2.4 Test weight (g)

The results of the experiment regarding the effect of nutrient management on rice bean in test weight (g) as presented in table 4.9, it indicated that there were no significant responses to the treatments. Hence, the performance of each of the treatments were therefore statistically at par with each other in terms of test weight (g) of rice bean grain.

Table 4.9: Effect of nutrient management on pod length and test weight attributes in ricebean

Treatment	Pod length (cm)			Test weight (g)		
	2019	2020	Pooled	2019	2020	Pooled
T_1	8.90	9.51	9.20	70.67	70.40	70.53
T_2	8.84	9.40	9.12	70.67	70.57	70.62
T_3	8.68	9.33	9.01	70.31	70.26	70.29
T_4	7.90	8.67	8.28	70.34	70.49	70.41
T_5	7.90	8.13	8.02	70.61	70.36	70.49
T_6	7.70	7.93	7.82	70.72	70.57	70.65
T_7	8.75	9.30	9.03	70.38	70.50	70.44
T_8	8.60	8.90	8.75	70.32	70.55	70.43
T_9	8.57	8.70	8.63	70.61	70.71	70.66
SEm ±	0.28	0.35	0.22	0.15	0.13	0.10
CD (P=0.05)	0.84	1.03	0.64	NS	NS	NS

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

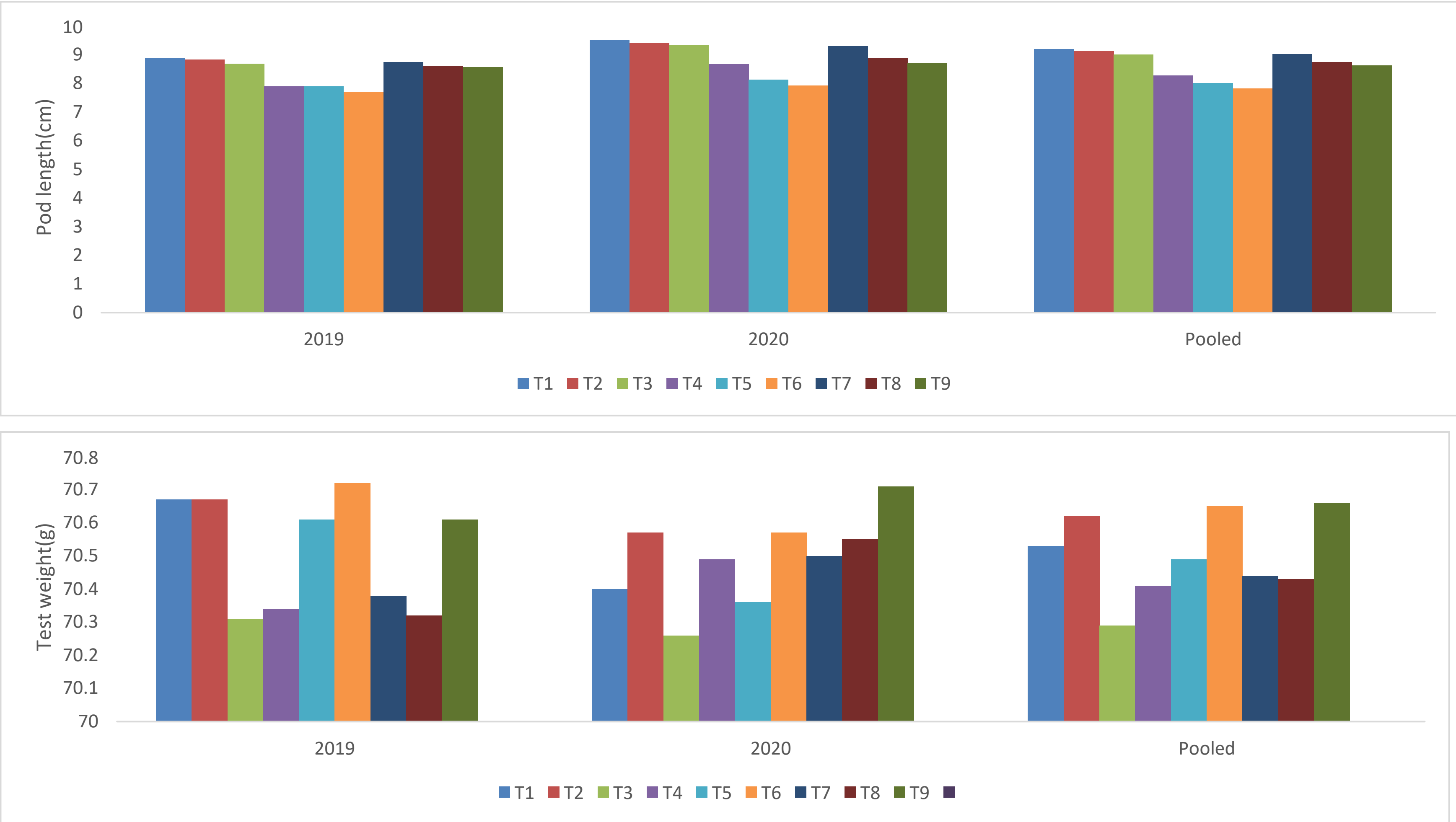


Fig 4.9: Effect of nutrient management on pod length and test weight in ricebean

4.2.5 Seed yield (kg ha^{-1})

The experiment data on effect of nutrient management on rice bean in seed yield (kg ha^{-1}) are presented in table 4.10 and illustrated in figure 4.10.

The data indicated that incorporation of poultry manure along with [Green manuring (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF] T_1 resulted significantly higher seed yield in both the years as well as in the pooled data compared to application of pig manure and FYM. It was also revealed that FYM application turned out superior than pig manure in both the years of investigation. The maximum seed yield (1161.83 kg ha^{-1}) was recorded with poultry @ 0.7 t ha^{-1} with 100 % RDF, however treatment T_4 (1028.94 kg ha^{-1}) and T_9 (1038.65 kg ha^{-1}) were almost statistically similar while the lowest yield was recorded with application of pig manure applied under the value of 1000.44 kg ha^{-1} in 2019 and 1079.07 kg ha^{-1} in 2020. The results indicate that the application of higher levels of fertilizer and poultry manure positively impacted seed yield by increasing the number of pods plant^{-1}, seeds pod^{-1}, and pod length. This outcome is likely a result of the enhanced efficiency in nitrogen utilization and improved availability of essential macronutrients in the T_1 treatment compared to the previous treatments using 50% or no RDF and T_1 treatment appear to provide the most favourable conditions for crop growth and yield.

The combined application of green manuring (*Sesbania*) with PM (0.7 t ha^{-1}) and 100 % RDF (T_1) gave the highest seed yield in 2020 (1217.77 kg ha^{-1}) and was similarly at par with T_2 (1217.10 kg ha^{-1}) while T_1 was significantly maximum in pooled value of 1189.80 kg ha^{-1} from the two years of experiment . The increased crop yield achieved by combining poultry manure at a rate of 0.7 tons per hectare with 100% recommended dose of fertilizer (RDF) can be attributed to the favourable nutrient levels in the soil, which led to enhanced crop biomass production. This, in turn, directly and indirectly contributed to higher crop yields as the combination of RDF and poultry manure, rich in essential nutrients like nitrogen, phosphorus, and potassium, played a significant role in improving crop growth and, yield similar findings were corroborated by Kawikhonliu (2022). One reason can also be that the residual effect of green manure may also have contributed to the improved soil fertility in ricebean by adding organic matter, nitrogen, P and K to the soil resulting as source of energy for soil micro flora which may have resulted in better root nodulation and nitrogen fixation respectively. One other reason for the superior performance could be attributed to the fact that poultry manure is a highly valuable organic source of major, secondary, and micronutrients. Its application enhances the availability of these micronutrients, which are directly related to both crop yield and their concentration within the crop. One of the probable reason why pig manure performed poorly was that the carbon-to-nitrogen ratio in pig manure is generally higher than in poultry manure, where high C:N ratio can result in the temporary immobilization of nitrogen, making it less readily available to plants, however poultry manure typically has a lower C:N ratio, promoting faster nutrient release (Babalola and Adigun, 2013). Poultry manure often has higher nitrogen content compared to pig manure. Nitrogen is a crucial nutrient for plant growth, and its availability can significantly impact crop performance. If nitrogen is a limiting factor, poultry manure may be more beneficial.

Additionally, the significant increase in yield may be attributed to the favourable impact of green manuring residues combined with poultry manure. This combination likely enhanced the soil's physiochemical and microbiological characteristics, creating a more conducive environment for plant growth and development. The impact of incorporating green manure from a previous crop can be primarily attributed to the enhancement of plant nutrient availability in the soil, benefiting the subsequent crop. *Sesbania* green manures are well-known for their positive effects on soil nitrogen dynamics. They help recover residual mineral nitrogen from the soil and fix atmospheric nitrogen for leguminous green manures. As a result, they make significant contributions to the nitrogen nutrition of the subsequent crop, as reported by Irin and Biswas (2023) and the current findings were in comparable agreement with Griffin *et al*. (2000), Chand *et al*. (2006).

4.2.6 Stover yield (kg ha^{-1})

The results of experiment regarding the effect of nutrient management in stover yield (kg ha^{-1}) of rice bean are presented in table 4.10 and illustrated in figure 4.10.

The data revealed that there was a significant variation to the responses of different nutrient sources and fertilizer combinations on stove yield of rice bean. The application of poultry manure @ 0.7 t ha^{-1} with 100 % RDF in T_1 were able to provide the highest significant stover yield during 2019 (1893.33 kg ha^{-1}) and 2020 (1904.28 kg ha^{-1}). The pooled data also revealed that a significant difference with the maximum recorded stover yield in T_1 (1898.80 kg ha^{-1}) and the minimum under treatment T_6 (1654.48 kg ha^{-1}) during both years of investigation respectively while T_1 (1898.80 kg ha^{-1}) and T_2 (1880.91 kg ha^{-1}) were almost statistically in pooled value. One of the probable reason why pig manure performed poorly was that the carbon-to-nitrogen ratio in pig manure is generally higher than in poultry manure, where high C:N ratio can result in the temporary immobilization of nitrogen, making it less readily available to plants, however poultry manure typically has a lower C:N ratio, promoting faster nutrient release (Babalola and Adigun, 2013). Poultry manure often has higher nitrogen content compared to pig manure. Nitrogen is a crucial nutrient for plant growth, and its availability can significantly impact crop performance and if nitrogen is a limiting factor, poultry manure may be more beneficial.

The superior performance observed could be attributed to the fact that poultry manure serves as a rich source of major, secondary, and micronutrients, thereby enhancing the availability of these essential micronutrients. This, in turn, positively affects both the yield and nutrient concentration within the crop. Furthermore, the increased stover yield observed in the mentioned treatments may be linked to enhanced vegetative growth. This includes factors like taller plant height, a greater number of branches, and a larger leaf area, all of which contribute to greater stover production.

The statistical analysis of the data indicated a notable variation in stover yield as a result of the different nutrient management sources. This finding aligns with the results reported by Reddy in 2008, where it was demonstrated that the accumulation of nitrogen in plants, achieved through the application of both fertilizers and organic manures, was beneficial for achieving higher production and yields. Evidently similar results were observed by Ghosh *et al*. (2014); Getachew and Tilahun (2017). The increase in yield and yield attributes may also be due to the reason that chicken manure has overtaken the use of other animal manure (e.g. pig manure, kraal manure) because of its high nutritional value it has high content of nitrogen, phosphorus and potassium.

4.2.7 Harvest Index (HI)

Data pertaining to the effect of nutrient management on harvest index of ricebean are presented in table 4.10 and illustrated in figure 4.10.

The data revealed that there was a significant variation to the responses of different nutrient sources and fertilizer combinations on harvest index in rice bean in both the years. The application of poultry manure @ 0.7 t ha^{-1} with 100 % RDF in T_1 were able to provide the highest significant HI during 2019 (38.70%) and 2020 (39.01%) while the minimum value was recorded in T6 during 2019 (31.00%) and 2020 (33.12%). The pooled data also revealed that a significant difference with the maximum recorded stover yield in T_1 (38.85%) and the minimum under treatment T_6 (32.06%) during both years of investigation respectively. The superior results can be explained by the fact that poultry manure provides a substantial supply of primary, secondary, and trace nutrients, thereby improving the accessibility of these vital micronutrients. This significant response in stover yield can also be attributed to the fact that poultry manure contains significantly higher levels of nitrogen, phosphorus, and potassium compared to other animal manures which enhances the plant growth associated with poultry manure application as a result of its capacity to provide more abundant nutrients throughout the entire growth period, as suggested by Farhad *et al*. (2009).

Consequently, this has a positive impact on both crop yield and the concentration of nutrients within the crop. Additionally, the higher harvest index observed in these treatments could be associated with improved vegetative growth, including factors such as increased plant height, a greater number of branches, and a larger leaf area, all of which contribute to higher stover and seed production.

Table 4.10: Effect of organic sources on seed yield, stover yield and harvest index in ricebean

Treatment	Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})			Harvest index (%)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	1161.83	1217.77	1189.80	1893.33	1904.28	1898.80	38.70	39.05	38.85
T_2	1102.06	1217.10	1159.58	1860.77	1901.05	1880.91	37.82	39.03	38.43
T_3	1088.70	1199.83	1144.26	1814.23	1895.95	1855.09	37.11	38.97	38.04
T_4	1028.94	1084.41	1056.68	1638.34	1850.42	1744.38	33.65	34.93	34.29
T_5	1012.18	1080.92	1046.55	1621.40	1759.47	1690.43	32.79	34.05	33.42
T_6	1000.44	1079.07	1039.75	1604.32	1704.64	1654.48	31.00	33.12	32.06
T_7	1079.14	1172.77	1125.96	1792.81	1888.14	1840.47	36.95	38.34	37.64
T_8	1057.73	1105.94	1081.84	1731.41	1884.94	1808.18	36.59	37.60	37.09
T_9	1038.65	1101.37	1070.01	1693.87	1872.57	1783.22	34.81	37.01	35.91
SEm ±	28.74	37.27	23.53	65.77	42.75	39.22	1.03	1.23	0.80
CD (P=0.05)	86.15	111.74	67.78	197.17	128.17	112.98	3.10	3.69	2.32

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

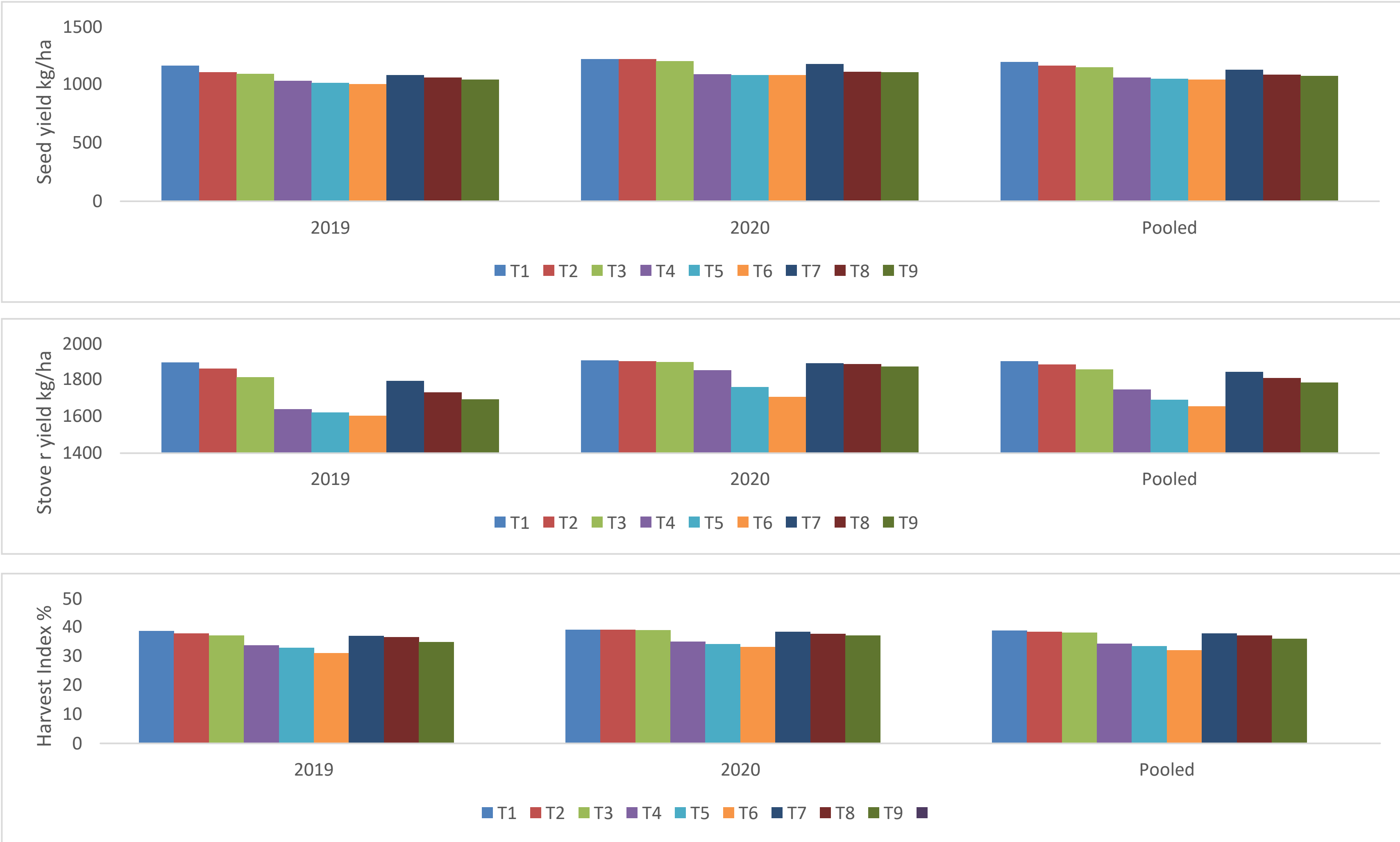


Fig 4.10: Effect of nutrient management on seed yield, stover yield and harvest index in ricebean

QUALITY PARAMETERS

Protein content (%)

The results of the experiment regarding the effect of nutrient management failed to show any significant difference as presented in table 4.11 and illustrated in figure 4.11.

Protein yield (kg ha^{-1})

The results of the experiment regarding the effect of nutrient management in protein yield of rice bean plants are presented in table 4.11 and illustrated in figure 4.11.

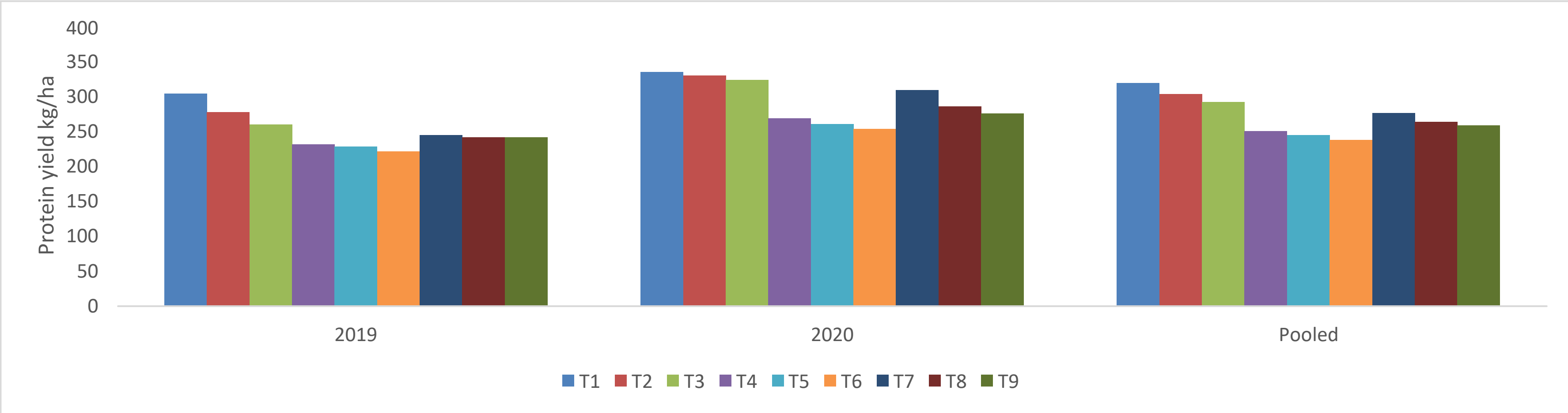
The statistical analysis of the data concerning ricebean protein yield revealed notable differences in the responses to different types of fertilizers, organic and inorganic, used in the study. Upon closer examination of the results, it was evident that in 2019 and 2020, incorporating poultry manure at a rate of 0.4 tons per hectare along with 100% RDF in T_1 resulted in significantly higher protein yields: 304.52 kg ha^{-1} and 335.42 kg ha^{-1}, respectively. When combining the data from both years, the pooled protein yield for T_1 was 319.97 kg ha^{-1} and T_6 displayed the least value of 237.88 kg ha^{-1}. Additionally, it was observed that the application of poultry manure outperformed pig manure and FYM in terms of protein yield over the two years of the study. This significant response can be attributed to the fact that poultry manure contains significantly higher levels of nitrogen, phosphorus, and potassium compared to other animal manures which enhances the plant growth associated with poultry manure application as a result of its capacity to provide more abundant nutrients throughout the entire growth period, as suggested by Farhad *et al*. (2009).

The enhanced protein production in ricebean following the use of poultry manure could be attributed to the improved accessibility of the necessary nutrients over an extended period in the plant's root area. This is a result of the mineralization process triggered by organic acids generated during

Table 4.11: Effect of nutrient management on protein content and protein yield in ricebean

Treatment	Protein content (%)			Protein yield (kg ha^{-1})		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1	25.21	27.54	26.38	304.52	335.42	319.97
T_2	23.94	26.48	25.21	278.08	330.24	304.16
T_3	23.94	25.19	24.56	260.48	324.41	292.45
T_4	19.92	23.48	21.70	231.89	269.10	250.50
T_5	17.68	23.52	20.60	228.69	261.23	244.96
T_6	18.06	21.19	19.62	221.97	253.79	237.88
T_7	21.47	23.96	22.72	244.81	309.23	277.02
T_8	21.56	22.92	22.24	242.05	286.39	264.22
T_9	21.58	20.75	21.17	241.67	276.22	258.95
SEm ±	16.12	1.87	8.11	14.60	11.23	9.21
CD (P=0.05)	NS	NS	NS	43.78	33.67	26.53

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF



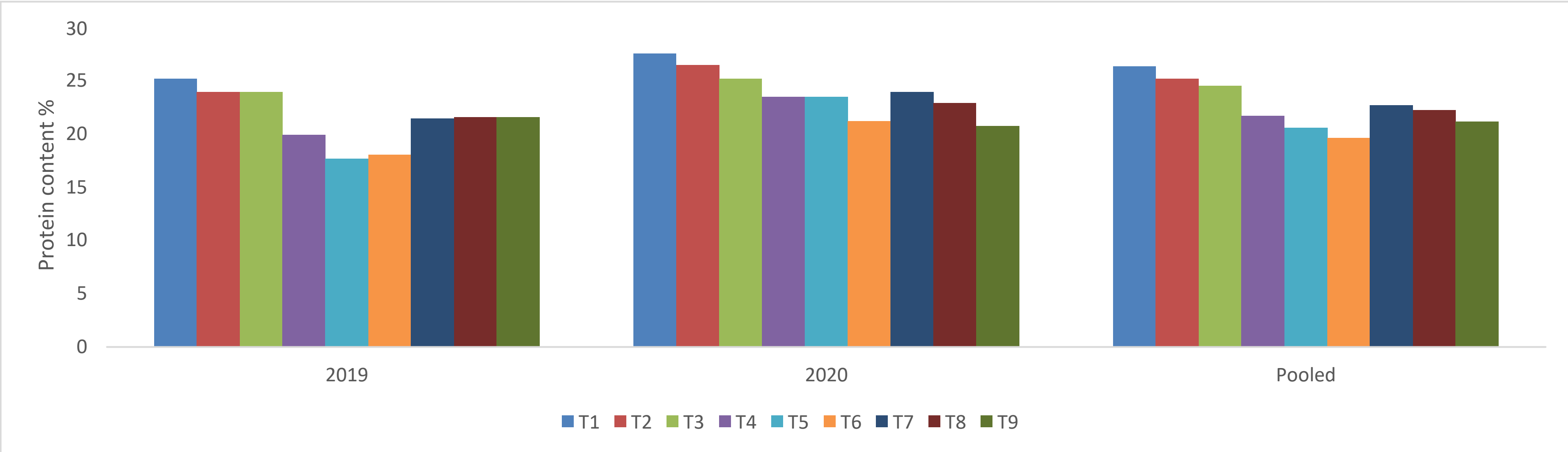


Fig 4.11: Effect of nutrient management on protein content (%) and protein yield (kg ha^{-1}) in ricebean

the decomposition of poultry manure, making the nutrients more readily available. The positive impact of organic matter on protein production might stem from the elevated nitrogen content found in the seeds, as noted by Khiriya *et al*. (2003). Nitrogen is a fundamental component of proteins, and phosphorus plays a structural role in the co-enzymes engaged in protein synthesis.

4.3.3 Plant nutrient uptake

4.3.3.1 Nitrogen content in seed and stover (%)

The data concerning the impact of nutrient management on the nitrogen content of rice bean plants is provided in table 4.12 and visually represented in figure 4.12.

The results exhibited towards the presence of significant differences in response to the various sources of organic manure. The highest nitrogen was evident in T_1 (4.19%) and T_2 (4.19%) which were at par with one another in both 2019 and in 2020 it was 4.41% under T_1 while T_2 recorded 4.33% and pooled value was 4.30%. Poultry manure showed the maximum significant positive effect which accumulated highest nitrogen in the seed. However, the application of pig manure in T_4 was statistically par in 2019 (3.95%) and 2020 (3.97%) and in pooled data (3.96%). Poultry manure is recognized for its capacity to serve as an organic reservoir of essential primary, secondary, and trace elements. Its utilization can improve the accessibility of these micronutrients, with their influence on crop yield and concentration being interrelated. The superior performance could be attributed to the fact that poultry manure stands out as one of the highly effective organic sources of major, secondary, and micronutrients and the application significantly enhances the availability of these essential micronutrients, which play a critical role in determining crop yield and concentration. Poultry manure's advantage over FYM and other organic manures in terms of augmenting nutrient content and uptake is well-documented. This could be due to its richer nutritional composition for crops, ease of mineralization, and low carbon-to-nitrogen (C:N) ratio, similar findings were reported Keelara in 2001, reinforcing the benefits of poultry manure in crop cultivation.

The data related to nitrogen content in the stover indicated that there were no significant distinctions in how the three types of manures (FYM, poultry manure, and pig manure) affected this parameter. This suggests that, statistically, all three manures had an equivalent impact on the nitrogen content in the stover of ricebean plants.

