Effect of Integrated Nutrient Management Practices on Soil Quality Indicators and Plant Growth in Greengram on *Alfisol*

ABSTRACT

A field experiment was conducted at farmer fields at Vagarai, Dindigul District (Tamil Nadu) during the *summer* season of 2022 with green gram as a test crop.A field experiment was conducted at farmer fields at Vagarai, Dindigul District during the summer season of 2022 with green gram as a test crop. The main objectives of the present study focus on studying the impact of Integrated Nutrient Management (INM) practices on soil quality indicators and the growth of green gram (Vigna radiata).*Alfisols* are a specific soil order found in various parts of the world, known for their natural fertility and suitability for agriculture. However, continuous cultivation and improper nutrient management can lead to soil degradation, nutrient depletion, and reduced crop productivity. To address these challenges, researchers are exploring the potential of INM practices, which involve the balanced use of organic and inorganic fertilizers, to improve soil health and optimize crop growth. The study aims to assess how various INM treatments impact soil quality indicators. These indicators may include soil organic matter content, nutrient levels (e.g., nitrogen, phosphorus, potassium), pH, and analyze how the different INM practices influence the growth and performance of greengram crops. Organic manures *viz.* Farm Yard Manure (FYM) and vermicompost on different combinations were evaluated in a Randomized Block Design with three replications *viz.* T_1-Absolute control, T_2 -Vermicompost alone @5 t ha^{-1}, T_3 -FYM alone @ 12.5 t ha^{-1}, T_4 -STCR - NPK alone -0.8 t/ha, T_5 -STCR -NPK alone -1 t/ha, T_6 -STCR -NPK alone -1.2 t/ha, T_7 -STCR -IPNS -0.8 t/ha, T_8 -STCR -IPNS -1 t/ha, T_9 -STCR -IPNS -1.2 t/ha, T_{10} -Blanket (100 % RDF), T_{11} -Blanket (25:50:25) + FYM@ 12.5t ha^{-1} and T_{12}-Farmer's practice. Evaluating the physical, chemical, and biological indicators, the integrated module of organic and inorganic fertilization reflected a significant improvement in soil characteristics such as the available nitrogen, phosphorus, potassium, and soil biological characteristics encircling bacterial, fungal and actinomycetes count. The STCR -IPNS - 1.2 t ha^{-1} (T_9) proved to be the best treatment in terms of SPAD chlorophyll meter reading, the maximum number of nodules (21.24, 30.49, 24.49 at 30, 45, and 60 DAS respectively), the highest grain yield (1225kg ha^{-1}), and nutrient (N, P, K) availability. The population of Bacteria, fungi, and Actinomycetes (27.5, 9.8, and 27.1 soil respectively), was also significantly higher in STCR -IPNS - 1.2 t ha^{-1}(T_9). Thus, the combined application of manures and fertilizers can be recommended as a nutrient management strategy for yield enhancement and soil quality maintenance of green gram cultivation in soils of the southern Tamil Nadu region.

Keywords: Green gram, Grain yield Integrated nutrient management; soil quality parameter.

1. INTRODUCTION

The green gram [*Vigna radiata*], sometimes known as the mung bean, is a Leguminosae family plant native to the Indian subcontinent. Pulses are commonly known as food legumes which are secondary to cereals in production and consumption in India. The total area covered under Greengram in India was 43.47 lakh hectares with a total production of 21.23

lakh tones. Because of its good climatic circumstances, the southern India region offers enormous potential for expanding pulse production and productivity [1].

Because of its great nutritional value, mung bean has an advantage over other pulses. It contains about 25% protein, which is around three times that of cereals. In addition to being a significant source of human food and animal feed, the mung bean crop is renowned for its ability to create a symbiotic relationship with specific bacteria, allowing biological nitrogen fixation in root nodules to meet the plant's nitrogen demands. Green biomass and waste from the crop can be absorbed into the soil to restore exported plant nutrients and improve soil fertility. Soil microbiological properties were also significantly better in mung bean-growing soils.