4.3.3.2 Total nitrogen uptake (kg ha^{-1})

The data pertaining to the total uptake of nitrogen in ricebean plant is presented in table 4.12 and illustrated in figure 4.12.

The data from 2019 shows that the significantly highest total nitrogen uptake was recorded from the application of poultry manure in treatment T_1 (84.45 kg ha^{-1}) while lowest total nitrogen uptake was recorded in T_6 (64.64 kg ha^{-1}). In 2020, the significant highest total nitrogen uptake was recorded from the application of poultry manure in treatment T_1 (92.75 kg ha^{-1}). The data pooled analysis also showed that the maximum nitrogen uptake was recorded from rice bean plant which were subjected to the poultry manure (88.60 kg ha^{-1}) application as a source of organic manure, however, in both the years and pooled data treatments integrated with pig manure consistently exhibited lowest total nitrogen uptake in ricebean plants. The superiority observed could be attributed to the fact that poultry manure is indeed a valuable organic source of major, secondary, and micronutrients and its application effectively increases the availability of these micronutrients, which play a crucial role in determining crop yield and nutrient concentration within the crop.

The study conducted by Sugihara *et al*. (2010) revealed that the early application of poultry manure in crop growth leads to an increase in microbial biomass nitrogen, and additionally, it results in the immobilization of potentially leachable nitrogen. They found that as immobilized nitrogen

Table 4.12: Effect of nutrient management on N content in seed and stover and their uptake in ricebean

Treatments	N content seed (%)			N content stover (%)			N uptake in seed (kg ha^{-1})			N uptake in stover (kg ha^{-1})			Total N uptake (kg ha^{-1}) (Seed + stover)		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1	4.19	4.41	4.30	1.89	2.05	1.97	48.72	53.67	51.20	35.72	41.09	38.40	84.45	92.75	88.60
T_2	4.19	4.33	4.26	1.88	2.03	1.95	46.29	52.84	49.57	34.89	39.29	37.09	81.18	91.46	86.32
T_3	4.18	4.33	4.25	1.80	2.03	1.91	45.48	51.91	48.69	32.63	38.96	35.79	78.11	90.36	84.23
T_4	3.95	3.97	3.96	1.71	1.87	1.79	40.61	43.06	41.83	27.95	34.53	31.24	68.55	77.59	73.07
T_5	3.95	3.87	3.91	1.69	1.88	1.79	39.96	41.80	40.88	27.46	33.01	30.23	67.42	74.81	71.11
T_6	3.85	3.76	3.81	1.61	1.84	1.73	38.93	40.61	39.77	25.71	31.57	28.64	64.64	72.18	68.41
T_7	4.13	4.31	4.22	1.77	2.01	1.89	44.54	50.54	47.54	31.81	37.77	34.79	76.36	88.31	82.34
T_8	4.04	4.15	4.09	1.77	1.92	1.84	42.70	45.82	44.26	30.59	36.14	33.36	73.28	81.96	77.62
T_9	3.99	4.01	4.00	1.74	1.89	1.82	41.48	44.20	42.84	29.29	35.46	32.37	70.77	79.65	75.21
SEm ±	0.06	0.12	0.07	0.07	0.10	0.06	1.33	1.75	1.10	1.14	1.92	1.12	1.84	2.50	1.55
CD (P=0.05)	0.19	0.36	0.20	NS	NS	NS	3.99	5.25	3.17	3.42	5.74	3.21	5.51	7.49	4.47

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

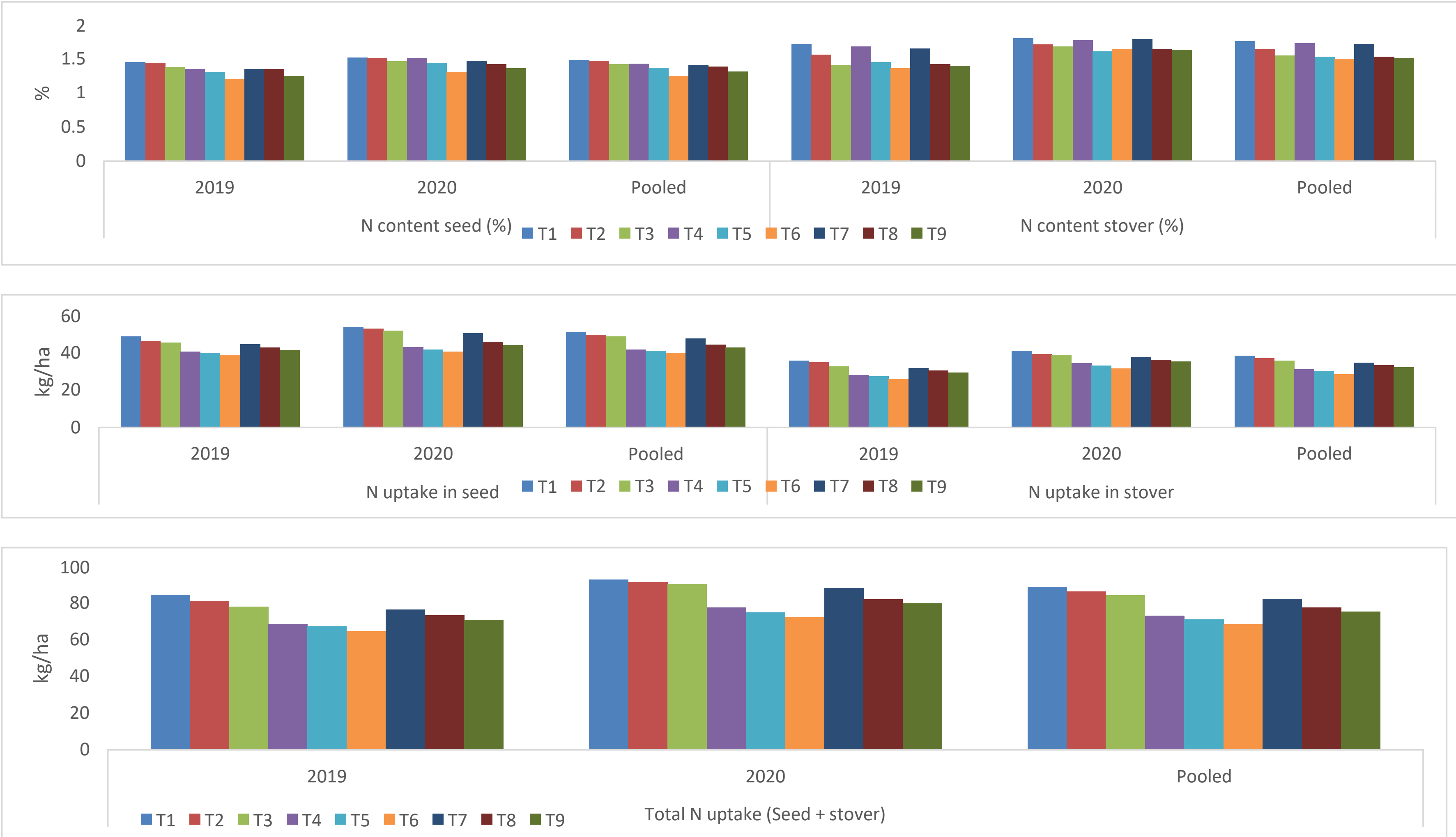


Fig 4.12: Effect of nutrient management on N content in seed, stover and their uptake in ricebean

re-mineralizes over time, it contributes to enhanced crop development. Furthermore, their research showed that the application of poultry manure also promotes greater nitrogen uptake by crops and similar findings were corroborated by Kawikhonliu (2022).

Diwale *et al*. (2020) reported that the notable increase in nutrient uptake from poultry manure can be attributed to the enhanced availability of nutrients released by organic manures as they decompose. These nutrients, both micro and macro, become readily available in the soil solution, leading to higher nutrient uptake by plants. It was also noted that nutrient uptake is a consequence of both nutrient content and crop yield.

Similar findings regarding increased uptake of NPK (nitrogen, phosphorus, and potassium) by cowpea were also reported by Kadam (2000) and Bhikane (2002), further supporting the idea that organic manures contribute to improved nutrient availability and uptake by crops.

4.3.3.3 Phosphorus content in seed and stover (%)

The data pertaining to the effect of phosphorus content in rice bean seed indicates towards a significant difference in response among the sources of organic manures presented in table 4.13 and figure 4.13.

Poultry manure had a significantly positive impact on phosphorus content in ricebean seeds, demonstrating the highest accumulation of nitrogen in the seeds compared to those treated with FYM and pig manure. This trend was consistent in both years of the study (0.49% in 2019 and 0.51% in 2020) and pooled data (0.50%), highlighting the effectiveness of poultry manure in enhancing phosphorus content in ricebean seeds over the other manure types. However, the application of FYM was statistically at par with the response of poultry manure during 2019 (0.40%) and 2020 (0.40%).

The results of the present experiment regarding the effect of nutrient management in phosphorus content of stover are presented in table 4.13 and figure 4.13. The significantly highest uptake in ricebean stover was recorded from the application of poultry manure along with RDF (T_1) during 2019 (0.43%) and 2020 (0.51%) and pooled data (0.47%). The overall trend showed that an increasing response of poultry manure where the increase in doses of poultry manures the average phosphorus uptake in seed and stover also increased. This trend was also followed by FYM during 2019 (0.39%), 2020 (0.46%) and pooled data (0.42%).

Phosphorus plays a crucial role in plant development as it is essential for the transition from the vegetative stage to the reproductive stage. Poultry manure has the potential to serve as a source of various micronutrients in addition to macronutrients. It is widely recognized that poultry manure enhances both the nutritional content and absorption by plants more effectively than FYM and other organic manures. This advantage can be attributed to the crop's richer nutritional composition, ease of mineralization, and a low carbon-to-nitrogen (C:N) ratio. Similar findings were reported by Keelara (2001), further substantiating the benefits of poultry manure in promoting plant growth and nutrient uptake.

4.3.3.4 Total phosphorus uptake (kg ha^{-1})

The data pertaining to the total uptake of phosphorus in ricebean plants is presented in the table 4.13 and illustrated in fig 4.13.

The data from 2019 shows that the significantly maximum total phosphorus uptake was recorded highest from the application of poultry manure (13.80 kg ha^{-1}), while in 2020, the highest significant uptake in ricebean plants was recorded form the application of poultry (15.94 kg ha^{-1}). The pooled data analysis exhibited that the maximum total phosphorus uptake in ricebean plant was recorded from the application of Green manure (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF (14.87 kg ha^{-1}) as the source of organic and inorganic manure.

Indeed, in addition to supplying macronutrients, poultry manure possesses the capacity to provide various micronutrients as well. Several

Table 4.13: Effect of nutrient management on P content in seed and stover and their uptake in ricebean

Treatments	P content seed (%)			P content stover (%)			P uptake in seed (kg ha^{-1})			P uptake in stover (kg ha^{-1})			Total P uptake (kg ha^{-1}) (Seed + stover)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	0.49	0.51	0.50	0.43	0.51	0.47	5.66	6.18	5.92	8.14	9.76	8.95	13.80	15.94	14.87
T_2	0.48	0.49	0.48	0.38	0.48	0.43	5.21	5.96	5.58	6.70	9.09	7.90	11.91	15.05	13.48
T_3	0.47	0.48	0.47	0.35	0.40	0.37	5.12	5.72	5.42	6.35	7.60	6.97	11.47	13.32	12.39
T_4	0.45	0.52	0.48	0.39	0.43	0.41	4.60	5.65	5.12	6.43	7.96	7.19	11.03	13.61	12.32
T_5	0.34	0.47	0.40	0.36	0.39	0.38	3.43	5.06	4.25	5.90	6.79	6.35	9.33	11.85	10.59
T_6	0.32	0.37	0.35	0.34	0.32	0.33	3.24	4.02	3.63	5.49	5.48	5.49	8.73	9.51	9.12
T_7	0.46	0.48	0.47	0.39	0.46	0.42	4.93	5.62	5.27	7.02	8.60	7.81	11.95	14.21	13.08
T_8	0.43	0.43	0.43	0.36	0.39	0.38	4.55	4.71	4.63	6.29	6.78	6.53	10.84	11.49	11.16
T_9	0.41	0.39	0.40	0.33	0.27	0.30	4.23	4.31	4.27	5.50	5.07	5.28	9.72	9.37	9.55
SEm ±	0.03	0.03	0.02	0.02	0.05	0.02	0.31	0.37	0.24	0.40	0.90	0.49	0.46	1.01	0.55
CD (P=0.05)	0.09	0.09	0.06	0.05	0.14	0.07	0.93	1.12	0.70	1.21	2.69	1.42	1.38	3.02	1.60

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

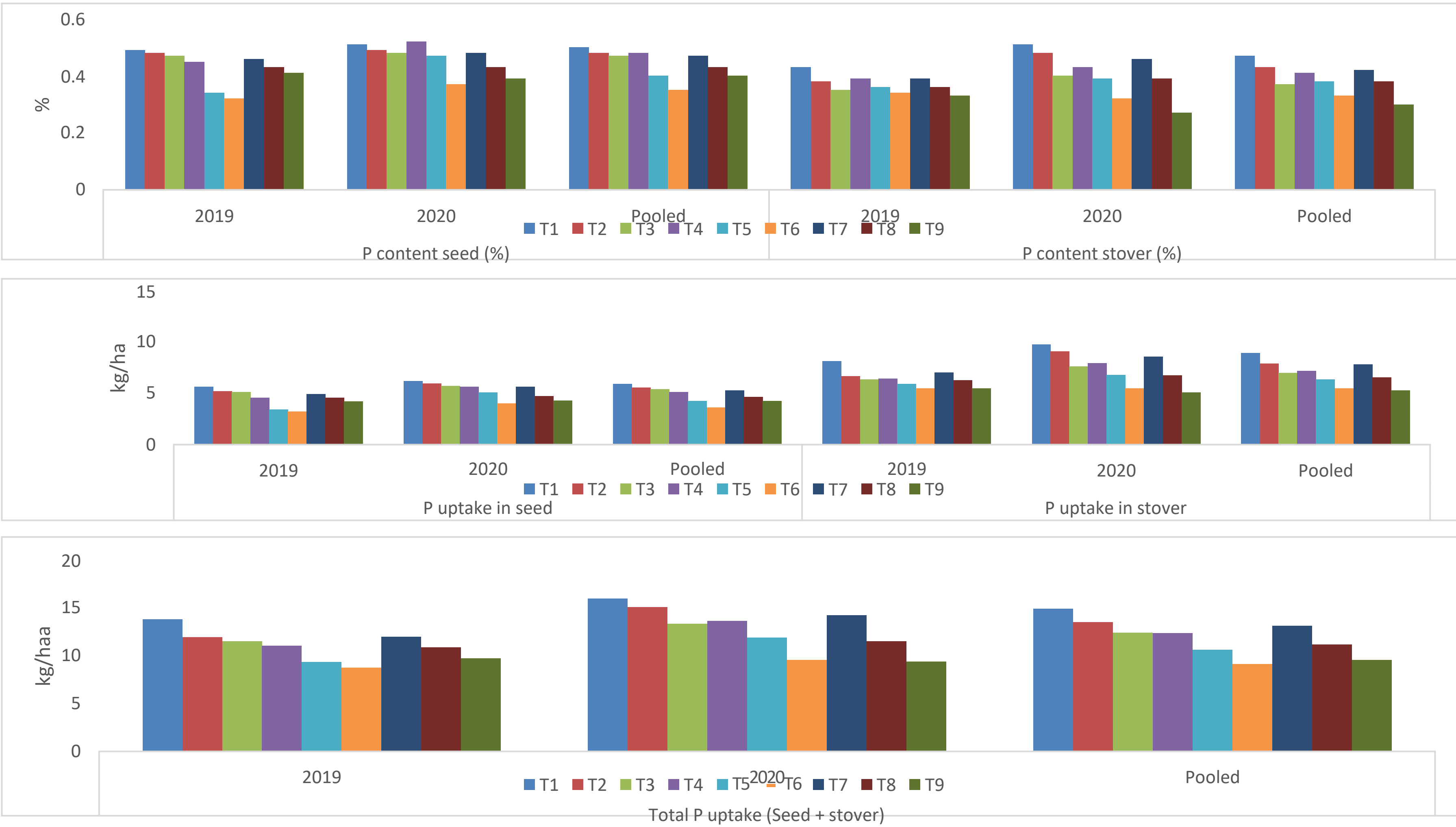


Fig 4.13: Effect of nutrient management on P content in seed, stover and their uptake in ricebean

studies have highlighted that when compared to other types of organic manures, poultry manure stands out as more effective in enhancing the availability of phosphorus in the soil. This enhanced availability is believed to result from the greater mineralization of organic matter under varying oxidation-reduction conditions, coupled with the subsequent uptake of these nutrients by plants. As a result, soils treated with poultry manure tend to exhibit improved phosphorus uptake by plants.

Similarly, Whalen *et al*. (2000) reported that phosphorus and potassium concentrations in manure-amended soils are substantially higher than those in unamended soils, which is good news for plants. Diwale *et al*. (2020) reported that the significant increase in uptake from poultry manure could be attributed to the increased availability of nutrients from manures that the organic manures release after decomposition of micro and macro to the soil solution, which become readily available resulting in higher uptake, it was also reported that as uptake is the result of nutrient content and yield, such significant were also reported by in uptake of NPK by cowpea was also reported by Kadam (2000) and Bhikane (2002).

4.3.3.5 Potassium content in seed and stover (%)

The data pertaining to the effect of various types of organic manure on the potassium content in seed and stover is presented in the table 4.14 and illustrated in figure 4.14.

The results indicated towards the presence of the significant difference in response to the various organic manures. The response varied in both years, the highest content in seed was under the application of poultry manure during 2019 (1.45%) and 2020 (1.52%) and at pooled data [Green manuring (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF] T_1 (1.48%) and T_2 (1.47%) were statistically at par with each other, while pooled data exhibited that the maximum potassium seed content was recorded with the application of poultry manure (1.48%). The superior performance of poultry manure can be attributed to its status as a valuable organic source of major, secondary, and micronutrients. When poultry manure is applied, it effectively enhances the availability of these micronutrients, which play a crucial role in determining both crop yield and nutrient concentration within the crop. Furthermore, in addition to supplying macronutrients, poultry manure possesses the capability to provide a diverse range of micronutrients, further contributing to its effectiveness as a soil amendment.

The data regarding phosphorus content in the stover demonstrated that the highest values were obtained when poultry manure was applied at a rate of 0.7 tons per hectare along with 100% RDF in T_1, this resulted in a phosphorus content of 1.72% in 2019, 1.80% in 2020, and an average of 1.76% when considering both years combined. It was also evident from the results that the application of poultry manure led to an increased response in potassium content in both the seed and stover of ricebean.

The results point to a positive relationship between poultry manure application and the phosphorus content in both the seeds and stover of the crops. The introduction of poultry manure into the soil not only improved the potassium content in the grains but also increased its availability in the soil solution for root absorption. Additionally, the decomposition of poultry manure released beneficial micronutrients, which further facilitated the movement of potassium within the plant, directing it towards the grain and similar beneficial effects on potassium content in grains due to poultry manure application were also reported by Keelara (2001), reinforcing the positive impact of poultry manure on potassium enrichment in crops.

4.3.3.6 Total potassium uptake (kg ha^{-1})

The data pertaining to the total potassium uptake of ricebean is presented in the table 4.14 and illustrated in figure 4.14.

According to the analysis of the data, application of poultry manure caused considerably higher potassium uptake for both the years *i.e.* 2019 (49.38 kg ha^{-1}) and 2020 (52.49 kg ha^{-1}) and pooled data (50.94 kg ha^{-1}) and the superiority of poultry manure can be attributed to its status as a valuable organic source of major, secondary, and micronutrients. When poultry manure is applied, it effectively enhances the availability of these micronutrients, which play a crucial role in determining both crop yield and the concentration of nutrients within the crop.

In addition to providing macronutrients, poultry manure has the ability to provide a variety of micronutrients. According to several studies, compared to other types of organic manures, the property of poultry manure makes it more effective at improving the availability of phosphorus in soil. The greater mineralization of organic matter in alternate oxidation-reduction conditions and plants' subsequent uptake of it are thought to be the causes of the beneficial effect on potassium uptake by plants in soils treated with poultry manure. Similarly, Whalen *et al*. (2000) reported that phosphorus and potassium concentrations in manure-amended soils are substantially higher than those in unamended soils, which is good news for plants. Diwale *et al*. (2020) reported that the significant increase in uptake from poultry manure could be attributed to the increased availability of nutrients from manures that the organic manures release after decomposition of micro and macro to the soil solution, which become readily available resulting in higher uptake, it was also reported that as uptake is the result of nutrient content and yield, such significant were also reported by in uptake of NPK by cowpea was also reported by Kadam (2000) and Bhikane (2002).

Table 4.14: Effect of nutrient management on K content in seed and stover and their uptake in ricebean

Treatments	K content seed (%)			K content stover (%)			K uptake in seed (kg ha^{-1})			K uptake in stover (kg ha^{-1})			Total K uptake (kg ha^{-1}) (Seed + stover)		
	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled	2019	2020	pooled
T_1	1.45	1.52	1.48	1.72	1.80	1.76	16.81	19.62	18.21	32.57	34.20	33.39	49.38	52.49	50.94
T_2	1.44	1.51	1.47	1.56	1.71	1.64	15.57	18.83	17.20	29.05	32.55	30.80	44.62	50.38	47.50
T_3	1.38	1.46	1.42	1.41	1.68	1.55	15.03	17.64	16.33	25.64	31.87	28.76	40.67	49.51	45.09
T_4	1.35	1.51	1.43	1.68	1.77	1.73	13.90	16.16	15.03	27.53	32.72	30.13	41.43	48.88	45.16
T_5	1.30	1.44	1.37	1.45	1.61	1.53	13.39	15.58	14.49	23.46	28.37	25.91	36.85	43.95	40.40
T_6	1.20	1.30	1.25	1.36	1.64	1.50	12.52	13.63	13.07	21.91	27.89	24.90	34.43	43.18	38.80
T_7	1.35	1.47	1.41	1.65	1.79	1.72	14.75	17.28	16.01	29.73	33.74	31.73	44.49	51.01	47.75
T_8	1.35	1.42	1.39	1.42	1.64	1.53	13.27	16.29	14.78	24.51	30.91	27.71	37.78	46.54	42.16
T_9	1.25	1.36	1.31	1.40	1.63	1.51	12.61	13.96	13.28	23.66	30.50	27.08	36.27	45.13	40.70
SEm ±	0.05	0.04	0.03	0.07	0.04	0.04	0.82	1.24	0.74	1.73	1.14	1.03	1.98	2.03	1.42
CD (P=0.05)	0.14	0.13	0.09	0.22	0.11	0.12	2.47	3.71	2.14	5.17	3.41	2.98	5.93	6.07	4.08

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

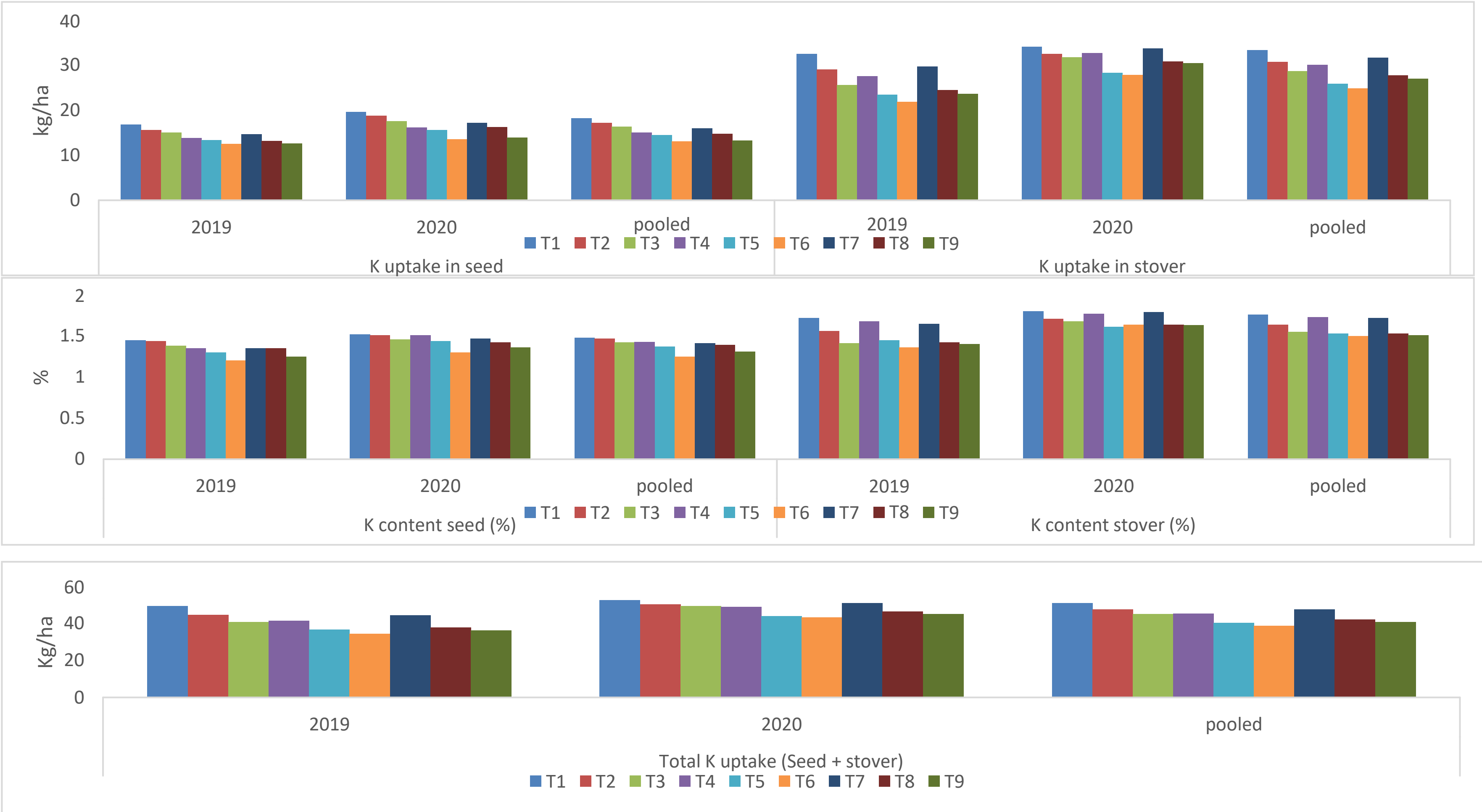


Fig 4.14: Effect of nutrient management on K content in seed, stover and their uptake in ricebean

4.4 SOIL PHYSICO CHEMICAL PROPERTIES

4.4.1 Soil pH

The data concerning the influence of nutrient management on ricebean and its impact on soil characteristics is presented in table 4.15. An analysis of the variations conducted to determine the significance of different sources of variation indicated that there was no noteworthy effect on soil pH as a result of applying these nutrient management practices.