In recent years, there has been an increase in dependence on organic sources of nutrients since they help maintain soil health and productivity. Organic materials are essential for nutrient replenishment and soil quality management due to their favorable able effects on soil's physical, chemical, and biological properties [2]. Organic materials' ability to provide nutrients vary depending on decomposition rates, nutrient release rates, and patterns [3]. Integration of organic manure and chemical fertilizer elements has been proven to be promising not only in maintaining higher crop yield but also in providing crop production stability, in addition to enhancing soil physical conditions [4]. There have been numerous reports of improved soil nutrient content, and green gram production as a result of using organic manures like vermicompost and Farm Yard Manure (FYM)[[5]. Organic manures promote soil biological activity, which increases nutrient mobilization from organic and chemical sources as well as the breakdown of toxic substances [6]. Green gram has recently emerged as one of India's best choices for increasing agriculture output and soil quality. Its adoption into cropping systems as a fast-growing summer crop has enormous potential for increasing farmer earnings while also improving soil fertility, health, and quality. However, for function maximum potential, a well-thought-out nutrient management plan must be in place. The current study was therefore done to investigate the possible function of organic manures and fertilizers in developing a nutrient management strategy for green gram to fit in the nutrient-depleted agricultural production systems of southern India, particularly Tamil Nadu.

2. MATERIAL AND METHODS

2.1 Experiment location and initial soil description

The experimental farm was located in the Vagarai, Dindigul District (Tamil Nadu State). Soils in the experimental field belong to the Palaviduthi soil series (*Typic Rhodustalf*) and were sandy loam in texture. The texture and initial fertility level of the soil were evaluated by randomly collecting representative soil samples at 0-15 cm depth with an auger. Th(e collected samples were air-dried and ground to pass through a 2 mm sieve and analyzed for physical, chemical, and biological parameters following standard analytical procedures. pH of initial samples was 8.02, OC 0.35% available N, P_2O_5 and K_2O was 230, 25 and 370 kg ha^{-1}respectively. bulk density 1.303g cm^{-3}. The initial microbial population was 12.5, 2.8, and 15.9 CFU g^{-1} soil for *bacteria, fungi,* and actinomycetes respectively.

2.2 Treatment Details

Summer green gram variety "CO 8" was grown following recommended cultivation practices. Twelve treatments consisting of T_1: Absolute control, T_2: Vermicompost alone @5 t ha^{-1}, T_3: FYM alone @ 12.5 t ha^{-1}, T_4: STCR - NPK alone -0.8 t ha^{-1}, T_5: STCR -NPK alone -1.0 t ha^{-1} T_6: STCR -NPK alone -1.2 t ha^{-1}, T_7: STCR -IPNS -0.8 t ha^{-1}, T_8: STCR -IPNS -1.0 t ha^{-1}, T_9:

STCR -IPNS -1.2 t ha^{-1}, T_{10}: Blanket (100 % RDF), T_{11}: Blanket (25:50:25) + FYM@ 12.5 t ha^{-1} and T_{12}: Farmer's practice were evaluated in a Randomized Block Design with three replications. The recommended dose of fertilizers 25: 50: 25 kg /ha (N_2:P_2O_5: K_2O) was applied as per treatments as basal dose at the time of sowing in furrows 30 cm apart at the depth of 10 cm. Vermicompost samples were taken and analyzed for available nitrogen (1.51%), phosphorus (0.81%), and potassium (1.03%). Vermicompost was applied as per treatment.

For STCR treatments, the fertilizer doses were computed using the fertilizer prescription equations developed for NPK alone and IPNS for green gram varieties.

For STCR – IPNS treatments, FYM was applied @ 12.5 t ha^{-1} basally. The quantities of N, P, and K contributed through FYM (with 25.5 % moisture, nitrogen (0.56%), phosphorus (0.34%), and potassium (0.55%)) were subtracted from the inorganic fertilizer doses and applied for STCR – IPNS treatments. As per the treatments, the entire dose of fertilizer N, P_2O_5, and K_2O was applied as urea, single super phosphate, and muriate of potash respectively at the time of sowing.

2.3 Experimental Methodology

Greengram variety C08 was sown at 20 kg/ha in line at 30 cm at a depth of 10 cm on 24th February 2023. Surface soil samples (0-30 cm depth) were collected from each plot during different growth stages and after the crop harvest and samples were analyzed for pH, organic carbon, available N, P, and K. Growth attributes *viz.*, SPAD chlorophyll and numbers of nodules were recorded at 30, 45, and 60 DAS (Days After Sowing). Grain yield was also recorded.