4.4.2 Soil electrical conductivity (dS m^{-1})

The results shown in table 4.15 and illustrated in figure 4.15, which pertain to the influence of nutrient management on ricebean and its effect on soil electrical conductivity (EC), indicate that there were notable variations among the responses of different types of organic manures in terms of raising the soil EC in the ricebean crop. Application of poultry manure (0.7 t ha^{-1}) with 100 % RDF showed significantly highest soil EC during 2019 (0.226 dS m^{-1}) and 2020 (0.261 dS m^{-1}) and in pooled data (0.244 dS m^{-1}) and this trend was followed by application of FYM in pooled data and lowest value was exhibited in pig manure. Similarly, Diwale *et al.* (2020) reported that the maximum increase in soil EC was observed in the treatments of poultry manure (0.086 dS m^{-1}) followed by other forms of organic manures like vermicompost (0.082 dS m^{-1}), FYM (0.072 dS $m^{-1)}$ etc. One reason of the superiority could be poultry manure is one of the potential organic sources of major, secondary, and micronutrients, its application enhances the availability of these micronutrients, which are a function of yield and concentration in the crop.

Fan *et al*. (2005) reported that the combined application of inorganic and organic fertilizers had led to improved water use efficiency and enhanced soil chemical properties. Similar beneficial effects of this combined approach had been previously documented in the findings of Sannathammappa *et al*. (2015). These studies collectively support the advantages of integrating both inorganic and organic sources of fertilizers for optimizing agricultural outcomes and soil quality.

4.4.3 Soil organic carbon (%)

The data pertaining to the effect of nutrient management on soil organic carbon is presented in the table 4.5 and illustrated in figure 4.15. The analysis of variance studies suggested that only the responses of various types of nutrient management showed significant differences in improving the overall soil organic carbon.

The data in table 4.15, exhibited that the application of nutrient management affected the soil carbon content in the soil. A perusal of the data further presented that the application of poultry manure exhibited superiority at 0.7 t ha^{-1} along with 100 % RDF in (T_1) and was found to be significantly increasing the soil organic carbon during both the years as well as in pooled data, the value recorded was 1.51% in 2019, 1.72% in 2020 and 1.62% in pooled data. Diwale *et al*. (2020) reported that the organic carbon content of soil after harvest of cowpea crop was increased significantly with poultry manure application (1.50%) over FYM (1.39%) and goat manure (1.42%) and was at par with vermicompost (1.47%) application and added that the amount of organic carbon in the soil rose together with the level of manure added. The direct addition of organic matter through organic manures and the addition of a sizable amount of crop leaf litter may both have contributed to the improvement in soil organic carbon in plots treated with organic manures. One reason for high OC may be due to when poultry manure is applied in cultivated soil, the soil's fertility is improved by increasing its organic matter, water-holding capacity, aggregate stability, and oxygen diffusion rate (Adeli *et al*., 2009).

The organic carbon content and the carbon-to-nitrogen (C:N) ratio in organic manure are crucial factors that influence the release and availability of

Table 4.15: Effect of nutrient management on soil pH, EC and organic carbon content in soil after harvest

Treatment	pH			Electrical conductivity (dS m^{-1})			Organic carbon content (%)		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**pooled**
T_1	4.75	4.78	4.77	0.226	0.261	0.244	1.510	1.729	1.620
T_2	4.63	4.70	4.67	0.220	0.257	0.239	1.487	1.680	1.583
T_3	4.70	4.76	4.73	0.204	0.256	0.230	1.431	1.673	1.552
T_4	4.79	4.78	4.79	0.152	0.191	0.172	1.320	1.419	1.369
T_5	4.69	4.75	4.72	0.143	0.186	0.165	1.299	1.398	1.348
T_6	4.77	4.73	4.75	0.123	0.183	0.153	1.275	1.329	1.302
T_7	4.67	4.76	4.71	0.196	0.247	0.221	1.411	1.643	1.527
T_8	4.75	4.72	4.74	0.195	0.241	0.218	1.381	1.560	1.471
T_9	4.79	4.74	4.77	0.184	0.236	0.210	1.365	1.543	1.454
SEm ±	0.12	0.06	0.07	0.013	0.020	0.012	0.049	0.088	0.050
CD (P=0.05)	NS	NS	NS	0.038	0.061	0.034	0.147	0.264	0.145

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

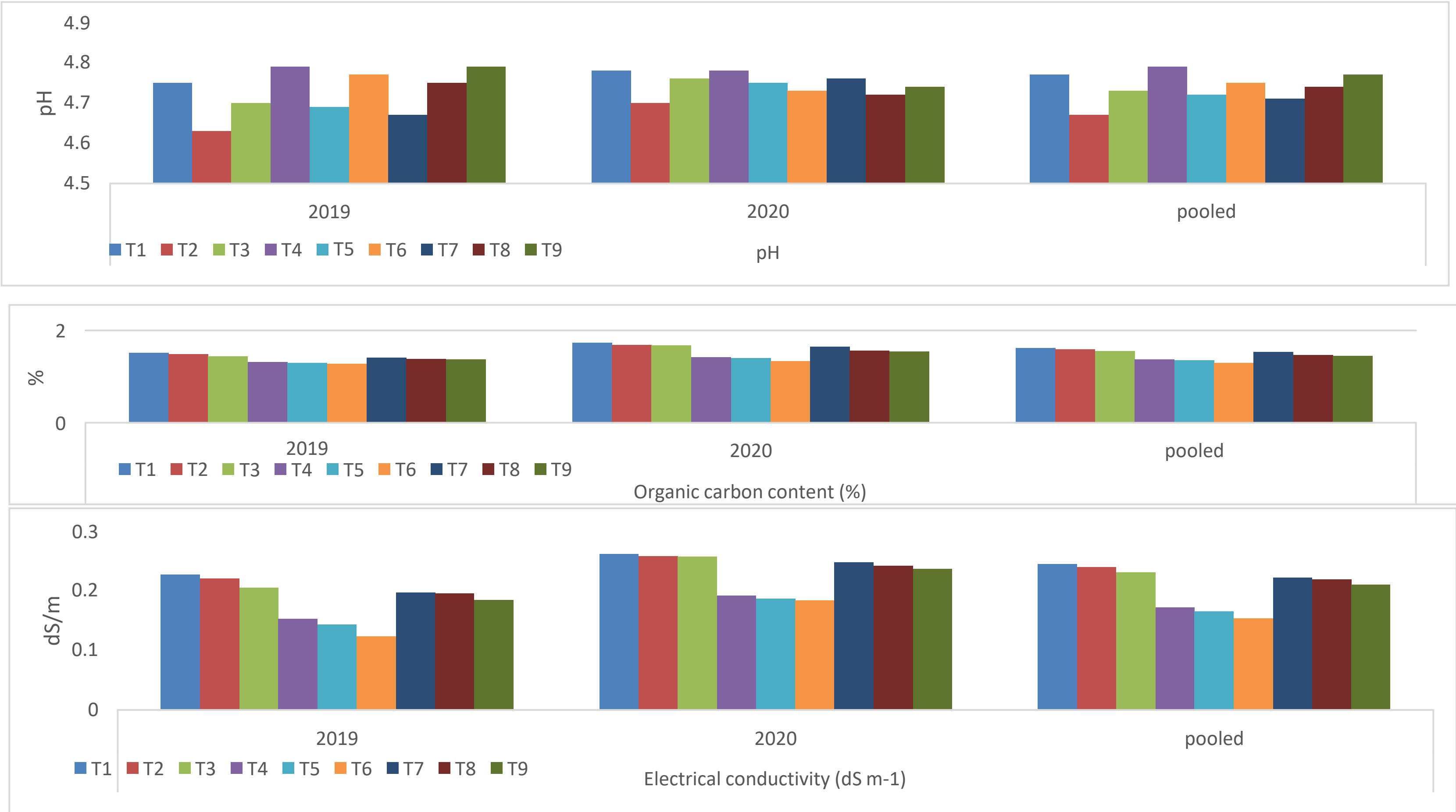


Fig 4.15: Effect of nutrient management on soil pH, EC (dS m^{-1}) and organic carbon (%) in ricebean after harvest

nutrients to crops. Carbon is a significant component of organic matter, and the assessment of organic matter content often involves the measurement of organic carbon, which is typically estimated to constitute about 58% of soil organic matter. These parameters are essential considerations in understanding soil fertility and nutrient cycling in agricultural systems. The current findings were in accordance with Saleem *et al*. (2017) and Sanjivkumar (2014), who exhibited that integration of soil organic manure in the soil using poultry manure increases the soil organic matter and also Anik *et al*. 2017 concluded that Poultry manure amendment in combination with chemical fertilizers resulted in the most biologically active soils with higher levels of microbial biomass carbon (MBC) and nitrogen (MBN) and it proved that poultry manure was a more efficient organic amendment than cow dung and rice straw for increasing soil fertility. The application of organic residues also increased the pH, and SOC, N, P, and K contents of the soil, further improving soil fertility and in comparison with the initial soil, the poultry manure treatment increased the soil pH, SOC by 62%, similar findings were also reported by Sannathammappa *et al*. (2015) who reported that the use of inorganic fertilizers together with soil-applied organic fertilizers increased the available nutrient status of plants and improved the physico-chemical and biological properties of the soil, which directly affect soil fertility.

4.4.4 Available soil nitrogen (kg ha^{-1})

The impact of nutrient management practices applied to ricebean on the available soil nitrogen was found to be significant where the corresponding data can be found in table 4.16 and illustrated in figure 4.16.

The critical examination of the data suggested that poultry manure @ 0.7 t ha^{-1} with 100 % RDF recorded higher available nitrogen (281.10 kg ha^{-1}) during 2019 which was comparatively higher than FYM and pig manure which were almost at par. In 2020, T_1 recorded significantly highest available phosphorus (288.33 kg ha^{-1}) while similar trend was evident on pooled data with poultry manure (0.7 t ha^{-1}) with 100 % RDF (284.67 kg ha^{-1}) with the maximum value and T_4 (239.97 kg ha^{-1}) and T_7 (239.08 kg ha^{-1}) were statistically at par in pooled data. One reason of the superiority could be poultry manure is one of the potential organic sources of major, secondary, and micronutrients, its application enhances the availability of these micronutrients, which are a function of yield and concentration in the crop.

The present outcomes align with the research by Puste *et al*. (2001), where the study similarly indicated that substituting 25% of the recommended nitrogen dose from synthetic fertilizers with organic alternatives, as opposed to exclusively relying on 100% chemical fertilizers, not only led to the highest rice yield but also had a substantial positive influence on the grain yield of pulse crops. Furthermore, the sustained benefits of Integrated Nutrient Management (INM) were observed in improved soil physical and chemical characteristics, which, in turn, contributed to an overall enhancement in the overall productivity of the rice-pulse cropping system. The findings are consistent with the results reported in studies by Akande *et al*. (2003), Maiksteniene and Arlauskiene (2004), Goulding *et al*. (2008), and Gudadhe (2008). Similarly, Luo *et al*. (2020) found that green manuring significantly improved soil properties. It reduced soil bulk density, increased porosity, and enhanced soil structure with water-stable aggregates and there was a notable increase in soil organic matter and a positive impact on both total and available nitrogen content.

4.4.5 Available soil phosphorus (kg ha^{-1})

The data pertaining to soil available phosphorus is presented in the table 4.16 and illustrated in figure 4.16.

The critical examination of the data suggested that poultry manure @ 0.7 t ha^{-1} with 100 % RDF recorded higher available phosphorus (37.24 kg ha^{-1}) during 2019 which was comparatively higher than FYM and pig manure which were almost at par. In 2020, T_1 recorded significantly highest available phosphorus (38.44 kg ha^{-1}) while similar trend was evident on pooled data with poultry manure (0.7 t ha^{-1}) with 100 % RDF (37.84 kg ha^{-1}) with the maximum value and FYM (34.99 ha^{-1}) and pig manure (34.62 ha^{-1}) were statistically at par in pooled data. Dikinya and Mufwanzala in 2010 reported that their research results indicated improved phosphorus (P) availability across all soil types when poultry manure was added at various application rates. This enhanced P availability can be attributed to anthropogenic sources such as the addition of fertilizers and organic manure to enhance soil fertility. Additionally, the mineralogical composition of the parent material also plays a role in influencing the concentration of phosphorus in soils. They found that there were significant increases in available phosphorus with increasing application rates of chicken manure in all soil types, underscoring the positive impact of poultry manure on phosphorus availability in the soil, similar results were reported from Duncan (2005).

It is widely recognized that poultry manure contains a richer nutrient content compared to other organic manures. The increase in soil phosphorus observed in treatments involving the incorporation of poultry manure may be attributed to the fact that organic materials, including poultry manure, not only contribute nitrogen to the soil but also have numerous other positive impacts on soil properties. This multifaceted influence of organic materials on soil health could be a contributing factor to the rise in soil phosphorus levels in these treatments. Poultry manure, in particular, possesses the inherent capacity to enhance the organic carbon content in the soil. This, in turn, accelerates the release of biologically-bound nitrogen present in the native soil. These findings align with the results reported by Keelara (2001), further highlighting the role of poultry manure in improving soil nitrogen dynamics. Simiarly, Luo *et al.* (2020) found that green manuring significantly improved soil properties. It reduced soil bulk density, increased porosity, and enhanced soil structure with water-stable aggregates and there was a notable increase in soil organic matter and a positive impact on both total and available nitrogen content.

4.4.6 Available soil potassium (kg ha^{-1})

Data pertaining to effect of different sources of organic manure in soil available potassium is presented in table 4.16 and illustrated in figure 4.16.

Close examination of the data revealed that in both the years as well as pooled data, application of poultry manure (0.7 t ha^{-1}) with 100 % RDF resulted in the maximum soil available potassium with the value of 154.22 kg ha^{-1} in 2019, 159.98 kg ha^{-1}in 2020 and pooled was 157.10 kg ha^{-1}; One reason of the superiority could be poultry manure is one of the potential organic sources of major, secondary, and micronutrients, its application enhances the availability of these micronutrients, which are a function of yield and concentration in the crop.

The application of farmyard manure (FYM) and poultry manure showed similar and comparable results in both years, as well as when the data from both years were combined. The increased availability of potassium (K) in the soil may be attributed to the beneficial effect of organic manures in reducing potassium fixation. Additional organic matter interacts with the soil's clay content, facilitating the release of potassium from the non-exchangeable portion of the soil to the accessible pool. This phenomenon has been reported by Diwale *et al*. (2020) and highlights the role of organic manures in enhancing potassium availability in the soil.

The beneficial effects of chicken manure may be caused by the potassium's gradual release over the course of the crop's growth season, as well as by the reduction of potassium fixation and release of the fixed potassium due to the interaction of chicken dung with clay minerals and similar beneficial effects were also reported by Keelara (2001).

Table 4.16: Effect of nutrient management on available soil nitrogen, phosphorus and potassium content

Treatment	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	pooled
T_1	281.00	288.33	284.67	37.24	38.44	37.84	154.22	159.98	157.10
T_2	277.83	280.41	279.12	35.32	37.76	36.54	154.23	152.04	153.13
T_3	276.45	271.34	273.89	34.02	34.43	34.23	142.23	145.22	143.72
T_4	235.69	244.24	239.97	32.69	37.30	34.99	149.85	156.65	153.25
T_5	219.03	220.08	219.56	32.47	35.73	34.10	145.55	151.26	148.41
T_6	218.76	224.95	221.85	31.00	34.18	32.59	136.53	147.85	142.19
T_7	239.11	239.04	239.08	33.72	35.52	34.62	147.74	156.71	152.23
T_8	252.10	246.05	249.08	33.06	34.22	33.64	141.43	150.78	146.11
T_9	265.99	257.32	261.66	32.07	32.13	32.10	140.48	142.65	141.56
SEm ±	15.31	12.17	9.78	1.16	0.91	0.74	3.82	3.01	2.43
CD (P=0.05)	45.90	36.49	28.17	3.47	2.73	2.12	11.44	9.04	7.00

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

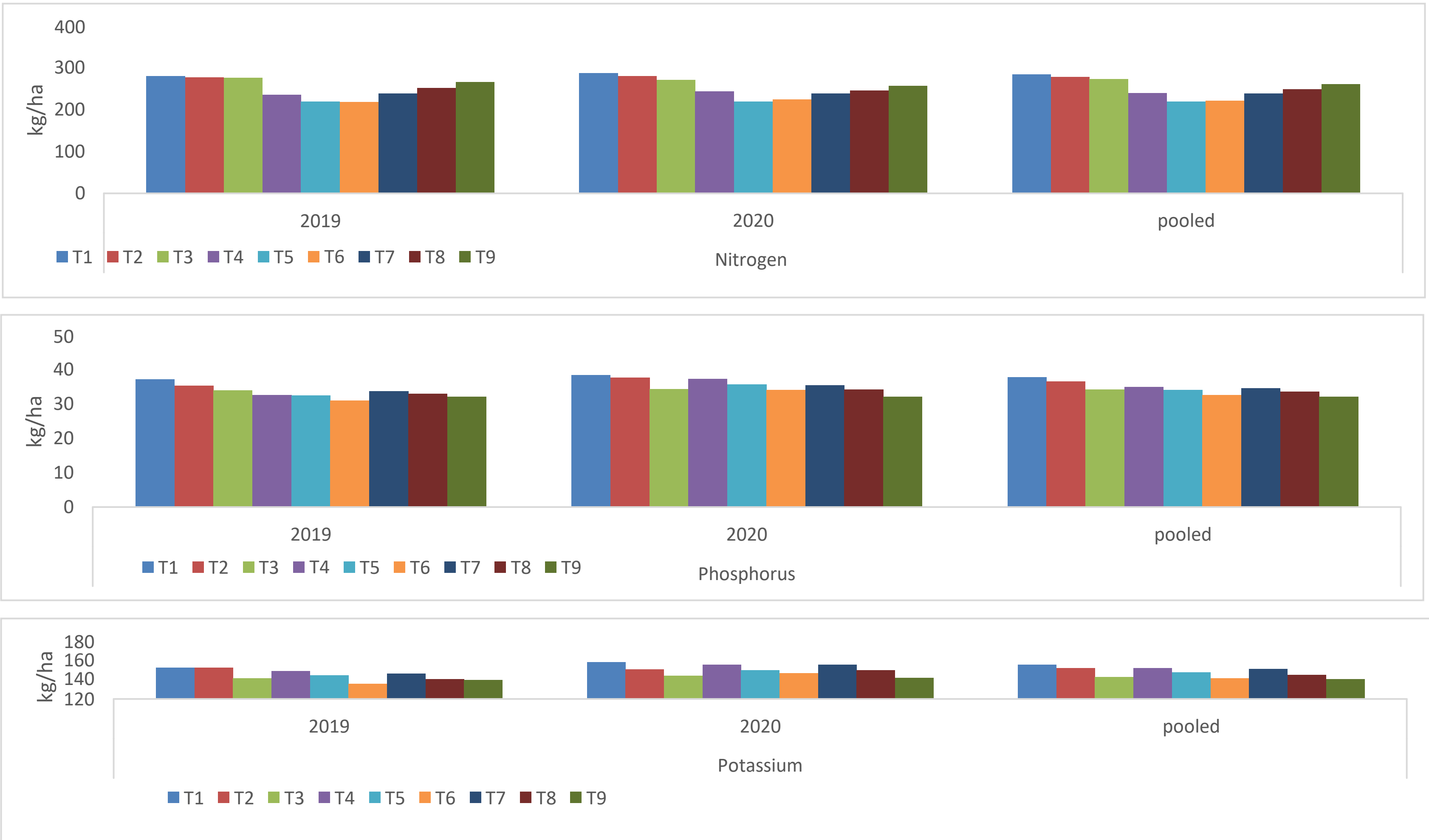


Fig. 4.16: Effect of nutrient management on available soil nitrogen, phosphorus and potassium (kg ha^{-1})

4.5 SOIL MICROBIAL PROPERTIES

The data on soil microbiological analysis viz. soil actinomycetes (Cfu x $10^5 g^{-1}$), soil bacteria population (Cfu x $10^6 g^{-1}$) and soil fungi population (Cfu x $10^3 g^{-1}$) are presented and explained with relevant references and available evidence.

4.5.1 Effect on soil actinomycetes (Cfu x $10^5 g^{-1}$ soil)

A reference to the data for both the years and average data pooled presented in table 4.17 and figure 4.17 revealed that the application of different sources of manure along with combined RDF showed significant variation with the effect of nutrient management on soil actinomycetes.

In 2019 and 2020 and pooled data, significantly revealed that maximum soil actinomycetes population with value of 1.96, 2.07 and 2.01 Cfu x $10^5 g^{-1}$ of soil respectively which was recorded in T_1 [GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF), this was followed by T_2, while the minimum soil actinomycetes population was recorded in T_6 (GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF), the superiority of poultry manure treatments can be attributed to the addition of poultry manure to soils, which not only helps address disposal issues but also enhances the physical, chemical, and biological fertility of the soil, as reported by Friend *et al*. (2006). This improvement may be due to the larger amount of organic matter returned to the soil through the breakdown of poultry manure. This increased organic matter content is primarily responsible for the higher population of actinomycetes in the treatment with poultry manure application. Actinomycetes are beneficial microorganisms that play a key role in soil health and nutrient cycling, further contributing to improved soil productivity.

Umadevi *et al*. (2019) concluded that the application of poultry manure led to a higher microbial population, including bacteria, fungi, and actinomycetes, in the soil compared to the application of farmyard manure. One major reason for this observation may be the relatively higher rate of microbial multiplication associated with organic manures. Organic manures serve as substrates that stimulate and support the rapid multiplication of microorganisms in the soil. Additionally, the increase in microbial population could be a result of the enhancement of soil organic matter. This is indicated by the positive correlation observed between enzyme activities (which are often used as indicators of microbial activity) and soil organic carbon. In essence, the higher microbial population associated with poultry manure application contributes to improved soil health and nutrient cycling, ultimately benefiting agricultural productivity. This can be ascribed to the decomposed food material available from organic sources and similar results were reported by Vineela *et al*., (2008), Nath *et al*., (2015).

Munji *et al*. (2010) reported that organic manures significantly increase the population of actinomycetes in the soil. This increase in actinomycetes population is associated with the higher biomass of microbes, as they have more resources to use as food, and it subsequently leads to an increase in the overall bacterial population in the soil. The majority of soil microorganisms are chemo-autotrophs, meaning they rely on organic carbon sources as their sustenance. When organic molecules are oxidized, it generates energy, as mentioned by Ingle *et al*. (2014). Application of organic manures, such as those from pigs, poultry, and cows, can boost microbial activity and this increased microbial activity contributes to the mineralization of organically-bound nitrogen into a form that is available to plants. Additionally, it may aid in the solubilization of native insoluble phosphates, thereby increasing the availability of phosphorus in the soil, as suggested by Diwale *et al*. in 2020. These findings also pointed out the role of organic manure in enhancing soil microbial activity and nutrient cycling, which in turn benefits plant growth and soil fertility.

4.5.2 Effect on soil fungi population (Cfu x $10^3 g^{-1}$soil)

Critical examination of the data on the effect of nutrient management on soil fungi population is presented in table 4.17 and illustrated in figure 4.17 and the results indicated a significant response was observed with the application of poultry manure in soil fungi in both the years of investigation.

The highest soil fungi population in 2019 was exhibited in T_1, T_2 and T_3 (33.04,29.26 and 25.93Cfu x $10^3 g^{-1}$) over pig manure (21.52, 20.15 and 19.85 Cfu x $10^3 g^{-1}$) and FYM (24.26, 23.48 and 22.9 Cfu x 10^3 g^{-1}). Similarly in 2020, it was observed that application of poultry manure T_1 (37.86 Cfu x $10^3 g^{-1}$) recorded the maximum soil fungi population and minimum was recorded in T_6 (23.92 Cfu x 10^3 g^{-1}), while the pooled (35.45 Cfu x $10^3 g^{-1}$) also revealed that there was a significant effect on number of nodules plant^{-1} due to the different organic manures and poultry manure exhibited superiority over the other manures. The superiority of poultry manure can indeed be attributed to its role as a potential organic source of major, secondary, and micronutrients, which enhances the availability of these micronutrients in the soil. This improved nutrient availability is closely related to crop yield and nutrient concentration in the crop. Additionally, the larger return of organic matter to the soil resulting from the breakdown of poultry manure plays a crucial role. This organic matter serves as a substrate for the rapid growth and multiplication of beneficial soil bacteria. The increased bacterial population in the treatment with poultry manure application contributes to the overall improvement in soil health, nutrient cycling, and ultimately, crop productivity. Therefore, both the nutrient content of poultry manure and its positive impact on soil microbial populations are key factors in its superiority for agricultural purposes.

Another reason for the superiority of poultry manure may indeed be its ability to increase microbial activity and population in the soil. This increase in microbial activity is a result of more carbon being available, along with essential nutrients like nitrogen and phosphorus. These nutrients provide soil microorganisms with additional energy and resources for growth and metabolic activities. The addition of organic inputs, such as poultry manure, can also lead to changes in the physico-chemical characteristics of the soil and an increase in its carbon content. These factors, combined with the availability of nutrients, promote the growth of soil microbes. Meena *et al*. (2015) obtained similar results, demonstrating the positive impact of organic inputs on soil microbial populations.

The microbial population of the experimental soil accelerated upon receiving nutrients either through chemical fertilizer or organic manure or biofertilizers as compared to control. Organic manure addition with inorganic fertilizer showed a profound increase in the microbial population in comparison to chemical fertilizer used alone. Added organic matter acts as a source of the nutrients and also as a substrate for decomposition and mineralization of nutrients, thereby creating a favourable condition for the proliferation of microbes in the soil.

4.5.3 Effect on soil bacteria population (Cfu x $10^6 g^{-1}$ soil)

A close analysis of the data presented in table 4.17 and figure 4.17 revealed that the application of different sources of manure integrated with combined RDF showed significant variation with the effect of nutrient management on soil a soil bacteria population.

In 2019 and 2020 and pooled data, application of poultry manure significantly increased the maximum soil bacteria population with the value of 38.74 in 2019, 40.22 in 2020 and the pooled value was 39.48 Cfu x $10^6 g^{-1}$ of soil respectively, which were recorded in T_1 (PM (0.7 t ha^{-1}) + 100 % RDF, this was followed by T_2 (39.39 Cfu x $10^6 g^{-1}$), while the minimum value of soil bacteria population was recorded in T_6 (33.62 Cfu x $10^6 g^{-1}$), the superiority of poultry manure treatments may be due to addition of poultry manure to soils not only aid to overcome the disposal issue but also increase the physical, chemical and biological prolificity of soils (Friend *et al*., 2006).