To assess the physical components of soil quality, we measured bulk density by core method [7], and mechanical analysis by international pipette method [8]. The chemical components of soil quality were assessed by determining Soil pH (1:2.5 soil/water) was measured using a glass electrode [9], soil available organic carbon by wet digestion method [10] available N [11], available P [12]and available K [13]. Finally, the biological component of soil quality was assessed by measuring microbial (*bacteria, fungi, and actinomycetes*) population by serial dilution method on Nutrient Agar Media (NA), Rose Bengal Agar (RBA) and Ken knight Agar respectively (KKA) [14].

The mean data of each quantitative trait were statistically analyzed by the technique of analysis of variance. The significant difference was tested by the f test the difference between the mean by using CD at a 5% level [15].

3. RESULTS AND DISCUSSION

3.1 Growth and yield of plants

3.1.1 SPAD Chlorophyll Meter Reading (SCMR)

The SPAD **(Soil Plant Analysis Development)** Chlorophyll Meter Reading of plants was delineated to be significant with the range of 25.44 to 43.98, 35.75 to 58.56, and 30.75 to 48.31during vegetative, flowering, and harvest stages respectively depicted in Table 1. The Application of STCR -IPNS - 1.2 t ha^{-1} (T9) gave the maximum value of chlorophyll content (SPAD meter reading).

During the vegetative stage, STCR (Soil Test Crop Response) -IPNS - 1.2 t ha^{-1}(T_9) recorded higher SCMR reading of 43.98. Next, with treatments STCR -NPK alone -1.2 t ha^{-1} (T_6) (40.58) and STCR -IPNS - 1.0 t ha^{-1}(T_8) (39.41). Treatment Blanket (25:50:25) + FYM@ 12.5t ha^{-1} (T_{11}), STCR -IPNS – 0.8 t ha^{-1} (T_7) and FYM alone @ 12.5 t ha^{-1} (T_3) which were statistically parallel to each other.

During the flowering stage, the elevated SCMR reading of 58.56 was noticed in STCR -IPNS - 1.2 t ha^{-1} (T_9) followed by STCR -NPK alone -1.2 t ha^{-1} (T_6) (55.58) and STCR -IPNS - 1.0 t ha^{-1}(T_8) (53.40).

A similar trend of SCMR reading was also reported during the harvest stage with the highest SCMR reading of 48.31 in STCR -IPNS - 1.2 t ha^{-1}(T_9) followed by STCR -NPK alone -1.2 t ha^{-1} (T_6) (45.34) and STCR -IPNS - 1.0 t ha^{-1}(T_8) (43.52).

The reason for the observed phenomenon could be attributed to the fact that organic fertilizers, as well as a combination of organic and chemical fertilizers, supply a greater amount of residual nitrogen to plants. This surplus nitrogen content likely led to an increase in chlorophyll levels, which is an essential component of photosynthetically active pigments responsible for the green color of leaves. Consequently, higher chlorophyll content was recorded in the plants. On the other hand, lower values for growth parameters were observed under the treatment of control (T_1). The study reveals that STCR - IPNS recorded higher values than SCMR for the STCR - NPK alone treatments at all phases of crop growth. The SCMR values for all STCR treatments were higher than for blanket, FYM, and control treatments. It is mostly caused by the application of increased nitrogen dosages with an increased yield target, which would enhance the chlorophyll concentration because of better utilization of provided nutrients in the vegetative stage [16].

3.1.2 Number of nodules

The experiment results showed that the involved treatments had a significant influence on the number of nodules which ranged from 12.14 to 21.24, 21.39 to 30.49, and 17.18 to 24.49 throughout the vegetative, flowering, and harvest stages, respectively were presented in Table 1.

At the vegetative stage, the number of nodules in STCR -IPNS - 1.2 t ha^{-1}(T_9) (21.24), which is similar to the treatment STCR -NPK alone -1.2 t ha^{-1} (T_6) (20.98). The consecutive highest number of nodule of 19.12 and 17.11 respectively were recorded in STCR -IPNS - 1.0 t ha^{-1} (T_8) and STCR -NPK alone -1.0 t ha^{-1} (T_5). During the flowering stage, a higher number of nodules was attained in STCR -IPNS - 1.2 t ha^{-1}(T_9) (30.49). Subsequently, STCR -NPK alone -1.2 t ha^{-1} (T_6) and STCR -IPNS - 1.0 t ha^{-1}(T_8) with 29.85 and 29.37 respectively seemed to be equivalent to each other.

Nutrient levels significantly impacted data on the number of root nodules present in greengram at different growth stages. The nodulation activities of leguminous plants, which are determined by the number of nodules present in the plant, were well recognized. In the current study, T_9 (STCR -IPNS-1.2 t ha^{-1}) treatment had 3.33 per cent more nodules observed than T_6 (STCR - NPK alone-1.2 t ha^{-1}) treatments. Application of both organic manure and inorganic fertilizers together might have created more favorable environment for improved root development and respiration as well as higher soil biological activity than when just inorganic fertilizers are used. These findings are also in close conformity with [17] who reported positive influence Application of 100% RDN from Vermicompost significantly better response increased root nodules over control.

3.1.3 Grain yield

The enhancement in fertilizer doses due to the executed treatments had inflicted a positive result on grain yield, which ranged from 599 to 1270 kg ha^{-1} and the values were shown in Table 1. Of, the remarkably elevated yield was recorded in STCR -IPNS - 1.2 t ha^{-1}(T_9) (1270 kg ha^{-1}) followed by STCR -NPK alone -1.2 t ha^{-1} (T_6) (1153 kg ha^{-1}) and STCR -IPNS - 1.0 t ha^{-1}(T_8) (1067 kg ha^{-1}). Grain yields in STCR -NPK alone -1.0 t ha^{-1} (T_5) and STCR - IPNS – 0.8 t ha^{-1} (T_7) were significantly different (1009 and 811 kg ha^{-1}, respectively), while they varied significantly from STCR - NPK alone -0.8 t ha^{-1} (T_4) (753 kg ha^{-1}).
Similarly, Blanket (25:50:25) + FYM@ 12.5t ha^{-1} (T_{11}) and Blanket (100 % RDF) (T_{10}) embraced with a yield of 855 and 770 kg per hectare, respectively. The FYM and vermicompost treatments were noticeably different, in that FYM alone @ 12.5 t ha^{-1} (T_3) recorded a much more grain yield (820 kg ha^{-1}) than Vermicompost alone @5 t ha^{-1} (T_2)(712 kg ha^{-1}) and Control (T_1)recorded a significantly lower yield (599 kg ha^{-1}) than the other treatments. The results indisputably showed that STCR-treated plants had a maximum yield than a blanket, FYM, and absolute control.

Greengram grain yield was substantially impacted by FYM, vermicompost and NPK fertilizers combination. In the current study, observed foot print of the acquisition of STCR-IPNS on desired yield was observed by the attainment of higher yield in STCR-IPNS - 1.2 t ha^{-1}, resulting in a surge of 10.14 and 64.93 percent while taking into account the STCR-NPK alone-1.2 t ha^{-1}, and blanket depicted in Table 1, Followed by STCR-IPNS, STCR-NPK alone treatments had a high impact on yield than FYM alone, blanket and absolute control respectively. Its efficiency was due to the quick release of nutrients from inorganics while FYM alone had a lesser impact due to the slow mineralization observed in [18].

Table.1 Effect of treatments on SPAD chlorophyll reading, Number of nodules, and Grain yield of greengram