Table 4.17: Effect of nutrient management on actinomycetes, fungi and bacterial population in soil

Treatment	Actinomycetes (10^5 x Cfu g^{-1})			Fungi (10^3 x Cfu g^{-1})			Bacteria (10^6 x Cfu g^{-1})		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1	1.96	2.07	2.01	33.04	37.86	35.45	38.74	40.22	39.48
T_2	1.95	2.06	2.01	29.26	32.31	30.78	38.66	40.12	39.39
T_3	1.92	1.98	1.95	25.93	31.05	28.49	37.85	39.46	38.66
T_4	1.85	1.91	1.88	21.52	25.76	23.64	33.59	37.37	35.48
T_5	1.80	1.86	1.83	20.15	24.04	22.09	32.55	36.36	34.46
T_6	1.79	1.84	1.82	19.85	23.92	21.89	31.29	35.95	33.62
T_7	1.90	1.94	1.92	24.26	30.90	27.58	35.78	39.22	37.50
T_8	1.88	1.94	1.91	23.48	27.90	25.69	35.37	39.21	37.29
T_9	1.88	1.93	1.91	22.96	26.32	24.64	35.10	39.19	37.15
SEm ±	0.03	0.04	0.03	2.54	2.64	1.83	1.50	0.83	0.86
CD (P=0.05)	0.09	0.13	0.08	7.63	7.92	5.28	4.50	2.50	2.47

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

Fig 4.17: Effect of nutrient management on actinomycetes, fungi and bacterial population in soil

The microbial population of the experimental soil accelerated upon receiving nutrients either through chemical fertilizer or organic manure or biofertilizers as compared to control. Organic manure addition with inorganic fertilizer showed a profound increase in the microbial population in comparison to chemical fertilizer used alone. Added organic matter acts as a source of the nutrients and also as a substrate for decomposition and mineralization of nutrients, thereby creating a favourable condition for the proliferation of microbes in the soil.

The higher rate of bacterial population in the treatment with poultry manure application may indeed be attributed to the larger return of organic matter to the soil resulting from the breakdown of poultry manure. The organic matter serves as a valuable substrate for bacterial growth and activity and as the organic matter decomposes, it provides a continuous source of nutrients and energy for bacteria, fostering their proliferation in the soil. This increased bacterial population contributes to improved soil health and nutrient cycling, ultimately benefiting agricultural productivity and a result, the soil's bacterial population tends to increase, leading to improved nutrient cycling, organic matter decomposition, and overall soil health. Additionally, some beneficial bacteria in poultry manure can enhance soil fertility and benefit plant growth. However, it's crucial to manage poultry manure application carefully to avoid overloading the soil with nutrients and maintain a balanced soil ecosystem.

4.6 Enzyme Activity

Enzyme activity is the fundamental aspect of biology and biochemistry, enabling organisms to carry out essential metabolic processes efficiently and with precision.

4.6.1 Effect on dehydrogenase activity (µg TPF g^{-1} h^{-1})

Dehydrogenase activity serves as an important intracellular index for soil microbial activity due to its role in organic matter decomposition.

The data pertaining to the effect on nutrient management in soil after the harvest during 2019 and 2020 and pooled analysis in presented in table 4.18 and illustrated in figure 4.18. A close examination of the data revealed that the significant differences among the response of various sources of nutrient management in the dehydrogenase activity.

Using poultry manure along with RDF (T_1 to T_3) dispalyed positive impact on soil dehydrogenase activity in 2019 (19.06 µg TPF g^{-1} h^{-1}), 2020 (20.79 µg TPF g^{-1} h^{-1}), and pooled data (19.92 µg TPF g^{-1} h^{-1}). The more poultry manure was applied, the higher the overall dehydrogenase activity in the soil. Application of FYM (T_7, T_8 and T_9) responded better than pig manure (T_4, T_5 and T_6) in both the years and in pooled data a similar trend was exhibited. One probable reason may be that as poultry manure introduces organic matter and nutrients into the soil, this organic matter serves as a food source for soil microbes and dehydrogenase is an enzyme produced by these microorganisms as they break down organic matter. An increase in organic matter from poultry manure can stimulate microbial activity, leading to higher dehydrogenase enzyme levels. This enzyme activity is an indicator of soil microbial vitality and their ability to decompose organic material, enhancing nutrient cycling and soil health.

The increased microbial activity observed in Integrated Nutrient Management (INM) treatments may be attributed to the presence of easily available nutrient sources in fertilizers. These readily available nutrients promote the rapid development of microbial populations in the soil. In contrast to organic inputs, which require time to decompose and release their nutrients, fertilizers provide a more immediate and accessible source of nutrition for soil microorganisms and this quicker microbial population development in INM treatments can have positive effects on nutrient cycling and soil health, ultimately benefiting crop growth and productivity.

4.6.2 Soil microbial biomass carbon (µg g^{-1})

Soil Microbial Biomass Carbon (SMBC) is a critical component of soil organic matter, serving as an indicator of soil health and plays a central role in carbon cycling, nutrient dynamics, and overall soil ecosystem function.

The data pertaining to soil microbial biomass carbon after harvesting ricebean are presented in the table 4.18 and figure 4.18. Integration of poultry manure along with fertilizer significantly increased SMBC in the soil when compared with pig manure and FYM treatments.

Maximum value of SMBC was observed in poultry manure treated plots which was followed by FYM treatment and lowest was pig manure treated plots. The highest SMBC was recorded in T_1 with 338.25 µg g^{-1} soil and 419.76 µg g^{-1} soil in the soil during 2019 and 2020 and the minimum was 274.13 µg g^{-1} soil and 331.38 µg g^{-1} soil in 2019 and 2020 while pooled data revealed that T_1 had the highest value of SMBC *i.e.* 379.01 µg g^{-1} soil and least was 302.76 µg g^{-1} soil from pig manure (0.7 t ha^{-1}) + 50 % RDF in T_6. The primary reason for the superiority of poultry manure could be attributed to several factors. Firstly, poultry manure serves as a rich source of major, secondary, and micronutrients, thereby enhancing the availability of these crucial elements in the soil and this, in turn, positively influences crop yield and the concentration of nutrients within the crops. Secondly, the introduction of poultry manure into the soil promotes an increase in microbial activity and population. This is a consequence of the greater availability of carbon, nitrogen, and phosphorus in poultry manure, which provides soil microorganisms with additional energy and resources for their growth and metabolic processes. Consequently, the soil experiences an upsurge in microbial counts. Additionally, the application of organic inputs, including poultry manure, can lead to alterations in the physical and chemical characteristics of the soil. These changes may include the addition of carbon to the soil, which serves as a substrate for microbial growth and activity. As demonstrated in the research conducted by Meena *et al*. (2015), higher microbial populations under the influence of organic manures, such as poultry manure, are indicative of soil fertility. This is due to the vital role played by these microbes in temporarily sequestering nutrient flux within the soil, thereby contributing to nutrient cycling and availability. In summary, poultry manure's superiority in enhancing soil fertility, microbial activity, and crop productivity can be attributed to its multifaceted impact on nutrient availability, microbial populations, and changes in soil characteristics, similar trend was reported by Anik *et al*. 2017, where poultry manure amendment in combination with chemical fertilizers under rice growing conditions resulted in the most biologically active soils with higher levels of microbial biomass carbon (MBC) and nitrogen (MBN) and it proved that poultry manure was a more efficient organic amendment than cow dung and rice straw for increasing soil fertility.

4.6.3 Acid phosphatase activity (µg p-nitrophenol g^{-1} h^{-1})

The effect of different sources of nutrient management on acid phosphatase activity in the soil after the harvest of ricebean was significant as exhibited in the data through table 4.18 and figure 4.18.

In 2019, acid phosphatase activity was found to be the highest under T_1 (54.52 µg p-nitrophenol g^{-1} h^{-1}) followed by T_2 (54.15 µg p-nitrophenol g^{-1} soil h^{-1}) and the least was recorded in T_6 (37.62 µg p-nitrophenol g^{-1} h^{-1}), while a similar trend was also observed in 2020 where the maximum acid phosphatase activity was observed under T_1 (58.95 µg p-nitrophenol g^{-1} h^{-1}) followed by T_2 (57.90 µg p-nitrophenol g^{-1} soil h^{-1}) and the least was recorded in T_6 (47.58 µg p-nitrophenol g^{-1} h^{-1}) and maximum in pooled data was in T_1 (56.74 µg p-nitrophenol g^{-1} h^{-1}). The plots that received a combination of poultry manure and RDF exhibited notably higher phosphatase activity compared to those treated with FYM and pig manure. This increase in phosphatase activity can be

Table 4.18: Effect of nutrient management on dehydrogenase activity, soil microbial biomass carbon and acid phosphatase activity

Treatment	Dehydrogenase activity (μg TPF g^{-1} h^{-1})			Soil microbial biomass carbon (μg g^{-1} soil)			Acid phosphatase activity (μg p-nitrophenol g^{-1} h^{-1})		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
T_1	19.06	20.79	19.92	338.25	419.76	379.01	54.52	58.95	56.74
T_2	18.82	20.05	19.44	337.58	417.79	377.68	54.15	57.90	56.02
T_3	18.42	19.97	19.20	331.97	413.10	372.54	49.16	52.51	50.84
T_4	17.72	18.72	18.22	278.52	373.32	325.92	44.24	49.68	46.96
T_5	17.55	18.59	18.07	274.88	346.27	310.58	42.41	48.45	45.43
T_6	16.71	18.28	17.49	274.13	331.38	302.76	37.62	47.58	42.60
T_7	18.25	19.42	18.83	328.63	401.44	365.04	49.93	52.02	50.97
T_8	18.14	19.25	18.70	324.65	394.75	359.70	46.46	50.01	48.24
T_9	17.84	18.92	18.38	322.26	379.63	350.94	45.42	49.80	47.61
SEm ±	0.42	0.47	0.32	17.05	19.37	12.90	3.35	2.37	2.05
CD (P=0.05)	1.27	1.42	0.92	51.13	58.07	37.17	10.06	7.10	5.91

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

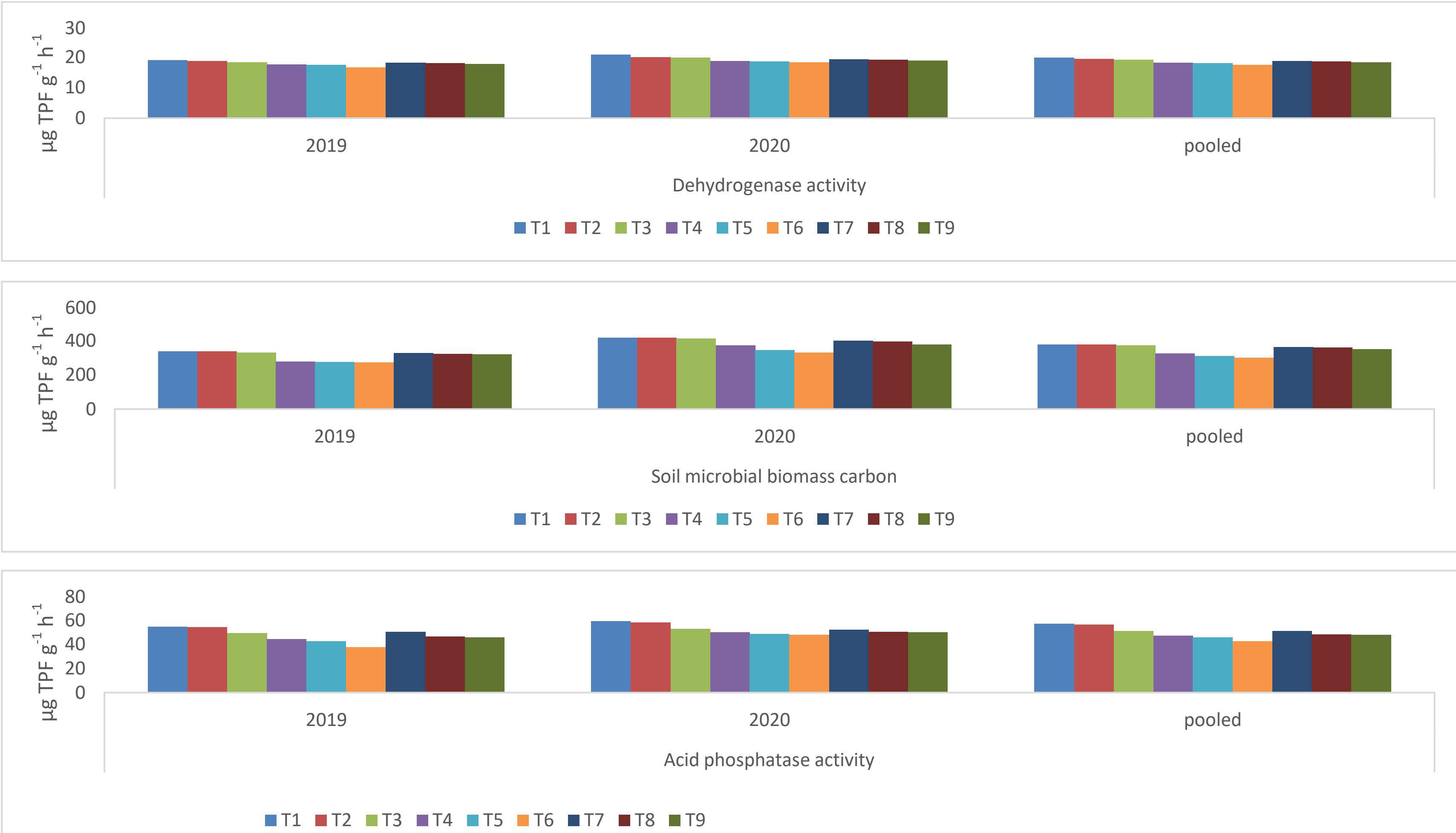


Fig 4.18: Effect of nutrient management on dehydrogenase activity, soil microbial biomass carbon and acid phosphatase activity

attributed to the stimulation caused by the application of both inorganic and organic manures. Acid phosphatase is another enzyme produced by soil microbes, playing a vital role in phosphorus mineralization, making phosphorus more available to plants. Poultry manure contributes phosphorus to the soil, which can enhance acid phosphatase activity and this increased enzyme activity aids in the release of phosphate from organic compounds in the soil, making it accessible for plant uptake.

4.7 Residual effect on the succeeding crop linseed

4.7.1 Number of pods plant^{-1}

The data pertaining to pods plant^{-1} on the effect of nutrient management are presented below in table 4.19 and illustrated in figure 4.19.

The differences in pods plant^{-1}was found to be significant under the different nutrient management treatments during both the years of experiment. In 2019, the maximum pods plant^{-1} (43.70) in linseed was recorded in T_1 and the following year also recorded significantly higher pods plant^{-1} (45.60) under poultry manure application with inorganic fertilizers combined, the pooled data also recorded significant variation with the same trend in T_1 (44.65) while the minimum was recorded in T_6 (32.20). This result is consistent with the observations made by Roul and Mahapatra (2006), who noted that the residual effects of both organic and inorganic sources contributed to the improved productivity of the subsequent crop. This phenomenon can be attributed to an increased availability of nutrients in the soil, arising from both the native nutrient pool and the residual impact of nutrient mineralization. Additionally, this process may lead to enhancements in the physico-chemical properties of the soil, thereby improving its capacity to retain water and nutrients. These findings align with research conducted by Gawai and Pawar in 2006 concerning sorghum-chickpea cultivation, Patil *et al*. (2008) for sorghum-chickpea, Gudadhe (2008) for cotton-chickpea systems, and Nawle in 2009. Additionally, the current findings were in accordance with the application of organic nutrient sources to previous crops can have a substantial positive impact on the subsequent crops, and this integrated approach of utilizing both organic and inorganic nutrient sources has the potential to enhance system productivity and contribute to the sustainability of agricultural practices.

4.7.2. Number of seeds pod^{-1}

The difference in the number of seeds per pod in the remaining linseed crop, influenced by nutrient management, was determined to be statistically significant for both years of the experiment and are presented below in table 4.19 and illustrated in figure 4.19.

The differences in number of seeds pod^{-1} were found to be significant under the different nutrient management treatments during both the years of experiment. In 2019, the maximum seeds pod^{-1} (7.91) linseed was recorded in T_1 and the following year also recorded significantly higher number of seeds pod^{-1} (11.00) under poultry manure application with inorganic fertilizers combined, the pooled data also recorded significant variation with the same trend in T_1 (9.46) while the minimum was recorded in T_6 (6.61). This result is consistent with the observations made by Roul and Mahapatra (2006), who noted that the residual effects of both organic and inorganic sources contributed to the improved productivity of the subsequent crop.

4.7.2 Test weight (g)

The data on test weight failed to show significant difference in response to the nutrient management on ricebean-linseed cropping system in both years of investigation.

Table 4.19: Effect **o**f nutrient management on number of pods, seeds and test weight in linseed

Treatment	Number of pods plant^{-1}			Number of seeds pod^{-1}			Test weight (g)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	43.70	45.60	44.65	7.91	11.00	9.46	7.36	7.37	7.37
T_2	42.11	44.33	43.22	7.87	10.86	9.37	7.34	7.37	7.35
T_3	40.11	42.55	41.33	7.83	10.31	9.07	7.35	7.36	7.35
T_4	35.07	37.27	36.17	6.89	8.50	7.70	7.31	7.37	7.34
T_5	36.78	38.97	37.87	6.55	7.54	7.05	7.32	7.35	7.33
T_6	30.53	33.87	32.20	6.22	7.00	6.61	7.31	7.32	7.31
T_7	40.00	43.48	41.74	7.48	10.56	9.02	7.31	7.33	7.32
T_8	41.74	42.02	41.88	7.55	9.18	8.36	7.32	7.35	7.34
T_9	40.22	41.27	40.74	7.19	9.08	8.13	7.32	7.33	7.33
SEm ±	2.25	1.56	1.37	0.35	0.87	0.47	0.01	0.01	0.01
CD(P=0.05)	6.74	4.67	3.94	1.05	2.61	1.35	NS	NS	NS

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

Fig 4.19: Effect of nutrient management on number of pods plant^{-1}, seeds pod^{-1} and test weight (g) in linseed

4.7.4 Seed yield (kg ha^{-1})

The experiment data on effect of nutrient management on succeeding crop linseed in seed yield (kg ha^{-1}) are presented in table 4.20 and illustrated in figure 4.20.

The data exhibited that application of poultry manure [Green manuring (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF] from T_1 resulted significantly higher seed yield in both the years as well as in the pooled data compared to application of pig manure and FYM. There was a similar trend where FYM application turned out superior than pig manure in both the years of investigation. The maximum yield in residual crop linseed was recorded poultry manure applied at T_1 (769.32 kg ha^{-1}) in 2019 and (776.04 kg ha^{-1}) 2020, and the pooled data was found to be 772.68 kg ha^{-1}.

The findings reported suggest that the highest number of nodules per plant (34.12) can be ascribed to the increased nutrient availability in the Integrated Nutrient Management (INM) treatments and this heightened the nutrient availability appears to have promoted a greater conversion of carbohydrates into protein. Consequently, this enhanced protein synthesis contributed to the growth of protoplasm and cell wall material, resulting in larger cell sizes. These changes were reflected morphologically through an increase in plant height, a larger leaf area, a greater number of branches, and ultimately, higher production of dry matter, as observed in the study by Koireng *et al*. (2018). These results are consistent with the possibility of enhanced nutrient availability in the soil, stemming from both the native nutrient pool and the residual effects of nutrient mineralization. Furthermore, this process could lead to improvements in the physico-chemical properties of the soil, consequently enhancing its ability to retain water and nutrients. These findings align with the research of Gawai and Pawar (2006) in the context of sorghum-chickpea cultivation, Patil (2008) in the case of sorghum-chickpea, Gudadhe (2008) for cotton-chickpea systems, and Nawle (2009). In addition, the current findings were in accordance with the application of organic nutrient sources to previous crops can have a substantial positive impact on the subsequent crops, and this integrated approach of utilizing both organic and inorganic nutrient sources has the potential to enhance system productivity and contribute to the sustainability of agricultural practices.

4.7.5 Stover yield (kg ha^{-1})

The results of experiment regarding the effect of nutrient management in stover yield (kg ha^{-1}) of residual crop linseed are presented in table 4.20 and illustrated in figure 4.20.

The data revealed that there was a significant variation to the residual crop linseed from the responses of different nutrient sources and fertilizer combinations in rice bean crop. The residues from the application of green manuring (*Sesbania*) + poultry manuring (0.7 t ha^{-1}) + 100 % RDF in T_1 was able to provide the highest significant stover yield during 2019 (1426.83 kg ha^{-1}) and 2020 (1440.28 kg ha^{-1}). The pooled data also revealed that a significant difference with the highest recorded stover yield in T_1 (1433.55 kg ha^{-1}) and the minimum under treatment T_6 (1210.59 kg ha^{-1}) during both years of investigation respectively. The increased stover yield observed in the mentioned treatments can be attributed to the growth of more vegetation, which includes factors like taller plant height, a higher number of branches, and a larger leaf area. The reported results suggest that the highest number of nodules per plant (34.12) can be explained by the greater availability of nutrients in the Integrated Nutrient Management (INM) treatments. This increased nutrient availability appears to have facilitated a higher conversion of carbohydrates into protein. As a result, this enhanced protein synthesis contributed to the growth of protoplasm and cell wall material, leading to larger cell sizes. These changes were evident in the plant's morphology, including increased plant height, a larger leaf area, a greater number of

Table 4.20: Effect of nutrient management on seed and stover yield of linseed

Treatment	Seed yield(kg ha^{-1})			Stover yield(kg ha^{-1})		
	2019	2020	Pooled	2019	2020	Pooled
T_1	769.32	776.04	772.68	1426.83	1440.28	1433.55
T_2	706.33	685.60	695.97	1360.80	1381.31	1371.06
T_3	703.79	673.97	688.88	1333.80	1347.25	1340.52
T_4	631.07	640.15	635.61	1252.39	1238.53	1245.46
T_5	600.27	598.71	599.49	1223.22	1220.74	1221.98
T_6	576.95	595.91	586.43	1204.08	1217.10	1210.59
T_7	702.82	706.51	704.67	1246.55	1225.47	1236.01
T_8	661.39	693.87	677.63	1213.99	1208.87	1211.43
T_9	646.30	643.88	645.09	1227.41	1227.66	1227.53
SEm ±	33.55	20.92	19.77	41.43	37.76	28.03
CD (P=0.05)	100.57	62.73	56.95	124.21	113.21	80.74

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

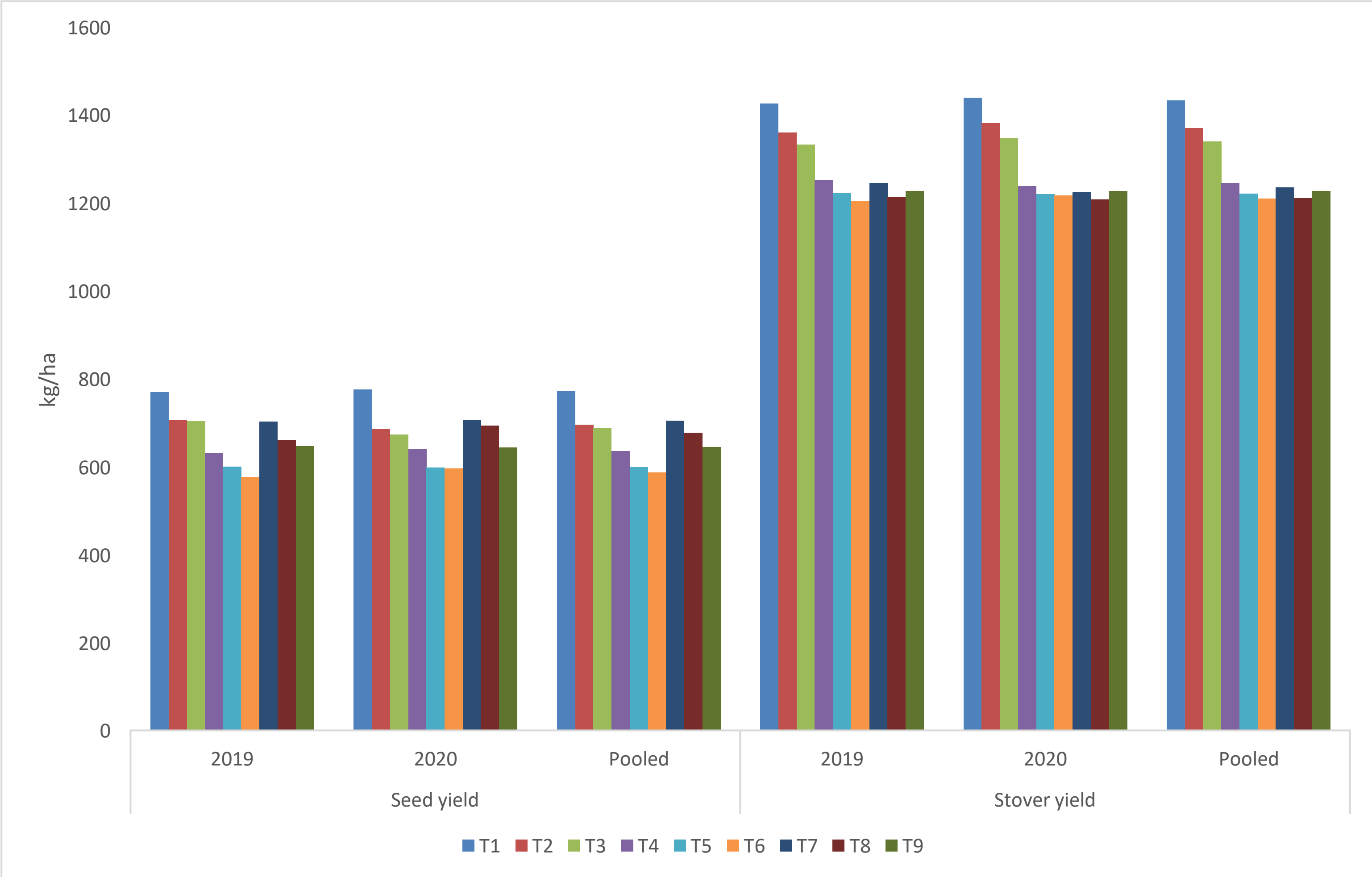


Fig 4.20: Effect of nutrient management on seed yield (kg ha^{-1}) and stover yield (kg ha^{-1}) in linseed

branches, and ultimately, higher dry matter production, as observed in the study by Koireng *et al*. (2018).

This effect may also be attributed to improved nutrient availability in the soil, arising from both the native nutrient pool and the residual effects of nutrient mineralization. Additionally, this process might lead to improvements in the physico-chemical properties of the soil, consequently enhancing its capacity to retain water and nutrients. These findings align with the research of Gawai and Pawar (2006) in the context of sorghum-chickpea cultivation, Patil *et al.* (2008) in the case of sorghum-chickpea, Gudadhe (2008) for cotton-chickpea systems, and Nawle (2009).