	Treatment	SPAD chlorophyll			Number of nodules			Grain yield (kg ha^{-1})
		30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	
T_1	Absolute control	25.44	35.75	30.75	12.14	21.39	17.18	599
T_2	Vermicompost alone @5 t ha^{-1}	30.12	39.37	34.75	14.88	25.02	19.87	712
T_3	FYM alone @ 12.5 t ha^{-1}	34.85	44.43	35.59	16.58	26.81	21.94	820
T_4	STCR - NPK alone -0.8 t ha^{-1}	30.47	40.72	34.47	15.23	26.48	20.78	753
T_5	STCR -NPK alone -1.0 t ha^{-1}	38.05	51.63	42.38	17.11	28.15	23.15	1009
T_6	STCR -NPK alone -1.2 t ha^{-1}	40.58	55.58	45.34	20.98	29.85	23.67	1153
T_7	STCR -IPNS – 0.8 t ha^{-1}	35.75	43.95	36.75	16.78	27.82	22.72	811
T_8	STCR -IPNS - 1.0 t ha^{-1}	39.41	53.4	43.52	19.12	29.37	23.22	1067
T_9	STCR -IPNS - 1.2 t ha^{-1}	43.98	58.56	48.31	21.24	30.49	24.49	1270
T_{10}	Blanket (100 % RDF)	34.61	43.51	36.53	15.62	26.87	20.66	770

T_{11}	Blanket (25:50:25) + FYM@ 12.5t ha^{-1}	35.81	45.68	37.36	17.01	28.92	22.87	855
T_{12}	Farmer's practice	28.37	38.25	36.28	13.54	22.65	18.77	645
	SEd	0.85	1.04	0.90	0.29	0.62	0.56	21.36
	CD (P=0.05)	1.76	2.16	1.87	0.60	1.29	1.17	44.30

STCR – IPNS = NPK + FYM @12.5 t ha^{-1}, RDF- Recommended dose of fertilizer

3.2 Soil quality parameter

3.2.1 pH and OC

pH of soils ranged between 7.61-8.02. The effect of the treatment on soil pH was found to be non-significant. This is by the findings of [19] who reported that soil pH did not differ significantly with the application of organic manures. Soil pH was found non-significant because of the release of organic acids that maintain the buffering capacity of the soil during the mineralization of organic manures. However, significantly higher OC (0.59%) was recorded in treatment STCR -IPNS - 1.2 t ha^{-1}(T_9) (Table 2.

Table 2: Effect of treatments on pH and organic carbon in soil

	Treatment	pH	OC (%)
T_1	Absolute control	7.61	0.38
T_2	Vermicompost alone @5 t ha^{-1}	7.65	0.41
T_3	FYM alone @ 12.5 t ha^{-1}	7.65	0.45
T_4	STCR - NPK alone -0.8 t ha^{-1}	7.81	0.45
T_5	STCR -NPK alone -1.0 t ha^{-1}	7.81	0.51
T_6	STCR -NPK alone -1.2 t ha^{-1}	7.82	0.57
T_7	STCR -IPNS – 0.8 t ha^{-1}	7.89	0.55
T_8	STCR -IPNS - 1.0 t ha^{-1}	8.01	0.56
T_9	STCR -IPNS - 1.2 t ha^{-1}	8.02	0.59
T_{10}	Blanket (100 % RDF)	7.75	0.43
T_{11}	Blanket (25:50:25) + FYM@ 12.5t ha^{-1}	7.76	0.45
T_{12}	Farmer's practice	7.74	0.39
	SEd	0.18	0.0101009
	CD (P=0.05)	NS	0.0202018

STCR – IPNS = NPK + FYM @12.5 t ha^{-1}, RDF- Recommended dose of fertilizer

3.2.2 Available N, P and K

3.2.2.1 Available N

The available nitrogen status of the soil varied from 218 to 253 kg ha^{-1} and the values were shown in Figure 1 at the vegetative stage, 206 to 239 kg ha^{-1} at the flowering stage, and 201 to 233 kg ha^{-1} at the harvest stage. From the vegetative stage to the harvest stage, there was a gradual decrease in available nitrogen status, it may be due to increased plant nitrogen uptake, nitrogen allocation to reproductive structures, microbial activity and decomposition, nitrogen losses, and nitrogen fixation. The highest available nitrogen was registered in STCR -IPNS - 1.2 t ha^{-1} (T_9) and comparing all the other treatments the lowest available nitrogen was recorded in control (T_1) regardless of stages. At all the stages of crop growth, the available nitrogen status of STCR-IPNS recorded higher values than STCR-NPK alone treatments and was significantly higher than blanket, FYM alone treatment and absolute control. In STCR-IPNS, soil nitrogen availability was higher and results were reported [20] and [21].

3.2.2.2 Available P

Irrespective of treatments, the available phosphorus status of the soil showed a gradual reduction from the vegetative to the harvest stage. The available phosphorus status varied from 20.21to 38.52kg ha^{-1}, 18.65to 36.96kg $ha^{-1}$and 17.31to 35.62kg ha^{-1} at vegetative, flowering, and harvest stages, respectively and the values were shown in Figure 2. Regardless of stages, compared to all the other treatments, the highest available phosphorus status was recorded by STCR -IPNS - 1.2 t ha^{-1} (T_9), and the lowest available phosphorus was reported by control(T_1). Soil P availability was higher in STCR - IPNS and comparable results were reported by [22]and [23]

3.2.2.3 Available K

The available potassium status of the soil at vegetative, flowering, and harvest stages ranged from 355 to 404, 348 to 398, and 343 to 392 kg ha^{-1}, respectively, and were presented in Figure 3. The available potassium status of the soil progressively reduced from the vegetative to the harvest stage. The highest available potassium regardless of stages was recorded in STCR -IPNS - 1.2 t ha^{-1}(T_9), while the control(T_1) recorded the relatively lowest available potassium status. Potassium availability increased similarly in STCR treatments, according to reports from [24] and [25]. STCR-IPNS had a higher available K than NPK alone, due to the application of FYM and inorganic fertilizer in IPNS. By combining FYM with inorganic fertilizers, soil CEC increased, allowing the soil to maintain more exchangeable potassium and make that potassium more available [2625]. The NPK fertilizers along with FYM increased the soil's available potassium status by lowering K fixation caused by clay and organic matter interaction, in addition to directly increasing the soils potassium levels [27].26].24] and [25]

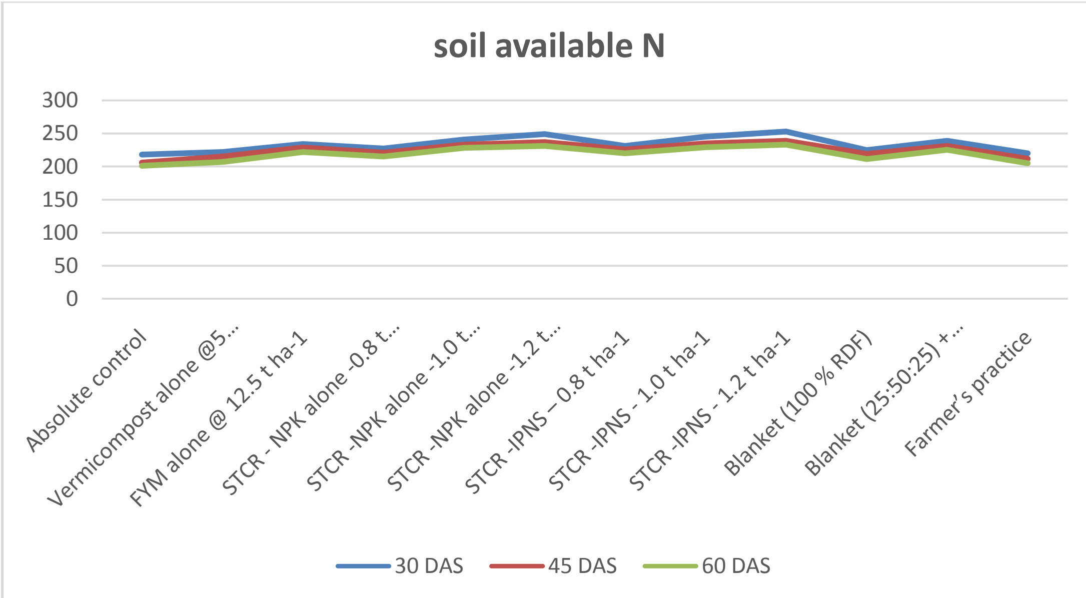

Figure 1 Effect of Integrated Nutrient Management Treatments on Available nitrogen