4.7.6 Plant analysis: Nutrient uptake (kg ha^{-1}) by succeeding linseed

4.7.6.1Nitrogen content in seed and stover (%)

The data concerning the impact of nutrient management on nitrogen content in both seeds and stover in linseed is displayed in table 4.21 and illustrated in figure 4.21.

The study found significant differences in the response of linseed as a residual crop to various sources of organic manure when grown after ricebean. In terms of nitrogen content in linseed seeds, the highest values were observed in treatment T_1, with a value of 1.45% in 2019 and 1.44% in 2020, and an average of 1.48% for T_1, while T_2 had the second-highest nitrogen content (1.44%), while T_6 had the lowest (1.20%).

Regarding nitrogen content in linseed stover, the highest value in 2019 was recorded in T_1 (5.84%), followed by T_2 (5.80%), with the lowest in T_6 (5.04%). Similarly, in 2020, T_1 had the highest value (6.10%), while T_6 had the lowest (5.17%) while Treatments T_3 (5.83%) and T_8 (5.83%) were at par with values. In the pooled data, T_1 (5.97%) exhibited the highest nitrogen content in both linseed seeds and stover. Current findings were in accordance with the application of organic nutrient sources to previous crops can have a substantial positive impact on the subsequent crop and this integrated approach of

Table 4.21: Effect of nutrient management on N content in seed and stover and their uptake by linseed

Treatments	N content grain (%)			N content stover (%)			N uptake by seed (kg ha^{-1})			N uptake by stover (kg ha^{-1})			Total N uptake (kg ha^{-1}) (Seed + stover)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	5.84	6.10	5.97	1.69	1.84	1.77	37.49	59.21	48.35	21.67	23.89	22.78	59.16	64.15	61.66
T_2	5.80	6.00	5.90	1.58	1.77	1.68	36.73	56.22	46.47	20.26	22.75	21.50	56.98	61.09	59.04
T_3	5.71	5.83	5.77	1.51	1.65	1.58	35.41	54.55	44.98	19.34	21.11	20.22	54.75	57.65	56.20
T_4	5.26	5.57	5.41	1.29	1.39	1.34	30.90	50.74	40.82	15.39	16.83	16.11	46.29	48.72	47.51
T_5	5.09	5.38	5.24	1.18	1.32	1.25	26.67	51.12	38.90	13.77	15.79	14.78	40.44	45.43	42.93
T_6	5.04	5.17	5.11	1.11	1.26	1.18	25.23	49.65	37.44	12.79	15.05	13.92	40.02	42.75	41.38
T_7	5.53	5.87	5.70	1.47	1.64	1.55	34.71	58.53	46.62	18.50	20.98	19.74	53.21	57.96	55.59
T_8	5.46	5.83	5.65	1.35	1.58	1.47	33.42	55.92	44.67	16.98	19.83	18.40	50.39	55.68	53.04
T_9	5.35	5.70	5.53	1.29	1.49	1.39	32.64	51.53	42.08	15.83	18.57	17.20	48.47	53.47	50.97
SEm ±	0.15	0.16	0.11	0.11	0.10	0.07	1.22	1.33	0.90	1.37	1.24	0.92	1.89	2.17	1.44
CD (P=0.05)	0.44	0.48	0.31	0.34	0.29	0.21	3.66	3.98	2.60	4.11	3.72	2.66	5.68	6.49	4.14

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

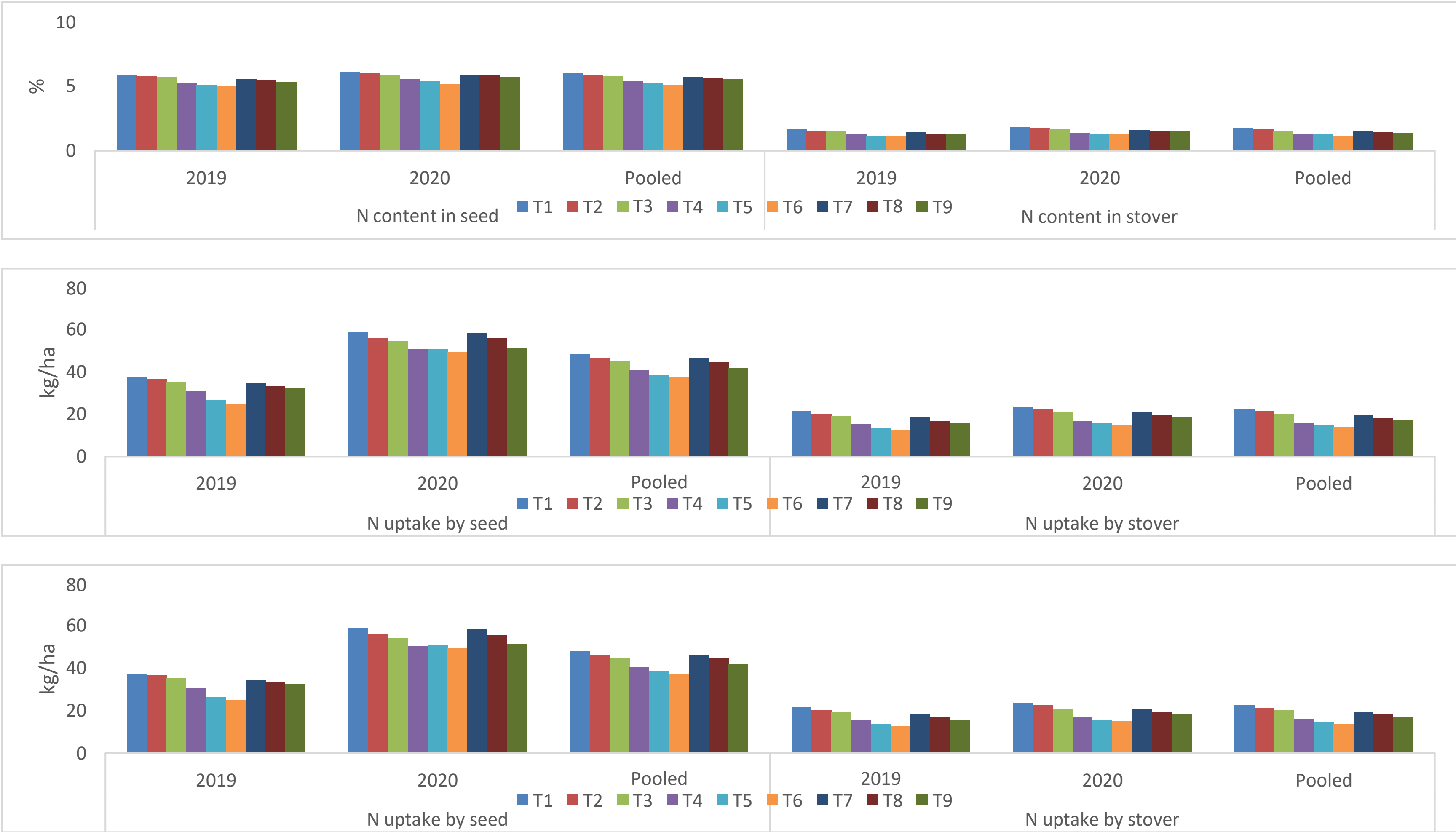


Fig 4.21: Effect of nutrient management on N content in seed, stover and their uptake in linseed

utilizing both organic and inorganic nutrient sources has the potential to enhance system productivity and contribute to the sustainability of agricultural practices, comparable to the results by Puste *et al*. (2001); Senthivalavan and Ravichandran (2019).

4.7.6.2Phosphorus content in seed and stover (%)

The data concerning the impact of nutrient management on phosphorus content in both seeds and stover in linseed is displayed in table 4.22 and illustrated in figure 4.22.

The results exhibited towards the presence of significant differences in response to the various sources of organic manure. The highest phosphorus content was evident in T_1 (1.58 %) followed by T_7 (1.54 %) while T_5 and T_8 (1.44%) were at par with one another in both 2019. In 2020, the maximum phosphorus content in stover was evident in T_1 (1.75 %) while pooled value was 1.66 % in terms of seed content.

Regarding the phosphorus content in stover, the study found significant differences in the response of linseed as a residual crop to various sources of organic manure when grown after ricebean where the highest values P content was in treatment T_1, with a value of 1.65% in 2019 and 1.84 % in 2020, and an average of 1.74 % for T_1, while T_7 had the second-highest phosphorus content (1.70 %), while T_9 had the lowest content (1.35%).

The current findings were in accordance with the application of organic nutrient sources to previous crops can have a substantial positive impact on the subsequent crops, and this integrated approach of utilizing both organic and inorganic nutrient sources has the potential to enhance system productivity and contribute to the sustainability of agricultural practices.

Table 4.22: Effect of nutrient management on P content in seed and stover and their uptake by linseed

Treatments	P content seed (%)			P content stover (%)			P uptake by seed (kg ha^{-1})			P uptake by stover (kg ha^{-1})			Total P uptake (kg ha^{-1}) (Seed + stover)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	1.58	1.75	1.66	1.65	1.84	1.74	10.15	11.52	10.84	21.16	23.83	22.49	31.31	35.35	33.33
T_2	1.51	1.70	1.60	1.52	1.75	1.64	9.54	10.84	10.19	19.51	22.51	21.01	29.05	33.35	31.20
T_3	1.40	1.66	1.53	1.46	1.63	1.55	8.69	10.35	9.52	18.74	20.89	19.82	27.43	31.24	29.33
T_4	1.56	1.73	1.65	1.60	1.78	1.69	9.35	9.83	9.59	19.10	21.55	20.32	28.45	31.38	29.91
T_5	1.44	1.61	1.52	1.47	1.65	1.56	7.52	8.86	8.19	17.19	19.78	18.49	24.72	28.64	26.68
T_6	1.38	1.57	1.47	1.42	1.53	1.48	6.89	8.39	7.64	16.39	18.35	17.37	23.28	26.74	25.01
T_7	1.54	1.52	1.53	1.62	1.78	1.70	9.65	9.58	9.61	20.43	22.76	21.59	30.07	32.34	31.21
T_8	1.44	1.48	1.46	1.49	1.73	1.61	8.83	9.08	8.95	18.68	21.69	20.19	27.51	30.77	29.14
T_9	1.29	1.46	1.37	1.30	1.40	1.35	7.84	8.92	8.38	15.96	17.44	16.70	23.81	26.36	25.08
SEm ±	0.05	0.07	0.04	0.06	0.08	0.05	0.40	0.45	0.30	0.75	1.09	0.66	0.88	1.32	0.79
CD(P=0.05)	0.15	0.20	0.12	0.17	0.24	0.14	1.21	1.35	0.87	2.24	3.28	1.91	2.63	3.96	2.28

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

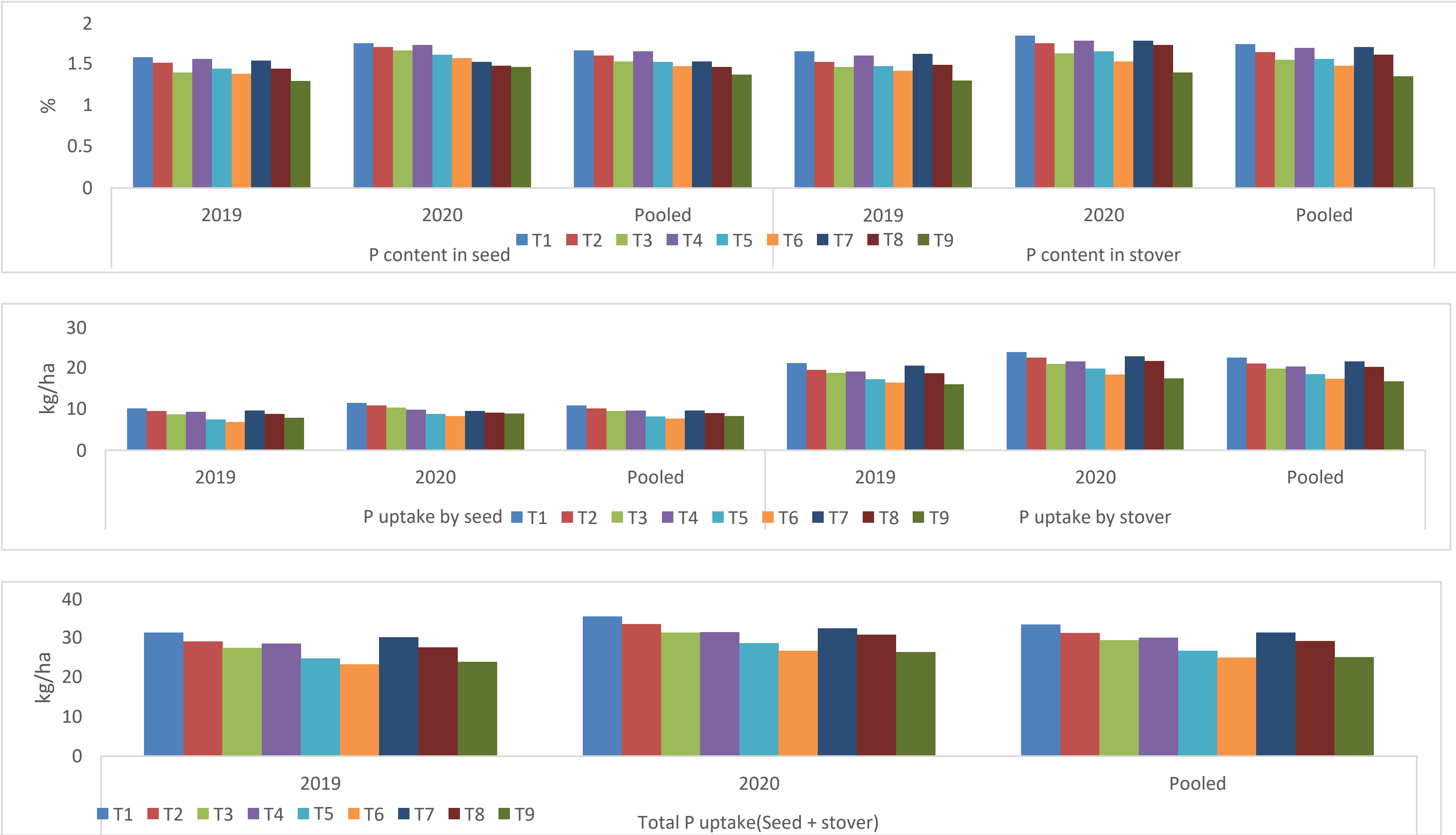


Fig 4.22: Effect of nutrient management on P content in seed, stover and their uptake in linseed

4.7.6.3 Potassium content in seed and stover (%)

The data concerning the impact of nutrient management on potassium content in both seeds and stover in succeeding crop, linseed were displayed in table 4.23 and illustrated in figure 4.23.

The results clearly demonstrate the presence of significant differences in response to the various sources of organic manure. In terms of potassium content in the seeds, the highest levels were observed in T_1, with a value of 2.06 % in 2019 followed by treatment T_4 with 2.00 % while during 2020, T_1 continued to exhibit the highest potassium content in the seeds, measuring 2.47%, with T_2 and T_7 following closely at 2.34 % while in the pooled data analysis, T_1 consistently displayed the maximum potassium content, with an average of 2.27%. The current findings were in accordance with the application of organic nutrient sources to previous crops can have a substantial positive impact on the subsequent crops, and this integrated approach of utilizing both organic and inorganic nutrient sources has the potential to enhance system productivity and contribute to the sustainability of agricultural practices.

4.7.6.4 Total N, P and K uptake by the plant (kg ha^{-1})

The data for the total uptake of nitrogen (N), phosphorus (P), and potassium (K) in linseed can be found in table 4.21, 4.22, 4.23 and is visually presented in figure 4.21, 4.22 and 4.23.

In 2019, the highest nitrogen (N) uptake, measuring 59.16 kg ha^{-1}, was observed in T_1, which had received poultry manure (0.7 t ha^{-1}) along with 100% recommended dose of fertilizer (RDF) in the previous season, T_2 followed with a total N uptake of 56.98 kg ha^{-1}. In 2020, T_1 again exhibited the highest N uptake at 64.15 kg ha^{-1} with an average data of 61.66 kg ha^{-1}.

For total phosphorus (P) uptake in 2019, the highest value of 31.31 kg ha^{-1} was recorded in T_1, which had been treated with poultry manure (0.7 t ha$^{-1)}$ and 100% RDF in the previous season, T_7 followed with a total P uptake of

Table 4.23: Effect of nutrient management on K content in seed and stover and their uptake by linseed

Treatments	K content seed (%)			K content stover (%)			K uptake by seed (kg ha^{-1})			K uptake by stover (kg ha^{-1})			Total K uptake (kg ha^{-1}) (Seed + stover)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	2.06	2.47	2.27	3.28	3.41	3.34	13.27	14.65	13.96	39.29	42.76	41.03	53.57	58.81	56.19
T_2	1.97	2.28	2.13	3.21	3.31	3.26	11.10	14.59	12.85	34.14	35.93	35.04	52.89	57.16	55.02
T_3	1.8	2.01	2.04	3.00	3.19	3.10	9.88	12.57	11.22	30.05	33.11	31.58	52.73	53.34	53.03
T_4	2.00	2.00	1.91	2.93	3.06	3.00	10.68	11.44	11.06	29.88	31.62	30.75	50.13	48.43	49.28
T_5	1.77	1.96	1.87	2.88	3.09	2.98	9.28	10.80	10.04	27.40	33.08	30.24	46.16	47.89	47.02
T_6	1.74	1.94	1.84	2.64	3.00	2.82	8.72	10.37	9.55	23.65	28.05	25.85	39.26	46.28	42.77
T_7	2.04	2.34	2.19	3.35	3.51	3.43	12.76	14.73	13.75	34.00	34.51	34.26	52.27	59.55	55.91
T_8	1.98	2.20	2.09	3.24	3.34	3.29	11.42	13.52	12.47	33.70	33.06	33.38	51.16	55.33	53.25
T_9	1.86	2.02	1.94	3.00	3.12	3.06	11.36	12.35	11.85	29.64	32.73	31.18	51.07	51.21	51.14
SEm ±	0.07	0.08	0.05	0.07	0.06	0.05	0.93	0.67	0.57	1.81	1.66	1.23	2.00	1.68	1.30
CD(P=0.05)	0.22	0.23	0.15	0.20	0.19	0.13	2.77	2.00	1.64	5.43	4.99	3.54	5.99	5.03	3.76

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

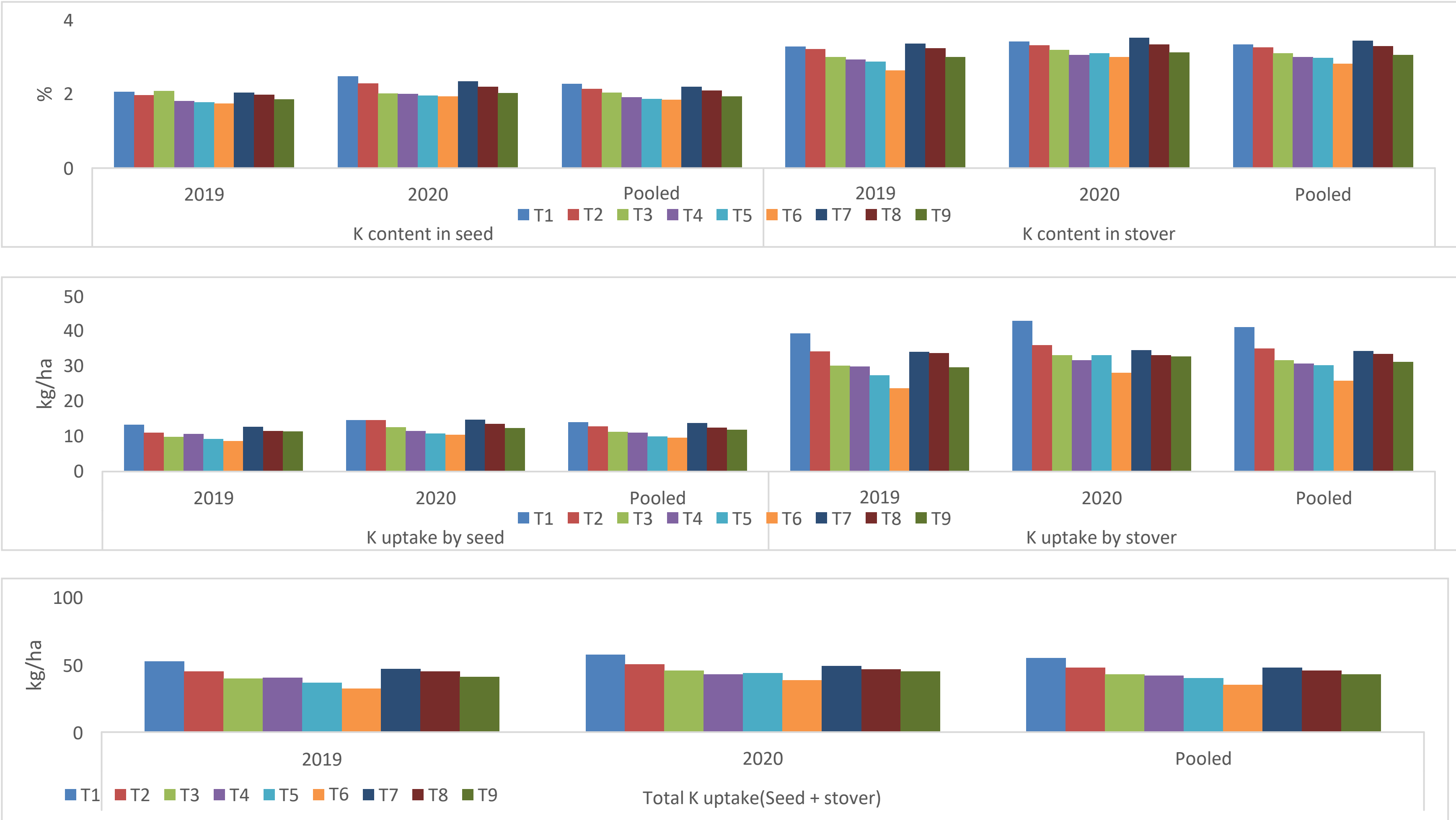


Fig 4.23: Effect of nutrient management on K content in seed, stover and their uptake in linseed

30.07 kg ha^{-1}. In 2020, T_1 once more showed the highest P uptake at 35.35 kg ha^{-1}, with a combined pooled average value of 33.33 kg ha^{-1}.

In terms of total potassium (K) uptake in 2019, T_1, which received poultry manure (0.7 t ha^{-1}) along with 100% RDF in the previous season, displayed the highest value of 53.57 kg ha^{-1} while in 2020, T_1 also exhibited the highest K uptake at 58.81 kg ha^{-1}, with the combined data showing a maximum value of 56.19 kg ha^{-1}. The high yield-associated factors can be attributed to a well-balanced supply of nitrogen, phosphorus, and potassium (NPK), coupled with an ample accumulation of nitrogen and organic content facilitated by organic manures where these combinations significantly enhances the primary vegetative growth and various other growth parameters of ricebean in the context of the linseed crop.

The current findings were in accordance with the application of organic nutrient sources to previous crops can have a substantial positive impact on the subsequent crops, and this integrated approach of utilizing both organic and inorganic nutrient sources has the potential to enhance system productivity and contribute to the sustainability of agricultural practices, comparable to the results by Putse *et al*. (2001); Maiksteniene and Arlauskiene (2004); Goulding *et al*. (2008); Gudadhe (2008); Senthivalavan and Ravichandran (2019). This increased nutrient availability appears to have facilitated a higher conversion of carbohydrates into protein. As a result, this enhanced protein synthesis contributed to the growth of protoplasm and cell wall material, leading to larger cell sizes. These changes were evident in the plant's morphology, including increased plant height, a larger leaf area, a greater number of branches, and ultimately, higher dry matter production, as observed in the study by Koireng *et al*. (2018).

4.8 Chemical parameters of soil

4.8.1 Soil pH

The data on pH of soil are depicted in the table 4.24 and illustrated in figure 4.24.

The effect of the treatment on soil pH was determined to be statistically insignificant, which is consistent with the findings reported by Parvathi *et al*. (2013). In the study, they also observed no significant variation in soil pH as a result of applying organic manures. This lack of significance in soil pH can be explained by the release of organic acids during the mineralization of organic manures and these organic acids help maintain the soil's buffering capacity, as explained by Srikanth *et al*. (2000).

4.8.2 Soil EC

The results presented in the table 4.24 regarding the effect of nutrient management on ricebean on soil EC revealed non-significant differences from the residues of the previous crop which was integrated with various sources of organic manures on increasing the soil EC in ricebean crop.

4.8.3 Organic carbon (%)

The data on the residual effect of the treatments on the soil organic carbon are given in the table 4.24 and illustrated in figure 4.24. The treatment had not much effect on the organic carbon of the soil and concluded to be non-significant.