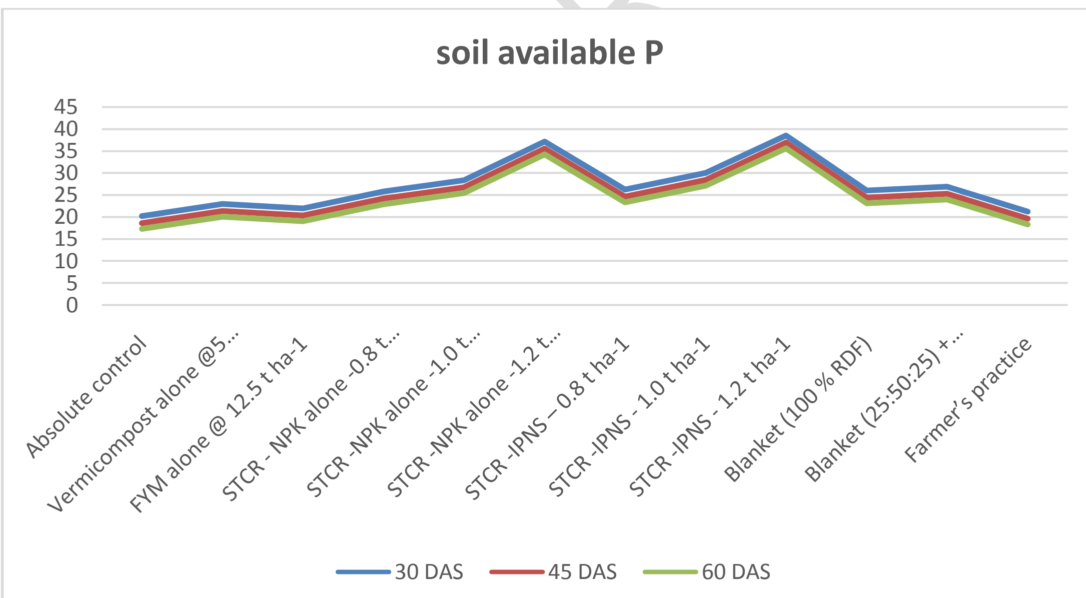

Figure 2 Effect of Integrated Nutrient Management Treatments on Available Phosphorous

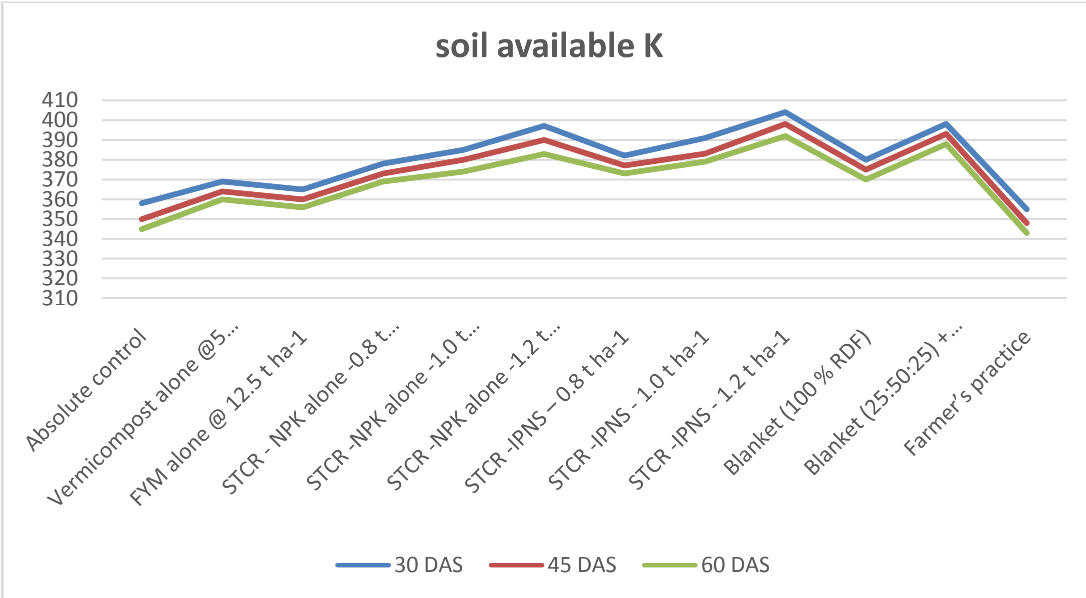

Figure 3 Effect of Integrated Nutrient Management Treatments on Available Potassium