Table 4.24: Effect of nutrient management on soil pH, EC and organic carbon

Treatment	pH			EC (dS m^{-1})			Organic carbon content (%)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	4.79	4.77	4.78	0.260	0.333	0.297	1.55	1.74	1.65
T_2	4.75	4.76	4.76	0.270	0.310	0.290	1.51	1.64	1.58
T_3	4.76	4.84	4.80	0.247	0.340	0.293	1.52	1.62	1.57
T_4	4.70	4.75	4.72	0.214	0.327	0.270	1.52	1.57	1.55
T_5	4.63	4.75	4.69	0.233	0.313	0.273	1.52	1.67	1.60
T_6	4.71	4.73	4.72	0.233	0.317	0.275	1.49	1.61	1.55
T_7	4.67	4.72	4.70	0.267	0.323	0.295	1.60	1.74	1.67
T_8	4.69	4.71	4.70	0.290	0.347	0.318	1.55	1.62	1.58
T_9	4.74	4.73	4.73	0.280	0.333	0.307	1.48	1.63	1.56
SEm ±	0.14	0.24	0.14	0.021	0.022	0.015	0.07	0.06	0.05
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

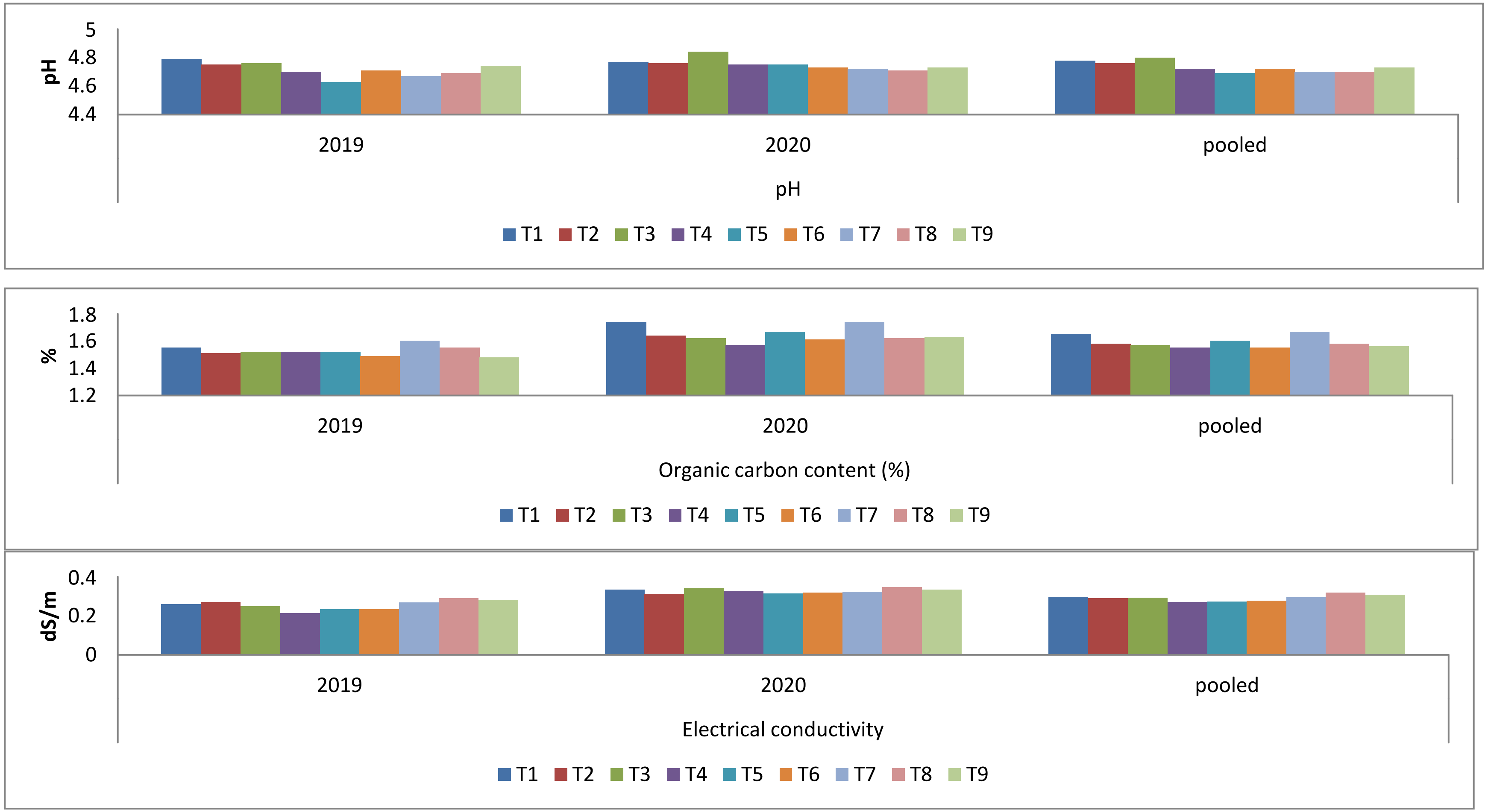


Fig 4.24: Effect of nutrient management on soil pH, EC (dS m^{-1}) and organic matter (%)

4.8.4 Available nitrogen (kg ha^{-1})

The residual impact of nutrient management practices applied to linseed on the available soil nitrogen for the following crop, linseed, was found to be significant where the corresponding data can be found in table 4.25 and visually represented in figure 4.25.

The critical examination of the data suggested that poultry manure @ 0.7 t ha^{-1} with 100 % RDF recorded higher available nitrogen (291.10 kg ha^{-1}) during 2019 which was comparatively higher than FYM and pig manure which were almost at par. In 2020, T_1 recorded significantly highest available phosphorus (289.58 kg ha^{-1}) while similar trend was evident on pooled data with poultry manure (0.7 t ha^{-1}) with 100 % RDF (290.34 kg ha^{-1}) with the maximum value and T_7 (277.99 kg ha^{-1}) and T_8 (278.53 kg ha^{-1}) were statistically at par in pooled data.

The present outcomes align with the research by Putse *et al*. (2001), where the study similarly indicated that substituting 25% of the recommended nitrogen dose from synthetic fertilizers with organic alternatives, as opposed to exclusively relying on 100% chemical fertilizers, not only led to the highest rice yield but also had a substantial positive influence on the grain yield of pulse crops. Furthermore, the sustained benefits of Integrated Nutrient Management (INM) were observed in improved soil physical and chemical characteristics, which, in turn, contributed to an overall enhancement in the overall productivity of the rice-pulse cropping system. The findings are consistent with the results reported in studies by Akande *et al*. (2003), Maiksteniene and Arlauskiene (2004), Goulding *et al*. (2008), and Gudadhe (2008).

4.8.5 Available phosphorus (kg ha^{-1})

The data regarding available soil phosphorus is presented in table 4.25 and depicted in figure 4.25.

In the year 2019, the highest levels of available soil phosphorus, at 38.14 kg ha^{-1}, were observed under treatment T_1, which involved the application of PM (0.7 t ha^{-1}) and 100% RDF (Recommended Dose of Fertilizer). Following T_1, treatment T_4 showed the next highest phosphorus content at 36.72 kg ha^{-1}, while the lowest levels were recorded in T_9, with 32.33.52 kg ha^{-1}.

Similarly in the year 2020, T_1 recorded the highest available soil phosphorus at 38.61 kg ha^{-1}. When considering the pooled data analysis, T_1 consistently exhibited the highest soil phosphorus content, with an average of 38.38 kg ha^{-1}. The current results are comparable with the findings of Puste *et al*. (2001) who came to the conclusion that replacing 25% of the recommended nitrogen dose from chemical fertilizers with an organic source, instead of using 100% chemical fertilizers, not only resulted in the highest rice yield but also had a significant impact on the grain yield of pulses. Additionally, the residual effect of Integrated Nutrient Management (INM) improved the physical and chemical properties of the soil, contributing to an overall increase in the total productivity of the rice-pulse cropping system. The findings align with the results by Akande *et al*. (2003), Maiksteniene and Arlauskiene (2004); Goulding *et al*. (2008) and Gudadhe (2008).

Table 4.25: Effect of nutrient management on available soil nitrogen, phosphorus and potassium

Treatment	Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
T_1	291.10	289.58	290.34	38.14	38.61	38.38	154.02	157.04	155.53
T_2	288.47	286.84	287.66	34.77	36.55	35.66	146.58	151.62	149.10
T_3	279.67	280.79	280.23	33.69	35.22	34.46	141.17	147.97	144.57
T_4	256.04	276.03	266.04	36.72	37.68	37.20	150.12	153.32	151.72
T_5	250.23	272.36	261.30	36.19	36.88	36.54	149.21	149.97	149.59
T_6	252.92	268.52	260.72	34.04	35.46	34.75	140.54	148.62	144.58
T_7	275.84	280.13	277.99	34.64	36.25	35.45	149.87	154.74	152.30
T_8	277.89	279.17	278.53	33.82	35.24	34.53	141.88	149.53	145.70
T_9	271.78	276.33	274.06	32.33	34.30	33.31	138.32	143.13	140.72
SEm ±	8.34	1.22	4.21	0.67	0.82	0.53	2.92	2.50	1.92
CD (P=0.05)	25.00	3.65	12.14	2.01	2.47	1.53	8.76	7.49	5.54

T_1 : GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 100 % RDF; T_2: GM (*Sesbania*) +PM (0.7 t ha^{-1}) + 75 % RDF; T_3: GM (*Sesbania*) + PM (0.7 t ha^{-1}) + 50 % RDF ; T_4: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 100 % RDF; T_5: GM (*Sesbania*) +PGM (0.7 t ha^{-1}) + 75% RDF; T_6: GM (*Sesbania*) + PGM (0.7 t ha^{-1}) + 50 % RDF; T_7: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 100 % RDF; T_8: GM (*Sesbania*) + FYM (4 t ha^{-1}) + 75 % RDF; T_9: GM (*Sesbania*) +FYM (4 t ha^{-1}) + 50 % RDF

Fig 4.25: Effect of nutrient management on available soil nitrogen, phosphorus and potassium (kg ha^{-1})

4.8.6 Available potassium (kg ha^{-1})

A close analysis of the data on available soil potassium data is provided in table 4.25 and fig 4.25 which sowed significant variation with effect of residual effect of integrated nutrient management in soil.

In terms of available soil potassium, the highest levels (154.02 kg ha^{-1}) were observed in treatment T_1, followed by T_4 (150.12 kg ha^{-1}) and T_7 (149.87 kg ha^{-1}). In the year 2020, the most significant increase in available soil potassium was recorded in treatment T_1 (157.04 kg ha^{-1}) when poultry manure was applied.

When looking at the pooled data analysis, it is evident that the highest soil potassium content in linseed plants was achieved when using green manuring (*Sesbania*) + PM (0.7 t ha^{-1}) + 100% RDF as the source of organic manure, with a value of 155.53 kg ha^{-1}, followed by T_7 (152.30 kg ha^{-1}), which was on par with T_4 (151.72 kg ha^{-1}). The findings align with the results by Akande *et al*. (2003), Maiksteniene and Arlauskiene (2004); Goulding *et al*. (2008) and Gudadhe (2008).

4.9 Economics

The economic data for various treatments in the current field study involving linseed are provided in table 4.26 (a), 4.26 (b) and 4.26 (c).

4.9.1 Cost of cultivation (₹ ha^{-1})

As per the data presented in table 4.26, highest cost of cultivation (₹ 42,093.38) was incurred at T_9 with FYM (4 t ha^{-1}) + 50 % RDF (T_4) which was followed by combined application FYM (4 t ha^{-1}) + 100 % RDF (T_7), respectively with an enumerated cost of ₹ 42,093.38, whilst the lowest was T_2 and T_5 which were at par (₹37,129.94). This was maybe due to high cost of farm yard manure as per the requirements for the application of given treatments.

4.9.2 Gross return (₹ ha^{-1})

From the data presented in the table 4.26, in 2019-2020, T_1 (₹95,379.81) exhibited the highest gross return and 2020-2021, a similar trend was observed with ₹98,058.04 in treatment T_1. The high gross return at application of poultry manure along with RDF can be attributed to its resultant high seed yield due to promotory effect of ricebean and succeeding crop on linseed at their vegetative and reproductive growth parameters, where higher seed and stover yields of crops can result into higher values of economic parameters.

4.9.3 Net return (₹ ha^{-1})

The data presented in table 4.26 shows that the highest net return was maximum in treatment T_1, ₹58249.03 in 2019-20 and ₹60,927.26 in 2020-21 were obtained in highest poultry treated plots with 100%RDF.

4.9.4 Benefit : Cost ratio (B:C)

The data in table 4.26 represents that the highest benefit: cost ratio of 1.57 in 2019-20 and 1.64 in 2020-21 has been noted by the application PM (0.7 t ha^{-1}) and 100% RDF.

Table 4.26 (a): Effect of nutrient management on economics of ricebean crop

Treatment	Cost of cultivation (₹ha^{-1})	Gross return (2019)	Gross return (2020)
T_1 : PM (0.7 t ha^{-1}) + 100 % RDF	37130.78	71603.33	74970.18
T_2: PM (0.7 t t ha^{-1}) + 75 % RDF	37129.94	67984.07	74926.85
T_3: PM (0.7 t t ha^{-1}) + 50 % RDF	37143.25	67136.03	73885.85
T_4: PGM (0.7 t ha^{-1}) + 100 % RDF	37130.78	63374.94	66915.02
T_5: PGM (0.7 t ha^{-1}) + 75% RDF	37129.94	62352	66614.57
T_6: PGM (0.7 t ha^{-1}) + 50 % RDF	37143.25	62230.42	66449.04
T_7: FYM (4 t ha^{-1}) + 100 % RDF	42080.78	66541.21	72254.34
T_8: FYM (4 t ha^{-1}) + 75 % RDF	42079.94	65195.41	68241.34
T_9: FYM (4 t ha^{-1}) + 50 % RDF	42093.38	64012.67	67954.87

Table 4.26 (b): Effect of nutrient management on economics of linseed crop

Treatment	Cost of cultivation (₹ha^{-1})	Gross return (2019)	Gross return (2020)
T_1 : PM (0.7 t ha^{-1}) + 100 % RDF	37130.78	32056.43	32347.56
T_2: PM (0.7 t t ha^{-1}) + 75 % RDF	37129.94	29534.13	29220
T_3: PM (0.7 t t ha^{-1}) + 50 % RDF	37143.25	29431.93	28902.43
T_4: PGM (0.7 t ha^{-1}) + 100 % RDF	37130.78	26438.39	26662.78
T_5: PGM (0.7 t ha^{-1}) + 75% RDF	37129.94	25176.56	25200.32
T_6: PGM (0.7 t ha^{-1}) + 50 % RDF	37143.25	24235.28	24674.14
T_7: FYM (4 t ha^{-1}) + 100 % RDF	42080.78	29376.15	29412.09
T_8: FYM (4 t ha^{-1}) + 75 % RDF	42079.94	27713.06	28314.1
T_9: FYM (4 t ha^{-1}) + 50 % RDF	42093.38	27082.88	27031.35

Table 4.26(c): Effect of nutrient management on economics of ricebean-linseed cropping system

Treatment	Total cost of cultivation (₹ha^{-1})		Gross return (₹)		Net return (₹)		B:C ratio	
	2019	2020	2019	2020	2019	2020	2019	2020
T_1 : PM (0.7 t ha^{-1}) + 100 % RDF	37130.78	37130.78	95379.81	98058.04	58249.03	60927.26	1.57	1.64
T_2: PM (0.7 t ha^{-1}) + 75 % RDF	37129.94	37129.94	91419.87	97284.03	54289.93	60154.09	1.46	1.62
T_3: PM (0.7 t ha^{-1}) + 50 % RDF	37143.25	37143.25	90132.36	95788.5	52989.11	58645.25	1.43	1.58
T_4: PGM (0.7 t ha^{-1}) + 100 % RDF	37130.78	37130.78	85164.67	86877.74	48033.89	49746.96	1.29	1.34
T_5: PGM (0.7 t ha^{-1}) + 75% RDF	37129.94	37129.94	81843.89	85871.57	44713.95	48741.63	1.20	1.31
T_6: PGM (0.7 t ha^{-1}) + 50 % RDF	37143.25	37143.25	80897.63	85206.7	43754.38	48063.45	1.18	1.29
T_7: FYM (4 t ha^{-1}) + 100 % RDF	42080.78	42080.78	89719.91	94312.5	47639.13	52231.72	1.13	1.24
T_8: FYM (4 t ha^{-1}) + 75 % RDF	42079.94	42079.94	87851.5	89755.49	45771.56	47675.55	1.09	1.13
T_9: FYM (4 t ha^{-1}) + 50 % RDF	42093.38	42093.38	86580.7	89381.87	44487.32	47288.49	1.06	1.12

Selling price of ricebean: ₹ 60 kg^{-1}

Selling price of linseed: ₹ 45 kg^{-1}

Selling price of stover: ₹ 1 kg^{-}

Plate No. 1: Field view of the standing crop in the experimental field

Plate No. 2: General view of the standing crop in the experimental plot

Plate No. 3: Plant at 35 DAS before and after weeding

Plate No. 4: Ricebean seeds after harvest from experimental plots

Plate No. 5: Tagged plants of ricbean in field

Plate No. 6: Tagged plants of linseed in the field

Plate No. 7: Flowering stage in linseed

Plate No. 8: Pod formation stage in linseed and seeds after harvest

CHAPTER V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

5.1 Summary

A field research project titled "Effect of nutrient management on ricebean [*Vigna umbellata* (Thunb.) Ohwi and Ohashi] – linseed (*Linum usitatissimum* L.) cropping system" was carried out over the period spanning 2019 to 2021. This study sought to explore multiple facets of this cropping system, encompassing aspects such as crop growth, yield characteristics, product quality, and nutrient absorption by plants, soil nutrient levels, and economic implications. The primary objectives of this research endeavor were as follows:

1. To find out the effect of nutrient management on growth, yield and quality of ricebean-linseed cropping system.
2. To assess the effect of nutrient management on nutrient concentration, their uptake and soil fertility status under ricebean-linseed cropping system.
3. To find out the economics of the treatments under study.

The information were gathered during the investigation underwent statistical analysis, both in terms of their scientific relevance and practical applicability. In this chapter, the key findings and significant outcomes of the investigation are summarized and presented for a comprehensive understanding of the research.

Growth parameters

The current experiment took into account several growth parameters to assess plant development, included plant height (cm), number of branches plant^{-1}, number of nodules plant^{-1}, LAI, dry matter (g plant^{-1}), CGR and day to maturity. These growth parameters were examined at various growth stages, specifically at 30 days after sowing (DAS), 60 DAS, 90 DAS, and during the final harvest stage. The results of the investigation indicate that the different sources of organic manures and fertilizers differed in their responses for various growth parameters except the number of nodules plant^{-1} at 30DAS, CGR 60-90, RGR, NAR and days to 50% flowering and maturity.

Among various nutrient management methods during 2019-2021, the application of 0.7 tons per hectare of poultry manure in combination with 100% recommended dose of fertilizer (RDF) resulted in significantly higher values for multiple plant parameters, these results were superior to those observed in plots treated with other poultry manure dosages along with RDF (T_1, T_2 and T_3) produced highest plant height, the number of branches per plant, the number of nodules per plant, Leaf Area Index (LAI), dry matter (g plant^{-1}), crop growth rate (g m^{-2} day^{-1}) in comparison to plots treated with FYM (Farm Yard Manure) and pig manure. The remarkable and exceptional performance observed in all the growth parameters can be attributed to the rich nutrient content and the presence of beneficial micronutrients in poultry manure.

With poultry manure recognized for its ability to boost nodule formation in leguminous plants, it also has the property to enhance soil fertility, stimulates beneficial microbial activity, and promotes the overall well-being and growth of legume plants and as a result, this leads to enhanced nitrogen fixation and ultimately results in improved yields of leguminous crops. These factors promote early root development, which is essential for robust plant growth, ultimately leading to enhanced and vigorous growth in ricebean crop.

The findings also indicated that FYM outperformed pig manure and had a more beneficial influence after poultry manure application. The superiority of FYM over pig manure in crop growth can be attributed to its balanced nutrient composition, microbial activity, organic matter content, and overall positive impact on soil quality, which collectively create a more favorable environment for plant growth and development.

Yield and yield contributing attributes

The yield and yield attributes viz, number of pods plant^{-1}, number of seeds pod^{-1}, pod length (cm), test weight (g), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%) were studied to determine the effect of nutrient management on ricebean. The results indicated that the poultry manure (T_1, application of 0.7 tons per hectare of poultry manure in combination with 100% RDF) was found to produce significantly highest number of pods plant^{-1}, number of seeds pod^{-1}, seed yield (kg ha^{-1}) and stover yield (kg ha^{-1}) than the rest of the treatments.

The use of 0.7 tons per hectare of poultry manure, along with 100% recommended dose of fertilizer (RDF), significantly enhanced crop yield and its contributing factors compared to plots treated with other types of poultry manure, Farm Yard Manure (FYM), and pig manure. One potential explanation for this outstanding performance is that the notable increase in yield could be ascribed to the positive impacts with incorporating green manure residues along with poultry manure. This practice creates a more favourable environment for plant growth and development by improving the availability of essential micronutrients. These micronutrients play a direct role in both crop yield and their concentration within the crop, which, in turn, have stimulated the growth of plant parts and subsequently enhanced the photosynthesis process.

The comprehensive results indicated that the combination of organic manures and fertilizers had a significant impact on the cropping system, affecting the growth, yield, soil microbial activity, and enzyme levels in both ricebean and linseed, with ricebean being the more dominant crop.

Quality parameters

In the case of quality parameters under study, application of 0.7 tons per hectare of poultry manure (T_1) significantly improved the status of the protein yield in ricebean crop while the protein content could not exert significant influence in regards to the effect of nutrient management.

According to the analysis of the data, application of poultry manure caused considerably maximum total nitrogen, phosphorus and potassium uptake and the superiority of poultry manure can be attributed to its status as a valuable organic source of major, secondary, and micronutrients. When poultry manure is applied, it effectively enhances the availability of these micronutrients, which play a crucial role in determining both crop yield and the concentration of nutrients within the crop.

Soil parameters

The responses of various types of nutrient management showed significant differences in improving the overall EC, soil organic carbon, available soil nitrogen, phosphorus and potassium.

Microbial population

The results indicated that the poultry manure (T_1, application of 0.7 tons per hectare of poultry manure in combination with 100% RDF) was found to produce significantly maximum soil microbiological analysis viz. soil actinomycetes (Cfu x $10^5 g^{-1}$), soil bacteria population (Cfu x $10^7 g^{-1}$) and soil fungi population Cfu x $10^4 g^{-1}$) which may be due to the higher microbial population associated with poultry manure application contributes to improved soil health and nutrient cycling, ultimately benefiting agricultural productivity.

Enzyme activity

The outcome demonstrated that the application of poultry manure (T_1, at a rate of 0.7 tons per hectare along with 100% recommended dose of fertilizer or RDF) resulted in significantly maximum levels of enzyme activity including dehydrogenase activity (µg TPF g^{-1} h^{-1}), soil microbial biomass carbon (SMBC) and soil acid phosphatase activity (µg p-nitrophenol g^{-1} soil h^{-1}). The plots that received a combination of poultry manure and RDF exhibited notably higher enzyme activity compared to those treated with FYM and pig manure.

Residual effect of nutrient management on the succeeding crop linseed

In the current experiment, the findings remained consistent across a range of yield and soil parameters when considering the residual effects of nutrient management on the following crop, which in this case was linseed. Specifically, the treatment involving the application of 0.7 tons per hectare of poultry manure (T_1) resulted in significant improvements in yield-related factors such as the number of pods per plant, seed yield (kg ha^{-1}), stover yield (kg ha^{-1}), as well as the total uptake of nitrogen, phosphorus, and potassium (kg ha^{-1}). However, it was noted that the treatments did not significantly affect the number of seeds per pod and the test weight

When looking at the responses of various nutrient management methods in the subsequent crop, there were notable differences, with the application of 0.7 tons per hectare of poultry manure (T_1) standing out as significantly superior in terms of available nitrogen, phosphorus, and potassium levels.

In economic anaylsis of ricebean-linseed production recorded that the application of 0.7 tons per hectare of poultry manure (T_1) increased the overall profitability with B:C ratio of ratio of 1.57 in 2019-20 and 1.64 in 2020-21 and highest net return in treatment in T_1 with ₹58249.03 in 2019-20 and ₹60,927.26 in 2020-21 .

5.2 Conclusion

Among the various organic and inorganic nutrient sources tested, the combination of poultry manure (0.7 tons per hectare) along with 100% recommended dose of fertilizer (RDF) emerged as the most effective treatment.

This particular treatment yielded the highest measurements for plant height, number of branches, nodules, dry matter production, and seed yield and stover yield. Furthermore, it demonstrated superiority by promoting an increase in the population of actinomycetes, bacteria, fungi, and enhancing other soil enzyme activities. This exceptional performance is likely attributed to the synergistic effects of combining organic manure with fertilizers.

In terms of the residual impact of nutrient management on the subsequent linseed crop, the most favourable yield-related and soil-related parameters were predominantly observed in plots treated with 100% RDF in combination with poultry manure (0.7 tons per hectare).

Simultaneously in economics, 100% RDF + PM @ 0.7 t ha^{-1} recorded highest gross return (₹95,379.81in 2019-2020 and ₹98,058.04 with 2020-2021), net return (₹ ₹ 58,249.03 in 2019-20 and ₹60,927.26 in 2020-21) and B:C ratio (1.57 ; 1.64) respectively.

5.3 Future line of research

From the findings of the following study, by pursuing these suggested research directions, we can acquire valuable insights into optimizing nutrient management practices in the ricebean-linseed cropping system, ultimately leading to improved crop quality and sustainability. This future research could explore various aspects such as:

1. **Micronutrient Analysis:** Examining the influence of micronutrients on crop performance and soil health within this specific cropping system.
2. **Analysis of Microbial Interactions:** To study the in-depth analysis of the interactions between soil microorganisms, organic amendments, and synthetic fertilizers to better understand their combined effects on nutrient availability and crop performance, thereby affecting their absorption by the ricebean plant.

3. **Crop Rotation Strategies:** Explore the potential benefits of different crop rotation patterns and how they affect nutrient cycling and soil fertility in the long term.
4. **Nutrient Synchronization:** Investigate the timing of nutrient application to optimize nutrient uptake by both ricebean and linseed, considering their specific nutrient requirements at different growth stages.

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APPENDICES

APPENDICES

ANOVA- 1: Analysis of variance as influenced by effect of nutrient management on plant height (cm) at 30DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	28.87	14.43	1.75	3.63	NS
Treatment	8	233.13	29.14	3.54	2.59	S
Error	16	131.85	8.24			
Total	26	393.85				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	60.35	30.18	1.83	3.63	NS
Treatment	8	526.16	65.77	3.98	2.59	S
Error	16	264.48	16.53			
Total	26	851.00				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	168.96	168.96	13.64	4.15	Si
Replication	4	89.22	22.30	1.80	2.67	NS
Treatment	8	710.79	88.85	7.17	2.24	S
Years x Treatment	8	48.50	6.06	0.49	2.24	NS
Error	32	396.33	12.39			
Total	53	1413.81				

ANOVA- 2: Analysis of variance as influenced by effect of nutrient management on plant height (cm) at 60DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	151.10	75.55	2.32	3.63	NS
Treatment	8	1014.23	126.78	3.89	2.59	S
Error	16	521.98	32.62			
Total	26	1687.32				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	24.44	12.22	0.53	3.63	NS
Treatment	8	948.49	118.56	5.16	2.59	S
Error	16	367.56	22.97			
Total	26	1340.49				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	477.87	477.87	17.19	4.15	S
Replication	4	175.55	43.89	1.58	2.67	NS
Treatment	8	1922.94	240.37	8.65	2.24	S
Years x Treatment	8	39.79	4.97	0.18	2.24	NS
Error	32	889.54	27.80			
Total	53	3505.69				

ANOVA-3: Analysis of variance as influenced by effect of nutrient management on plant height (cm) at 90DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	45.42	22.71	0.81	3.63	NS
Treatment	8	689.31	86.16	3.06	2.59	S
Error	16	450.31	28.14			
Total	26	1185.04				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	106.35	53.17	0.61	3.63	NS
Treatment	8	2720.11	340.01	3.91	2.59	S
Error	16	1391.75	86.98			
Total	26	4218.21				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	682.35	682.35	11.85	4.15	S
Replication	4	151.77	37.94	0.66	2.67	NS
Treatment	8	3031.42	378.93	6.58	2.24	S
Years x Treatment	8	377.99	47.25	0.82	2.24	NS
Error	32	1842.06	57.56			
Total	53	6085.60				

ANOVA-4: Analysis of variance as influenced by effect of nutrient management on plant height (cm) at harvest

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	1000.12	500.06	1.67	3.63	NS
Treatment	8	7228.04	903.51	3.01	2.59	S
Error	16	4795.81	299.74			
Total	26	13023.98				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	343.56	171.78	0.41	3.63	NS
Treatment	8	8913.19	1114.15	2.64	2.59	S
Error	16	6743.44	421.46			
Total	26	16000.18				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	318.43	318.43	0.88	4.15	NS
Replication	4	1343.68	335.92	0.93	2.67	NS
Treatment	8	15782.41	1972.80	5.47	2.24	S
Years x Treatment	8	358.83	44.85	0.12	2.24	NS
Error	32	11539.25	360.60			
Total	53	29342.59				

ANOVA-5: Analysis of variance as influenced by effect of nutrient management on number of branches at 30 DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	1.51	0.76	3.43	3.63	NS
Treatment	8	4.75	0.59	2.69	2.59	S
Error	16	3.53	0.22			
Total	26	9.79				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.15	0.07	1.52	3.63	NS
Treatment	8	1.96	0.25	5.02	2.59	S
Error	16	0.78	0.05			
Total	26	2.89				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	1.63	1.63	12.07	4.15	S
Replication	4	1.66	0.42	3.08	2.67	S
Treatment	8	5.95	0.74	5.52	2.24	S
Years x Treatment	8	0.76	0.09	0.70	2.24	NS
Error	32	4.31	0.13			
Total	53	14.31				

ANOVA-6: Analysis of variance as influenced by effect of nutrient management on number of branches at 60DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.23	0.11	1.02	3.63	NS
Treatment	8	4.20	0.53	4.73	2.59	S
Error	16	1.78	0.11			
Total	26	6.21				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.16	0.08	0.41	3.63	NS
Treatment	8	4.30	0.54	2.76	2.59	S
Error	16	3.12	0.19			
Total	26	7.57				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.44	0.44	2.86	4.15	NS
Replication	4	0.39	0.10	0.63	2.67	NS
Treatment	8	8.43	1.05	6.89	2.24	S
Years x Treatment	8	0.07	0.01	0.06	2.24	NS
Error	32	4.89	0.15			
Total	53	14.22				

ANOVA-7: Analysis of variance as influenced by effect of nutrient management on number of branches at 90DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.62	0.31	2.11	3.63	NS
Treatment	8	4.71	0.59	3.98	2.59	S
Error	16	2.36	0.15			
Total	26	7.70				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.27	0.13	0.82	3.63	NS
Treatment	8	4.97	0.62	3.83	2.59	S
Error	16	2.59	0.16			
Total	26	7.84				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.45	0.45	2.90	4.15	NS
Replication	4	0.89	0.22	1.44	2.67	NS
Treatment	8	9.48	1.18	7.64	2.24	S
Years x Treatment	8	0.20	0.03	0.16	2.24	NS
Error	32	4.96	0.15			
Total	53	15.98				

ANOVA-8: Analysis of variance as influenced by effect of nutrient management on number of nodules at 30DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	1.62	0.81	1.22	3.63	NS
Treatment	8	2.89	0.36	0.54	2.59	NS
Error	16	10.62	0.66			
Total	26	15.13				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.42	0.21	0.24	3.63	NS
Treatment	8	6.36	0.79	0.89	2.59	NS
Error	16	14.31	0.89			
Total	26	21.09				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	3.69	3.69	4.74	4.15	S
Replication	4	2.05	0.51	0.66	2.67	NS
Treatment	8	8.64	1.08	1.39	2.24	NS
Years x Treatment	8	0.60	0.08	0.10	2.24	NS
Error	32	24.93	0.78			
Total	53	39.92				

ANOVA-9: Analysis of variance as influenced by effect of nutrient management on number of nodules at 50DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	8.54	4.27	2.13	3.63	NS
Treatment	8	97.92	12.24	6.11	2.59	S
Error	16	32.05	2.00			
Total	26	138.52				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	108.51	54.25	2.96	3.63	NS
Treatment	8	382.64	47.83	2.61	2.59	S
Error	16	293.41	18.34			
Total	26	784.56				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	158.65	158.65	15.60	4.15	S
Replication	4	117.05	29.26	2.88	2.67	S
Treatment	8	427.26	53.41	5.25	2.24	S
Years x Treatment	8	53.31	6.66	0.66	2.24	NS
Error	32	325.46	10.17			
Total	53	1081.73				

ANOVA-10: Analysis of variance as influenced by effect of nutrient management on number of nodules at 70DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	13.34	6.67	1.05	3.63	NS
Treatment	8	217.28	27.16	4.28	2.59	S
Error	16	101.52	6.34			
Total	26	332.14				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	2.91	1.46	0.21	3.63	NS
Treatment	8	147.82	18.48	2.62	2.59	S
Error	16	112.99	7.06			
Total	26	263.72				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	71.42	71.42	10.65	4.15	S
Replication	4	16.25	4.06	0.61	2.67	NS
Treatment	8	354.93	44.37	6.62	2.24	S
Years x Treatment	8	10.17	1.27	0.19	2.24	NS
Error	32	214.51	6.70			
Total	53	667.27				

ANOVA-11: Analysis of variance as influenced by effect of nutrient management on LAI at 30DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.0001	0.0001	1.296	3.634	NS
Treatment	8	0.021	0.0027	47.023	2.591	S
Error	16	0.0009	0.0001			
Total	26	0.022				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.0004	0.0002	3.548	3.634	NS
Treatment	8	0.0191	0.0024	43.915	2.591	S
Error	16	0.0009	0.0001			
Total	26	0.0203				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.0003	0.0003	4.94	4.14	S
Replication	4	0.0005	0.0001	2.39	2.66	NS
Treatment	8	0.0401	0.0050	90.52	2.24	S
Years x Treatment	8	0.0002	0.0000	0.47	2.24	NS
Error	32	0.0018	0.0001			
Total	53	0.0429				

ANOVA-12: Analysis of variance as influenced by effect of nutrient management on LAI at 60DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.00001	0.00001	0.23	3.63	NS
Treatment	8	0.0085	0.0010	44.81	2.59	S
Error	16	0.00038	0.00002			
Total	26	0.0089				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.00025	0.00012	1.52	3.63	NS
Treatment	8	0.0068	0.00086	10.59	2.59	S
Error	16	0.0012	0.00008			
Total	26	0.0083				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.00009	0.00009	1.78	4.14	NS
Replication	4	0.00026	0.00006	1.23	2.66	NS
Treatment	8	0.015	0.00189	36.14	2.24	S
Years x Treatment	8	0.00024	0.00003	0.58	2.24	NS
Error	32	0.0016	0.00005			
Total	53	0.017				

ANOVA-13: Analysis of variance as influenced by effect of nutrient management on LAI at 90DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.000045	0.000022	1.14	3.63	NS
Treatment	8	0.0036	0.00045	23.34	2.59	S
Error	16	0.00031	0.000019			
Total	26	0.0039				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.0001	0.0001	0.43	3.63	NS
Treatment	8	0.0063	0.0008	5.58	2.59	S
Error	16	0.0023	0.0001			
Total	26	0.0087				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.000001	0.000001	0.01	4.15	NS
Replication	4	0.00016	0.000042	0.52	2.67	NS
Treatment	8	0.0096	0.0012	15.02	2.24	S
Years x Treatment	8	0.00028	0.000036	0.44	2.24	NS
Error	32	0.0025	0.000080			
Total	53	0.012				

ANOVA-14: Analysis of variance as influenced by effect of nutrient management on dry matter at 30DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.00	0.00	0.00	3.63	NS
Treatment	8	2.21	0.28	2.66	2.59	S
Error	16	1.66	0.10			
Total	26	3.86				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.13	0.07	0.73	3.63	NS
Treatment	8	2.24	0.28	3.09	2.59	S
Error	16	1.46	0.09			
Total	26	3.83				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.99	0.99	10.18	4.15	S
Replication	4	0.13	0.03	0.34	2.67	NS
Treatment	8	4.36	0.54	5.60	2.24	S
Years x Treatment	8	0.09	0.01	0.12	2.24	NS
Error	32	3.11	0.10			
Total	53	8.68				

ANOVA-15: Analysis of variance as influenced by effect of nutrient management on dry matter at 60DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	13.58	6.79	1.81	3.63	NS
Treatment	8	182.40	22.80	6.08	2.59	S
Error	16	60.04	3.75			
Total	26	256.02				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	88.36	44.18	2.61	3.63	NS
Treatment	8	377.02	47.13	2.79	2.59	S
Error	16	270.35	16.90			
Total	26	735.73				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	87.07	87.07	8.43	4.15	S
Replication	4	101.94	25.49	2.47	2.67	NS
Treatment	8	526.08	65.76	6.37	2.24	S
Years x Treatment	8	33.34	4.17	0.40	2.24	NS
Error	32	330.39	10.32			
Total	53	1078.82				

ANOVA-16: Analysis of variance as influenced by effect of nutrient management on dry matter at 90DAS

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	32.24	16.12	1.82	3.63	NS
Treatment	8	392.04	49.01	5.52	2.59	S
Error	16	142.00	8.88			
Total	26	566.28				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	54.37	27.18	3.08	3.63	NS
Treatment	8	207.62	25.95	2.94	2.59	S
Error	16	141.39	8.84			
Total	26	403.38				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	102.66	102.66	11.59	4.15	S
Replication	4	86.61	21.65	2.44	2.67	NS
Treatment	8	572.84	71.60	8.09	2.24	S
Years x Treatment	8	26.82	3.35	0.38	2.24	NS
Error	32	283.39	8.86			
Total	53	1072.32				

ANOVA-17: Analysis of variance as influenced by effect of nutrient management on dry matter at harvest

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	382.72	191.36	2.25	3.63	NS
Treatment	8	2032.11	254.01	2.98	2.59	S
Error	16	1362.26	85.14			
Total	26	3777.08				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	50.38	25.19	0.76	3.63	NS
Treatment	8	1068.13	133.52	4.05	2.59	S
Error	16	527.17	32.95			
Total	26	1645.68				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	677.73	677.73	11.48	4.15	S
Replication	4	433.11	108.28	1.83	2.67	NS
Treatment	8	2922.09	365.26	6.19	2.24	S
Years x Treatment	8	178.15	22.27	0.38	2.24	NS
Error	32	1889.43	59.04			
Total	53	6100.50				

ANOVA-18: Analysis of variance as influenced by effect of nutrient management CGR 30-60

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.50	0.25	2.75	3.63	NS
Treatment	8	8.61	1.08	11.73	2.59	S
Error	16	1.47	0.09			
Total	26	10.58				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	2.88	1.44	2.86	3.63	NS
Treatment	8	10.60	1.32	2.63	2.59	S
Error	16	8.05	0.50			
Total	26	21.52				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	2.98	2.98	10.02	4.15	S
Replication	4	3.38	0.85	2.84	2.67	S
Treatment	8	18.28	2.29	7.68	2.24	S
Years x Treatment	8	0.92	0.12	0.39	2.24	NS
Error	32	9.52	0.30			
Total	53	35.09				

ANOVA-19: Analysis of variance as influenced by effect of nutrient management CGR 60-90

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.64	0.32	2.46	3.63	NS
Treatment	8	2.41	0.30	2.32	2.59	NS
Error	16	2.08	0.13			
Total	26	5.12				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.26	0.13	0.47	3.63	NS
Treatment	8	2.29	0.29	1.06	2.59	NS
Error	16	4.33	0.27			
Total	26	6.87				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	4.04	4.04	20.18	4.15	S
Replication	4	0.90	0.22	1.12	2.67	NS
Treatment	8	4.18	0.52	2.61	2.24	S
Years x Treatment	8	0.52	0.07	0.33	2.24	NS
Error	32	6.40	0.20			
Total	53	16.04				

ANOVA-20: Analysis of variance as influenced by effect of nutrient management RGR 30-90

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.000022	0.000011	0.780	3.63	NS
Treatment	8	0.00025	0.000031	2.26	2.59	NS
Error	1	0.00022	0.000014			
Total	26	0.00050				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.00013	0.000070	1.82	3.63	NS
Treatment	8	0.00060	0.000076	1.98	2.59	NS
Error	16	0.00060	0.000038			
Total	26	0.0013				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.000030	0.000030	1.15	4.14	NS
Replication	4	0.000161	0.000040	1.54	2.66	NS
Treatment	8	0.000781	0.000098	3.74	2.24	S
Years x Treatment	8	0.000079	0.000010	0.380	2.24	NS
Error	32	0.000834	0.000026			
Total	53	0.001886				

ANOVA-21: Analysis of variance as influenced by effect of nutrient management RGR 60-90

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.00003	0.00002	1.50642	3.63372	NS
Treatment	8	0.00020	0.00003	2.50382	2.59110	NS
Error	16	0.00016	0.00001			
Total	26	0.00039				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.00021	0.00011	1.79510	3.63372	NS
Treatment	8	0.00046	0.00006	0.96658	2.59110	NS
Error	16	0.00095	0.00006			
Total	26	0.00163				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.0000002	0.0000002	0.006	4.14	NS
Replication	4	0.00024	0.000061	1.75	2.66	NS
Treatment	8	0.00044	0.000055	1.58	2.24	NS
Years x Treatment	8	0.00021	0.000027	0.78	2.24	NS
Error	32	0.0011	0.000034			
Total	53	0.002				

ANOVA-22: Analysis of variance as influenced by effect of nutrient management NAR 30-60

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	5898.97	2949.48	2.25	3.63	NS
Treatment	8	24200.98	3025.12	2.30	2.59	NS
Error	16	21001.99	1312.62			
Total	26	51101.94				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	10743.39	5371.70	1.72	3.63	NS
Treatment	8	23260.57	2907.57	0.93	2.59	NS
Error	16	49875.80	3117.24			
Total	26	83879.77				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	4492.09	4492.09	2.03	4.15	NS
Replication	4	16642.36	4160.59	1.88	2.67	NS
Treatment	8	41417.36	5177.17	2.34	2.24	S
Years x Treatment	8	6044.19	755.52	0.34	2.24	NS
Error	32	70877.79	2214.93			
Total	53	#######				

ANOVA-23: Analysis of variance as influenced by effect of nutrient management NAR 60-90

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	9485.51	4742.75	1.700	3.634	NS
Treatment	8	3155.35	394.41	0.141	2.591	NS
Error	16	#######	2790.09			
Total	26	#######				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	5079.11	2539.55	1.35	3.63	NS
Treatment	8	5016.40	627.05	0.33	2.59	NS
Error	16	#######	1879.25			
Total	26	#######				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	494.93	494.93	0.21	4.14	NS
Replication	4	#######	#######	1.55	2.66	NS
Treatment	8	#######	993.54	0.42	2.24	NS
Years x Treatment	8	223.07	27.88	0.01	2.24	NS
Error	32	#######	#######			
Total	53	#######				

ANOVA-24: Analysis of variance as influenced by effect of nutrient management on 50 % flowering

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	133.18	66.59	1.43	3.63	**NS**
Treatment	8	83.62	10.45	0.22	2.59	**NS**
Error	16	746.57	46.66			
Total	26	963.36				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	48.42	24.21	1.04	3.63	NS
Treatment	8	104.73	13.09	0.56	2.59	NS
Error	16	371.66	23.23			
Total	26	524.81				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	59.19	59.19	1.69	4.15	NS
Replication	4	181.60	45.40	1.30	2.67	NS
Treatment	8	164.96	20.62	0.59	2.24	NS
Years x Treatment	8	23.38	2.92	0.08	2.24	NS
Error	32	1118.23	34.94			
Total	53	1547.36				

ANOVA-25: Analysis of variance as influenced by effect of nutrient management on 100% maturity

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	80.72	40.36	1.82	3.63	NS
Treatment	8	489.84	61.23	2.76	2.59	S
Error	16	355.05	22.19			
Total	26	925.61				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	26.82	13.41	0.52	3.63	NS
Treatment	8	712.03	89.00	3.42	2.59	S
Error	16	416.58	26.04			
Total	26	1155.44				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	267.70	267.70	11.10	4.15	S
Replication	4	107.54	26.88	1.11	2.67	NS
Treatment	8	987.40	123.43	5.12	2.24	S
Years x Treatment	8	214.47	26.81	1.11	2.24	NS
Error	32	771.63	24.11			
Total	53	2348.75				

ANOVA-27: Analysis of variance as influenced by effect of nutrient management on pods plant^{-1}

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	3.37	1.68	0.58	3.63	NS
Treatment	8	60.85	7.61	2.60	2.59	S
Error	16	46.79	2.92			
Total	26	111.00				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	7.44	3.72	2.72	3.63	NS
Treatment	8	43.87	5.48	4.02	2.59	S
Error	16	21.84	1.37			
Total	26	73.15				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	88.86	88.86	41.43	4.15	S
Replication	4	10.80	2.70	1.26	2.67	NS
Treatment	8	102.65	12.83	5.98	2.24	S
Years x Treatment	8	2.08	0.26	0.12	2.24	NS
Error	32	68.63	2.14			
Total	53	273.01				

ANOVA-28: Analysis of variance as influenced by effect of nutrient management on seeds pod^{-1}

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	1.04	0.52	2.48	3.63	NS
Treatment	8	7.34	0.92	4.37	2.59	S
Error	16	3.36	0.21			
Total	26	11.74				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.67	0.33	0.52	3.63	NS
Treatment	8	15.16	1.89	2.96	2.59	S
Error	16	10.24	0.64			
Total	26	26.07				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	2.66	2.66	6.26	4.15	S
Replication	4	1.71	0.43	1.01	2.67	NS
Treatment	8	21.24	2.66	6.25	2.24	S
Years x Treatment	8	1.26	0.16	0.37	2.24	NS
Error	32	13.60	0.43			
Total	53	40.47				

ANOVA-29: Analysis of variance as influenced by effect of nutrient management on pod length

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.24	0.12	0.51	3.63	NS
Treatment	8	5.09	0.64	2.73	2.59	S
Error	16	3.73	0.23			
Total	26	9.06				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.66	0.33	0.93	3.63	NS
Treatment	8	7.73	0.97	2.70	2.59	S
Error	16	5.72	0.36			
Total	26	14.11				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	2.71	2.71	9.19	4.15	S
Replication	4	0.90	0.23	0.76	2.67	NS
Treatment	8	12.22	1.53	5.18	2.24	S
Years x Treatment	8	0.61	0.08	0.26	2.24	NS
Error	32	9.44	0.30			
Total	53	25.88				

ANOVA-30: Analysis of variance as influenced by effect of nutrient management on test weight (g)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.11	0.06	0.81	3.63	NS
Treatment	8	0.71	0.09	1.25	2.59	NS
Error	16	1.13	0.07			
Total	26	1.95				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.37	0.18	3.62	3.63	NS
Treatment	8	0.43	0.05	1.05	2.59	NS
Error	16	0.81	0.05			
Total	26	1.60				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.01	0.01	0.12	4.15	NS
Replication	4	0.48	0.12	1.98	2.67	NS
Treatment	8	0.74	0.09	1.52	2.24	NS
Years x Treatment	8	0.39	0.05	0.81	2.24	NS
Error	32	1.94	0.06			
Total	53	3.56				

ANOVA-31: Analysis of variance as influenced by effect of nutrient management on seed yield (kg ha^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	731.06	365.53	0.15	3.63	NS
Treatment	8	61474.27	7684.28	3.10	2.59	S
Error	16	39635.42	2477.21			
Total	26	#######				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	227.13	113.57	0.03	3.63	NS
Treatment	8	88770.30	11096.29	2.66	2.59	S
Error	16	66675.53	4167.22			
Total	26	#######				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	79238.87	79238.87	23.85	4.15	S
Replication	4	958.19	239.55	0.07	2.67	NS
Treatment	8	#######	17862.04	5.38	2.24	S
Years x Treatment	8	7348.28	918.53	0.28	2.24	NS
Error	32	#######	3322.22			
Total	53	#######				

ANOVA-32: Analysis of variance as influenced by effect of nutrient management on stover yield (kg ha^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	25144.16	12572.08	0.97	3.63	NS
Treatment	8	#######	34273.95	2.64	2.59	S
Error	16	#######	12975.37			
Total	26	#######				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	15605.08	7802.54	1.42	3.63	NS
Treatment	8	#######	15060.15	2.75	2.59	S
Error	16	87735.77	5483.49			
Total	26	#######				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	#######	#######	18.46	4.15	S
Replication	4	40749.24	10187.31	1.10	2.67	NS
Treatment	8	#######	43042.26	4.66	2.24	S
Years x Treatment	8	50334.74	6291.84	0.68	2.24	NS
Error	32	#######	9229.43			
Total	53	#######				

ANOVA-33: Analysis of variance as influenced by effect of nutrient management on HI (%)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	6.01	3.00	0.93	3.63	NS
Treatment	8	158.92	19.86	6.18	2.59	S
Error	16	51.41	3.21			
Total	26	216.34				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.76	0.38	0.08	3.63	NS
Treatment	8	126.29	15.79	3.47	2.59	S
Error	16	72.89	4.56			
Total	26	199.95				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	26.67	26.67	6.87	4.15	**S**
Replication	4	6.77	1.69	0.44	2.67	**NS**
Treatment	8	281.06	35.13	9.04	2.24	**S**
Years x Treatment	8	4.15	0.52	0.13	2.24	**NS**
Error	32	124.30	3.88			
Total	53	442.95				

ANOVA-34: Analysis of variance as influenced by effect of nutrient management on protein content (%)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	-12357.20	-6178.60	-7.93	3.63	NS
Treatment	8	163.67	20.46	0.03	2.59	NS
Error	16	12469.84	779.36			
Total	26	276.30				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	4.47	2.24	0.21	3.63	NS
Treatment	8	120.43	15.05	1.44	2.59	NS
Error	16	167.03	10.44			
Total	26	291.93				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	78.23	78.23	0.20	4.15	NS
Replication	4	-12352.73	-3088.18	-7.82	2.67	NS
Treatment	8	244.19	30.52	0.08	2.24	NS
Years x Treatment	8	39.90	4.99	0.01	2.24	NS
Error	32	12636.87	394.90			
Total	53	646.47				

ANOVA-35: Analysis of variance as influenced by effect of nutrient management on protein yield (kg ha^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	1283.27	641.64	1.00	3.63	NS
Treatment	8	16788.18	2098.52	3.28	2.59	S
Error	16	10234.03	639.63			
Total	26	28305.48				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	1565.15	782.57	2.07	3.63	NS
Treatment	8	23609.63	2951.20	7.80	2.59	S
Error	16	6053.25	378.33			
Total	26	31228.03				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	25592.89	25592.89	50.28	4.15	S
Replication	4	2848.42	712.10	1.40	2.67	NS
Treatment	8	38199.64	4774.96	9.38	2.24	S
Years x Treatment	8	2198.17	274.77	0.54	2.24	NS
Error	32	16287.27	508.98			
Total	53	85126.39				

ANOVA-36: Analysis of variance as influenced by effect of nutrient management on N content in seed (%)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.02	0.01	0.65	3.63	NS
Treatment	8	0.38	0.05	4.09	2.59	S
Error	16	0.18	0.01			
Total	26	0.58				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.30	0.15	3.46	3.63	NS
Treatment	8	1.29	0.16	3.71	2.59	S
Error	16	0.70	0.04			
Total	26	2.29				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.08	0.08	2.82	4.15	NS
Replication	4	0.32	0.08	2.87	2.67	S
Treatment	8	1.52	0.19	6.91	2.24	S
Years x Treatment	8	0.15	0.02	0.67	2.24	NS
Error	32	0.88	0.03			
Total	53	2.95				

ANOVA-37: Analysis of variance as influenced by effect of nutrient management on N% content in stover (%)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.03	0.01	1.08	3.63	NS
Treatment	8	0.18	0.02	1.70	2.59	NS
Error	16	0.22	0.01			
Total	26	0.43				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.00	0.00	0.03	3.63	NS
Treatment	8	0.16	0.02	0.63	2.59	NS
Error	16	0.52	0.03			
Total	26	0.69				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.46	0.46	20.03	4.15	S
Replication	4	0.03	0.01	0.34	2.67	NS
Treatment	8	0.33	0.04	1.80	2.24	NS
Years x Treatment	8	0.02	0.00	0.09	2.24	NS
Error	32	0.74	0.02			
Total	53	1.58				

ANOVA-38: Analysis of variance as influenced by effect of nutrient management on total N uptake (kg ha^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	34.80	17.40	1.72	3.63	NS
Treatment	8	1063.47	132.93	13.11	2.59	S
Error	16	162.26	10.14			
Total	26	1260.54				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	64.11	32.05	1.71	3.63	NS
Treatment	8	1423.41	177.93	9.50	2.59	S
Error	16	299.62	18.73			
Total	26	1787.14				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	1184.74	1184.74	82.08	4.15	S
Replication	4	98.91	24.73	1.71	2.67	NS
Treatment	8	2449.23	306.15	21.21	2.24	S
Years x Treatment	8	37.65	4.71	0.33	2.24	NS
Error	32	461.88	14.43			
Total	53	4232.42				

ANOVA-39: Analysis of variance as influenced by effect of nutrient management on P content in seed (%)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.0004	0.0002	0.07	3.63	NS
Treatment	8	0.085	0.0107	4.03	2.59	S
Error	16	0.042	0.0027			
Total	26	0.13				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.007	0.003	1.11	3.63	NS
Treatment	8	0.063	0.008	2.66	2.59	S
Error	16	0.048	0.003			
Total	26	0.12				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.015	0.015	5.32	4.15	S
Replication	4	0.007	0.002	0.61	2.67	NS
Treatment	8	0.125	0.016	5.56	2.24	S
Years x Treatment	8	0.023	0.003	1.03	2.24	NS
Error	32	0.090	0.003			
Total	53	0.26				

ANOVA-40: Analysis of variance as influenced by effect of nutrient management on P content in stover (%)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.003	0.001	1.52	3.63	NS
Treatment	8	0.023	0.003	2.97	2.59	S
Error	16	0.015	0.001			
Total	26	0.041				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.03	0.01	2.27	3.63	NS
Treatment	8	0.14	0.02	2.78	2.59	S
Error	16	0.10	0.01			
Total	26	0.27				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.02	0.016	4.29	4.15	S
Replication	4	0.03	0.008	2.17	2.67	NS
Treatment	8	0.13	0.017	4.57	2.24	S
Years x Treatment	8	0.03	0.004	1.04	2.24	NS
Error	32	0.12	0.004			
Total	53	0.33				