3.2.3 Microbial population

The nutrient management practices exerted a significant influence on the buildup of the soil microbial population. Among different treatments, application of STCR -IPNS - 1.2 t ha^{-1} (T_9) recorded significantly highest *bacterial* population (21.9 CFU×10^{-6}), fungal *population* (8.1CFU ×10^{-4}), and actinomycetes population (34.4CFU ×10^{-3}) followed by the treatment receiving STCR -NPK alone -1.2 t ha^{-1}(T_9); while the lowest population was recorded in the treatment control(T_1) (Table 3). Such improvement in soil microbial population might be due to an adequate supply of nutrients and energy from different applied nutrient management approaches. [2726] reported that the population of bacteria, f,ungi and actinomycetes decreased in higher proportion in control followed by farmer's practice, however, the highest population of microbes was observed in the treatment receiving FYM.

nutrient and energy from different applied nutrient management approaches. [28] reported that the population of bacteria, fungi and actinomycetes decreased in higher proportion in control followed by farmer's practice, however, highest population of microbes was observed in the treatment receiving FYM.

Table 3. Effect of various treatments on soil microbial population and soil microbial biomass carbon under Greengram

Microbial population				
		Bacteria @ 10^{-6} (cfu g^{-1} soil)	Fungi@ 10^{-4} (cfu g^{-1} soil)	Actinomycetes @10^{-3} (cfu g^{-1} soil)
T_1	Absolute control	14.8	3.7	17.1
T_2	Vermicompost alone @5 t ha^{-1}	15.6	3.1	23.5
T_3	FYM alone @ 12.5 t ha^{-1}	17.7	5.6	25.9
T_4	STCR - NPK alone -0.8 t ha^{-1}	17.1	5.0	24.2
T_5	STCR -NPK alone -1.0 t ha^{-1}	18.9	6.3	26.9
T_6	STCR -NPK alone -1.2 t ha^{-1}	19.9	7.8	32.2
T_7	STCR -IPNS – 0.8 t ha^{-1}	17.5	5.3	25.2
T_8	STCR -IPNS - 1.0 t ha^{-1}	19.4	7.2	28.8
T_9	STCR -IPNS - 1.2 t ha^{-1}	21.9	8.1	34.4
T_{10}	Blanket (100 % RDF)	16.6	3.4	23.9
T_{11}	Blanket (25:50:25) + FYM@ 12.5t ha^{-1}	18.7	5.9	26.8
T_{12}	Farmer's practice	14.9	3.9	20.6
	SEd	0.39	0.16	0.51
	CD (P=0.05)	0.81	0.33	1.05

CONCLUSION

When compared to conventional practices, Integrated Nutrient Management (INM) boosts crop yields, increases water and nutrient usage efficiency, and increases farmers' economic returns, all while enhancing grain quality, soil health, and sustainability. INM not only boosted Green Gram yield but also raised nutrient usage efficiency and minimized nutrient loss. INM also improved the physico-chemical and biological features of soil, providing a better soil environment for crop growth. the current study demonstrates the remarkable potential of using STCR-IPNS-1.2 t ha^{-1} to significantly boost crop yields, showcasing an impressive 96.9% increment compared to traditional farmer practices,offers hope and inspiration for the future of agriculture.

Embracing such innovative and sustainable practices can pave the way for a more resilient, efficient, and environmentally conscious agricultural sector, capable of meeting the nutritional needs of a growing population while preserving the planet for generations to come. These findings underscore the importance of adopting innovative and scientifically-backed approaches, such as the STCR-IPNS technique, to address the challenges of modern agriculture and meet the increasing demands for food production.

Based on the results of the field experiment, it can be inferred that the application of T9 had a significant and positive effect on the physio-chemical properties, growth, and yield attributes of Greengram CO8. This particular treatment demonstrated remarkable effectiveness in promoting higher growth and yield in Greengram. Therefore, STCR -IPNS - 1.2 t ha^{-1} (T_9) can be considered as a recommended practice for achieving better crop performance and increased yield in green gram cultivation.

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