ANOVA-41: Analysis of variance as influenced by effect of nutrient management on total P uptake (kg ha^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.13	0.06	0.10	3.63	NS
Treatment	8	58.11	7.26	11.42	2.59	S
Error	16	10.18	0.64			
Total	26	68.41				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	8.75	4.38	1.43	3.63	NS
Treatment	8	128.89	16.11	5.28	2.59	S
Error	16	48.81	3.05			
Total	26	186.45				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	40.32	40.32	21.87	4.15	S
Replication	4	8.88	2.22	1.20	2.67	NS
Treatment	8	171.66	21.46	11.64	2.24	S
Years x Treatment	8	15.34	1.92	1.04	2.24	NS
Error	32	58.99	1.84			
Total	53	295.18				

ANOVA-42: Analysis of variance as influenced by effect of nutrient management on K content in seed (%)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.02	0.01	1.48	3.63	NS
Treatment	8	0.15	0.02	2.75	2.59	S
Error	16	0.11	0.01			
Total	26	0.29				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.02	0.01	1.52	3.63	NS
Treatment	8	0.13	0.02	2.87	2.59	S
Error	16	0.09	0.01			
Total	26	0.23				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.142	0.142	22.632	4.15	S
Replication	4	0.038	0.009	1.498	2.67	NS
Treatment	8	0.269	0.034	5.353	2.24	S
Years x Treatment	8	0.013	0.002	0.257	2.24	NS
Error	32	0.201	0.006			
Total	53	0.66				

ANOVA-43: Analysis of variance as influenced by effect of nutrient management on K content in stover (%)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.02	0.01	0.74	3.63	NS
Treatment	8	0.46	0.06	3.72	2.59	S
Error	16	0.25	0.02			
Total	26	0.73				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.007	0.003	0.83	3.63	NS
Treatment	8	0.125	0.016	3.87	2.59	S
Error	16	0.065	0.004			
Total	26	0.196				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.43	0.43	44.08	4.15	S
Replication	4	0.03	0.01	0.76	2.67	NS
Treatment	8	0.52	0.07	6.64	2.24	S
Years x Treatment	8	0.07	0.01	0.86	2.24	NS
Error	32	0.31	0.01			
Total	53	1.36				

ANOVA-44: Analysis of variance as influenced by effect of nutrient management on total K uptake (kg ha^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	33.05	16.52	1.41	3.63	NS
Treatment	8	563.76	70.47	5.99	2.59	S
Error	16	188.08	11.75			
Total	26	784.89				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	12.88	6.44	0.52	3.63	NS
Treatment	8	263.53	32.94	2.68	2.59	S
Error	16	196.96	12.31			
Total	26	473.36				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	707.48	707.48	58.80	4.15	S
Replication	4	45.92	11.48	0.95	2.67	NS
Treatment	8	782.84	97.85	8.13	2.24	S
Years x Treatment	8	44.46	5.56	0.46	2.24	NS
Error	32	385.04	12.03			
Total	53	1965.73				

ANOVA-45: Analysis of variance as influenced by effect of nutrient management on soil pH

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.18	0.09	1.95	3.63	NS
Treatment	8	0.08	0.01	0.22	2.59	NS
Error	16	0.74	0.05			
Total	26	0.99				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.068	0.034	3.10	3.63	NS
Treatment	8	0.017	0.002	0.19	2.59	NS
Error	16	0.175	0.011			
Total	26	0.26				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.005	0.005	0.19	4.15	NS
Replication	4	0.247	0.062	2.17	2.67	NS
Treatment	8	0.065	0.008	0.28	2.24	NS
Years x Treatment	8	0.031	0.004	0.14	2.24	NS
Error	32	0.911	0.028			
Total	53	1.26				

ANOVA-46: Analysis of variance as influenced by effect of nutrient management on soil EC

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.0002	0.0001	0.19	3.63	NS
Treatment	8	0.0303	0.0038	7.85	2.59	S
Error	16	0.0077	0.0005			
Total	26	0.0383				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.003	0.002	1.27	3.63	NS
Treatment	8	0.026	0.003	2.59	2.59	S
Error	16	0.020	0.001			
Total	26	0.049				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.028	0.028	33.44	4.15	S
Replication	4	0.0033	0.0008	0.96	2.67	NS
Treatment	8	0.055	0.0069	8.02	2.24	S
Years x Treatment	8	0.0008	0.0001	0.12	2.24	NS
Error	32	0.027	0.0009			
Total	53	0.12				

ANOVA-47: Analysis of variance as influenced by effect of nutrient management on soil organic carbon (%)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.04	0.02	3.03	3.63	NS
Treatment	8	0.16	0.02	2.75	2.59	S
Error	16	0.12	0.01			
Total	26	0.32				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.01	0.01	0.27	3.63	NS
Treatment	8	0.49	0.06	2.61	2.59	S
Error	16	0.37	0.02			
Total	26	0.87				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.37	0.37	24.42	4.15	S
Replication	4	0.06	0.01	0.92	2.67	NS
Treatment	8	0.59	0.07	4.85	2.24	S
Years x Treatment	8	0.05	0.01	0.44	2.24	NS
Error	32	0.49	0.02			
Total	53	1.56				

ANOVA-48: Analysis of variance as influenced by effect of nutrient management on soil nitrogen (kg ha^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	234.03	117.01	0.17	3.63	NS
Treatment	8	14775.12	1846.89	2.63	2.59	S
Error	16	11251.82	703.24			
Total	26	26260.96				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	303.17	151.59	0.34	3.63	NS
Treatment	8	13627.28	1703.41	3.83	2.59	S
Error	16	7111.18	444.45			
Total	26	21041.63				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	S/NS
Years	1	5.58	5.58	0.01	4.15	NS
Replication	4	537.20	134.30	0.23	2.67	NS
Treatment	8	27941.79	3492.72	6.09	2.24	S
Years x Treatment	8	460.60	57.58	0.10	2.24	NS
Error	32	18363.00	573.84			
Total	53	47308.17				

ANOVA- 49: Analysis of variance as influenced by effect of nutrient management on soil phosphorus (kg ha^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	3.61	1.81	0.45	3.63	NS
Treatment	8	83.60	10.45	2.60	2.59	S
Error	16	64.25	4.02			
Total	26	151.46				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	5.36	2.68	1.08	3.63	NS
Treatment	8	98.82	12.35	4.96	2.59	S
Error	16	39.83	2.49			
Total	26	144.00				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	54.73	54.73	16.83	4.15	S
Replication	4	8.97	2.24	0.69	2.67	NS
Treatment	8	155.88	19.48	5.99	2.24	S
Years x Treatment	8	26.54	3.32	1.02	2.24	NS
Error	32	104.08	3.25			
Total	53	350.20				

ANOVA-50: Analysis of variance as influenced by effect of nutrient management on soil potassium (kg ha^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	97.18	48.59	1.11	3.63	NS
Treatment	8	924.85	115.61	2.65	2.59	S
Error	16	698.67	43.67			
Total	26	1720.70				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	63.79	31.90	1.17	3.63	NS
Treatment	8	772.79	96.60	3.54	2.59	S
Error	16	436.08	27.26			
Total	26	1272.66				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	431.54	431.54	12.17	4.15	S
Replication	4	160.98	40.24	1.13	2.67	NS
Treatment	8	1489.26	186.16	5.25	2.24	S
Years x Treatment	8	208.38	26.05	0.73	2.24	NS
Error	32	1134.75	35.46			
Total	53	3424.90				

ANOVA-51: Analysis of variance as influenced by effect of nutrient management on soil actinomycetes (Cfu x 10^5 g^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.018	0.009	3.23	3.63	NS
Treatment	8	0.088	0.011	3.89	2.59	S
Error	16	0.045	0.003			
Total	26	0.152				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.034	0.017	2.81	3.63	NS
Treatment	8	0.14	0.018	3.04	2.59	S
Error	16	0.097	0.006			
Total	26	0.27				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.058	0.058	13.05	4.15	**S**
Replication	4	0.052	0.013	2.94	2.67	**S**
Treatment	8	0.228	0.028	6.40	2.24	**S**
Years x Treatment	8	0.008	0.001	0.22	2.24	**NS**
Error	32	0.142	0.004			
Total	53	0.488				

ANOVA-52: Analysis of variance as influenced by effect of nutrient management on soil fungi (Cfu x $10^4 g^{-1}$)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	4.37	2.19	0.11	3.63	NS
Treatment	8	451.44	56.43	2.91	2.59	S
Error	16	310.76	19.42			
Total	26	766.57				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	44.41	22.21	1.06	3.63	NS
Treatment	8	499.29	62.41	2.98	2.59	S
Error	16	334.88	20.93			
Total	26	878.59				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	261.36	261.36	12.95	4.15	S
Replication	4	48.79	12.20	0.60	2.67	NS
Treatment	8	937.23	117.15	5.81	2.24	S
Years x Treatment	8	13.49	1.69	0.08	2.24	NS
Error	32	645.65	20.18			
Total	53	1906.52				

ANOVA-53: Analysis of variance as influenced by effect of nutrient management on soil bacteria (Cfu x $10^7 g^{-1}$)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	31.56	15.78	2.34	3.63	NS
Treatment	8	168.91	21.11	3.13	2.59	S
Error	16	107.93	6.75			
Total	26	308.40				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	8.12	4.06	1.95	3.63	NS
Treatment	8	61.03	7.63	3.67	2.59	S
Error	16	33.26	2.08			
Total	26	102.41				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	132.04	132.04	29.93	4.15	S
Replication	4	39.69	9.92	2.25	2.67	NS
Treatment	8	211.06	26.38	5.98	2.24	S
Years x Treatment	8	18.88	2.36	0.53	2.24	NS
Error	32	141.18	4.41			
Total	53	542.85				

ANOVA-54: Analysis of variance as influenced by effect of nutrient management on soil dehydrogenase activity activity (µg TPF g^{-1} h^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	2.58	1.29	2.40	3.63	NS
Treatment	8	11.98	1.50	2.79	2.59	S
Error	16	8.58	0.54			
Total	26	23.14				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	1.95	0.97	1.44	3.63	NS
Treatment	8	15.76	1.97	2.92	2.59	S
Error	16	10.79	0.67			
Total	26	28.49				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	21.97	21.97	36.28	4.15	S
Replication	4	4.52	1.13	1.87	2.67	NS
Treatment	8	26.87	3.36	5.55	2.24	S
Years x Treatment	8	0.87	0.11	0.18	2.24	NS
Error	32	19.37	0.61			
Total	53	73.60				

ANOVA-55: Analysis of variance as influenced by effect of nutrient management on soil microbial biomass carbon (µg g^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	4774.07	2387.03	2.74	3.63	NS
Treatment	8	18646.83	2330.85	2.67	2.59	S
Error	16	13960.86	872.55			
Total	26	37381.75				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	3857.88	1928.94	1.71	3.63	NS
Treatment	8	23884.64	2985.58	2.65	2.59	S
Error	16	18010.42	1125.65			
Total	26	45752.94				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	74054.08	74054.08	74.12	4.15	S
Replication	4	8631.94	2157.99	2.16	2.67	NS
Treatment	8	40792.70	5099.09	5.10	2.24	S
Years x Treatment	8	1738.77	217.35	0.22	2.24	NS
Error	32	31971.28	999.10			
Total	53	#######				

ANOVA-56: Analysis of variance as influenced by effect of nutrient management on soil acid phosphatase activity (µg p-nitrophenol g^{-1} h^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	196.29	98.15	2.91	3.63	NS
Treatment	8	720.75	90.09	2.67	2.59	S
Error	16	540.02	33.75			
Total	26	1457.06				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	9.70	4.85	0.29	3.63	NS
Treatment	8	388.51	48.56	2.89	2.59	S
Error	16	269.31	16.83			
Total	26	667.52				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	307.78	307.78	12.17	4.15	S
Replication	4	205.99	51.50	2.04	2.67	NS
Treatment	8	1047.74	130.97	5.18	2.24	S
Years x Treatment	8	61.52	7.69	0.30	2.24	NS
Error	32	809.34	25.29			
Total	53	2432.37				

ANOVA-57: Analysis of variance as influenced by effect of nutrient management on number of pods plant^{-1} in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	1.98	0.99	0.07	3.63	NS
Treatment	8	405.50	50.69	3.34	2.59	S
Error	16	242.58	15.16			
Total	26	650.07				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	21.49	10.74	1.48	3.63	NS
Treatment	8	332.67	41.58	5.71	2.59	S
Error	16	116.51	7.28			
Total	26	470.66				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	60.76	60.76	5.41	4.15	S
Replication	4	23.47	5.87	0.52	2.67	NS
Treatment	8	726.03	90.75	8.09	2.24	S
Years x Treatment	8	12.13	1.52	0.14	2.24	NS
Error	32	359.09	11.22			
Total	53	1181.48				

ANOVA-58: Analysis of variance as influenced by effect of nutrient management on number of seeds pod^{-1} in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.54	0.27	0.72	3.63	NS
Treatment	8	8.91	1.11	3.00	2.59	S
Error	16	5.94	0.37			
Total	26	15.39				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	13.03	6.51	2.87	3.63	NS
Treatment	8	50.95	6.37	2.81	2.59	S
Error	16	36.29	2.27			
Total	26	100.27				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	57.21	57.21	43.34	4.15	S
Replication	4	13.56	3.39	2.57	2.67	NS
Treatment	8	50.35	6.29	4.77	2.24	S
Years x Treatment	8	9.50	1.19	0.90	2.24	NS
Error	32	42.23	1.32			
Total	53	172.86				

ANOVA-59: Analysis of variance as influenced by effect of nutrient management on test weight (g) in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.0021	0.0010	2.16	3.63	NS
Treatment	8	0.0087	0.0011	2.26	2.59	NS
Error	16	0.0077	0.0005			
Total	26	0.0184				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.00010	0.00005	0.08	3.63	NS
Treatment	8	0.0085	0.0010	1.67	2.59	NS
Error	16	0.010	0.00064			
Total	26	0.018				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.0071	0.0071	12.72	4.15	S
Replication	4	0.0022	0.0005	0.97	2.67	NS
Treatment	8	0.0147	0.0018	3.29	2.24	S
Years x Treatment	8	0.0025	0.0003	0.55	2.24	NS
Error	32	0.0179	0.0006			
Total	53	0.04				

ANOVA-60: Analysis of variance as influenced by effect of nutrient management on seed yield (kg ha^{-1}) in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	3263.35	1631.67	0.48	3.63	NS
Treatment	8	86895.49	10861.94	3.22	2.59	S
Error	16	54014.34	3375.90			
Total	26	#######				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	2757.68	1378.84	1.05	3.63	NS
Treatment	8	76576.69	9572.09	7.29	2.59	S
Error	16	21016.99	1313.56			
Total	26	#######				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	44.78	44.78	0.02	4.15	NS
Replication	4	6021.02	1505.26	0.64	2.67	NS
Treatment	8	#######	19899.21	8.49	2.24	S
Years x Treatment	8	4278.47	534.81	0.23	2.24	NS
Error	32	75031.33	2344.73			
Total	53	#######				

ANOVA-61: Analysis of variance as influenced by effect of nutrient management on stover yield (kg ha^{-1}) in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	9383.39	4691.70	0.91	3.63	NS
Treatment	8	#######	18325.01	3.56	2.59	S
Error	16	82396.50	5149.78			
Total	26	#######				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	6650.97	3325.49	0.78	3.63	NS
Treatment	8	#######	22656.47	5.30	2.59	S
Error	16	68444.16	4277.76			
Total	26	#######				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	54.85	54.85	0.01	4.15	NS
Replication	4	16034.37	4008.59	0.85	2.67	NS
Treatment	8	#######	40684.31	8.63	2.24	NS
Years x Treatment	8	2377.36	297.17	0.06	2.24	S
Error	32	#######	4713.77			
Total	53	#######				

ANOVA-62: Analysis of variance as influenced by effect of nutrient management on N content in seed (%) in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.03	0.01	0.22	3.63	NS
Treatment	8	2.04	0.26	3.91	2.59	S
Error	16	1.04	0.07			
Total	26	3.11				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.26	0.13	1.72	3.63	NS
Treatment	8	2.14	0.27	3.52	2.59	S
Error	16	1.21	0.08			
Total	26	3.62				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.93	0.93	13.20	4.15	S
Replication	4	0.29	0.07	1.02	2.67	NS
Treatment	8	4.08	0.51	7.23	2.24	S
Years x Treatment	8	0.10	0.01	0.18	2.24	NS
Error	32	2.26	0.07			
Total	53	7.66				

ANOVA-63: Analysis of variance as influenced by effect of nutrient management on N content in stover (%) in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.003	0.002	0.044	3.634	NS
Treatment	8	0.876	0.110	2.882	2.591	S
Error	16	0.608	0.038			
Total	26	1.487				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.04	0.02	0.77	3.63	NS
Treatment	8	0.96	0.12	4.37	2.59	S
Error	16	0.44	0.03			
Total	26	1.45				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.36	0.36	11.18	4.15	S
Replication	4	0.04	0.012	0.35	2.67	NS
Treatment	8	1.82	0.22	6.94	2.24	S
Years x Treatment	8	0.01	0.002	0.07	2.24	NS
Error	32	1.04	0.033			
Total	53	3.30				

ANOVA-64: Analysis of variance as influenced by effect of nutrient management on total N uptake (kg ha^{-1}) in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	7.46	3.73	0.35	3.63	NS
Treatment	8	1118.65	139.83	13.00	2.59	S
Error	16	172.11	10.76			
Total	26	1298.22				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	91.17	45.59	3.24	3.63	NS
Treatment	8	1239.93	154.99	11.02	2.59	S
Error	16	225.07	14.07			
Total	26	1556.17				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	230.32	230.32	18.56	4.15	S
Replication	4	98.63	24.66	1.99	2.67	NS
Treatment	8	2343.13	292.89	23.60	2.24	S
Years x Treatment	8	15.45	1.93	0.16	2.24	NS
Error	32	397.18	12.41			
Total	53	3084.70				

ANOVA-65: Analysis of variance as influenced by effect of nutrient management on P content in seed (%) in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.006	0.003	0.394	3.634	NS
Treatment	8	0.224	0.028	3.630	2.591	S
Error	16	0.123	0.008			
Total	26	0.353				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.01	0.01	0.53	3.63	NS
Treatment	8	0.28	0.03	2.63	2.59	S
Error	16	0.21	0.01			
Total	26	0.50				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.29	0.29	28.19	4.15	S
Replication	4	0.02	0.01	0.48	2.67	NS
Treatment	8	0.42	0.05	4.98	2.24	S
Years x Treatment	8	0.08	0.01	1.01	2.24	NS
Error	32	0.33	0.01			
Total	53	1.15				

ANOVA-66: Analysis of variance as influenced by effect of nutrient management on P content in stover (%) in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.03	0.01	1.63	3.63	NS
Treatment	8	0.29	0.04	3.91	2.59	S
Error	16	0.15	0.01			
Total	26	0.46				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.02	0.01	0.43	3.63	NS
Treatment	8	0.47	0.06	3.05	2.59	S
Error	16	0.31	0.02			
Total	26	0.80				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.414	0.414	29.098	4.149	S
Replication	4	0.047	0.012	0.817	2.668	NS
Treatment	8	0.732	0.092	6.428	2.244	S
Years x Treatment	8	0.026	0.003	0.227	2.244	NS
Error	32	0.456	0.014			
Total	53	1.674				

ANOVA-67: Analysis of variance as influenced by effect of nutrient management on total P uptake (kg ha^{-1}) in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	7.38	3.69	1.60	3.63	NS
Treatment	8	189.63	23.70	10.29	2.59	S
Error	16	36.87	2.30			
Total	26	233.88				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.98	0.49	0.09	3.63	NS
Treatment	8	212.69	26.59	5.09	2.59	S
Error	16	83.60	5.23			
Total	26	297.27				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	155.55	155.55	41.32	4.15	S
Replication	4	8.36	2.09	0.56	2.67	NS
Treatment	8	396.46	49.56	13.16	2.24	S
Years x Treatment	8	5.86	0.73	0.19	2.24	NS
Error	32	120.47	3.76			
Total	53	686.69				

ANOVA-68: Analysis of variance as influenced by effect of nutrient management on K content in seed (%) in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.11	0.05	3.35	3.63	NS
Treatment	8	0.39	0.05	3.11	2.59	S
Error	16	0.25	0.02			
Total	26	0.75				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.04	0.02	1.17	3.63	NS
Treatment	8	0.90	0.11	6.15	2.59	S
Error	16	0.29	0.02			
Total	26	1.23				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.61	0.61	35.93	4.15	S
Replication	4	0.15	0.04	2.18	2.67	NS
Treatment	8	1.08	0.14	7.93	2.24	S
Years x Treatment	8	0.21	0.03	1.56	2.24	NS
Error	32	0.55	0.02			
Total	53	2.60				

ANOVA-69: Analysis of variance as influenced by effect of nutrient management on K content in stover (%) in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.09	0.04	3.12	3.63	NS
Treatment	8	1.26	0.16	11.26	2.59	S
Error	16	0.22	0.01			
Total	26	1.57				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.08	0.04	3.33	3.63	NS
Treatment	8	0.72	0.09	7.71	2.59	S
Error	16	0.19	0.01			
Total	26	0.99				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.36	0.36	28.24	4.15	S
Replication	4	0.17	0.04	3.21	2.67	S
Treatment	8	1.91	0.24	18.51	2.24	Si
Years x Treatment	8	0.08	0.01	0.78	2.24	NS
Error	32	0.41	0.01			
Total	53	2.93				

ANOVA-70: Analysis of variance as influenced by effect of nutrient management on total K uptake (kg ha^{-1}) in linseed

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	48.34	24.17	2.02	3.63	NS
Treatment	8	498.99	62.37	5.22	2.59	S
Error	16	191.35	11.96			
Total	26	738.68				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	32.62	16.31	1.93	3.63	NS
Treatment	8	584.35	73.04	8.64	2.59	S
Error	16	135.21	8.45			
Total	26	752.18				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	137.89	137.89	13.51	4.15	S
Replication	4	80.96	20.24	1.98	2.67	NS
Treatment	8	963.63	120.45	11.80	2.24	S
Years x Treatment	8	119.71	14.96	1.47	2.24	NS
Error	32	326.55	10.20			
Total	53	1628.74				

ANOVA-71: Analysis of variance as influenced by effect of nutrient management on soil pH

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.08	0.04	0.63	3.63	NS
Treatment	8	0.06	0.01	0.12	2.59	NS
Error	16	0.97	0.06			
Total	26	1.11				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.12	0.06	0.34	3.63	NS
Treatment	8	0.03	0.004	0.02	2.59	NS
Error	16	2.80	0.18			
Total	26	2.95				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.017	0.017	0.14	4.15	NS
Replication	4	0.195	0.049	0.41	2.67	NS
Treatment	8	0.068	0.008	0.072	2.24	NS
Years x Treatment	8	0.023	0.003	0.024	2.24	NS
Error	32	3.773	0.118			
Total	53	4.08				

ANOVA-72: Analysis of variance as influenced by effect of nutrient management on soil EC (dS m^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2.0000	0.0002	0.0001	0.0894	3.6337	NS
Treatment	8.0000	0.0149	0.0019	1.4653	2.5911	NS
Error	16.0000	0.0203	0.0013			
Total	26.0000	0.0354				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2.0000	0.0094	0.0047	3.3697	3.6337	NS
Treatment	8.0000	0.0037	0.0005	0.3318	2.5911	NS
Error	16.0000	0.0223	0.0014			
Total	26.0000	0.0354				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.0703	0.0703	52.88	4.14	S
Replication	4	0.009	0.0024	1.80	2.66	NS
Treatment	8	0.012	0.0015	1.155	2.24	NS
Years x Treatment	8	0.0063	0.0008	0.58	2.24	NS
Error	32	0.042	0.0013			
Total	53	0.141				

ANOVA-73: Analysis of variance as influenced by effect of nutrient management on soil organic matter (%)

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.058	0.029	1.752	3.634	NS
Treatment	8	0.028	0.003	0.207	2.591	NS
Error	16	0.266	0.017			
Total	26	0.353				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	0.021	0.010	0.968	3.634	***NS***
Treatment	8	0.083	0.010	0.972	2.591	***NS***
Error	16	0.172	0.011			
Total	26	0.276				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	0.20	0.20	14.54	4.15	S
Replication	4	0.08	0.02	1.45	2.67	NS
Treatment	8	0.09	0.01	0.81	2.24	NS
Years x Treatment	8	0.02	0.00	0.20	2.24	NS
Error	32	0.44	0.01			
Total	53	0.83				

ANOVA-74: Analysis of variance as influenced by effect of nutrient management on soil available soil nitrogen (kg ha^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	1081.45	540.72	2.59	3.63	NS
Treatment	8	5505.91	688.24	3.30	2.59	S
Error	16	3336.71	208.54			
Total	26	9924.06				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	14.52	7.26	1.64	3.63	NS
Treatment	8	1042.60	130.33	29.38	2.59	S
Error	16	70.96	4.44			
Total	26	1128.08				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	721.41	721.41	6.77	4.15	S
Replication	4	1095.97	273.99	2.57	2.67	NS
Treatment	8	5500.53	687.57	6.46	2.24	S
Years x Treatment	8	1047.97	131.00	1.23	2.24	NS
Error	32	3407.67	106.49			
Total	53	11773.55				

ANOVA-75: Analysis of variance as influenced by effect of nutrient management on soil phosphorus (kg ha^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	8.15	4.07	3.02	3.63	NS
Treatment	8	76.59	9.57	7.09	2.59	S
Error	16	21.60	1.35			
Total	26	106.34				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	7.34	3.67	1.80	3.63	NS
Treatment	8	43.93	5.49	2.69	2.59	S
Error	16	32.66	2.04			
Total	26	83.94				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	23.36	23.36	13.78	4.15	S
Replication	4	15.49	3.87	2.28	2.67	NS
Treatment	8	117.49	14.69	8.66	2.24	S
Years x Treatment	8	3.04	0.38	0.22	2.24	NS
Error	32	54.26	1.70			
Total	53	213.65				

ANOVA-76: Analysis of variance as influenced by effect of nutrient management on soil potassium (kg ha^{-1})

ANOVA Table First Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	28.19	14.10	0.55	3.63	NS
Treatment	8	706.60	88.32	3.45	2.59	S
Error	16	410.20	25.64			
Total	26	1144.99				

ANOVA Table Second Trial						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Replication	2	2.25	1.13	0.06	3.63	NS
Treatment	8	405.64	50.71	2.71	2.59	S
Error	16	299.63	18.73			
Total	26	707.53				

ANOVA Table of Pooled Final						
Source of Variance	**Degree of Freedom**	**Sum of Square**	**Mean Sum of Square**	**F Cal**	**F Tab at 5%**	**S/NS**
Years	1	326.15	326.15	14.70	4.15	S
Replication	4	30.44	7.61	0.34	2.67	NS
Treatment	8	1044.80	130.60	5.89	2.24	S
Years x Treatment	8	67.44	8.43	0.38	2.24	NS
Error	32	709.84	22.18			
Total	53	2178.67				