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Yoganathan G
Senior Assistant Professor, Department of Soil Science and Agricultural Chemistry, PGP College of Agricultural Sciences, Affiliated with Tamil Nadu Agricultural University, Accredited by ICAR Namakkal, Tamil Nadu, India

Gopinath VT
B. Sc. (Hons.) Agriculture, PGP College of Agricultural Sciences, Affiliated with Tamil Nadu Agricultural University, Namakkal, Tamil Nadu, India

Ezhilarasi
B. Sc. (Hons.) Agriculture, PGP College of Agricultural Sciences, Affiliated with Tamil Nadu Agricultural University, Namakkal, Tamil Nadu, India

Gausika G
B. Sc. (Hons.) Agriculture, PGP College of Agricultural Sciences, Affiliated with Tamil Nadu Agricultural University, Namakkal, Tamil Nadu, India

Gobika S
B. Sc. (Hons.) Agriculture, PGP College of Agricultural Sciences, Affiliated with Tamil Nadu Agricultural University, Namakkal, Tamil Nadu, India

Gokul K
B. Sc. (Hons.) Agriculture, PGP College of Agricultural Sciences, Affiliated with Tamil Nadu Agricultural University, Namakkal, Tamil Nadu, India

Gokulapriya K
B. Sc. (Hons.) Agriculture, PGP College of Agricultural Sciences, Affiliated with Tamil Nadu Agricultural University, Namakkal, Tamil Nadu, India

Gopika K
B. Sc. (Hons.) Agriculture, PGP College of Agricultural Sciences, Affiliated with Tamil Nadu Agricultural University, Namakkal, Tamil Nadu, India

Corresponding Author:
B. Sc. (Hons.) Agriculture, PGP College of Agricultural Sciences, Affiliated with Tamil Nadu Agricultural University, Namakkal, Tamil Nadu, India

Effect of different nutrient sources on growth, yield parameters and nutrient dynamics of green gram using pot experiment and RDF in Namakkal district of Tamil Nadu

Yoganathan G, Gopinath VT, Ezhilarasi, Gausika G, Gobika S, Gokul K, Gokulapriya K and Gopika K

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Abstract
Green gram (*Vigna radiata* L.) is an important pulse crop valued for its protein content, nitrogen-fixing ability, and contribution to sustainable agriculture. A pot culture experiment was conducted at PGP College of Agricultural Sciences, Namakkal, during June-September 2025 to evaluate the effects of organic and inorganic nutrient sources on growth, yield, and nutrient dynamics of green gram. Eight treatments comprising control, recommended dose of fertilizer (RDF) with farmyard manure (FYM), sludge, vermicompost, and press mud compost at 75% and 100% RDF levels were arranged in a Completely Randomized Design with four replications. Growth parameters (plant height, leaf area, biomass) and yield attributes (pod length, pods per plant, seeds per pod, 100-seed weight) were recorded, while soil nutrient availability (N, P, K) was assessed at periodic intervals. Results revealed that 100% RDF + Sludge (T_4) significantly outperformed all other treatments in terms of growth, yield, and sustained nutrient release, followed by 100% RDF + Vermicompost (T_6) and 100% RDF + FYM (T_2). The control (T_1) recorded the lowest performance. The findings highlight that integrating organic sources with RDF, particularly sludge, enhances soil fertility, nutrient dynamics, and green gram productivity.

Keywords: Green gram, integrated nutrient management, sludge, vermicompost, soil fertility, sustainable agriculture

1. Introduction

Green gram (*Vigna radiata* L.), commonly known as mung bean, is an important pulse crop cultivated widely in tropical and subtropical regions. It serves as a vital source of dietary protein, vitamins, and minerals, thereby contributing significantly to food and nutritional security, particularly in developing countries. Its short duration, adaptability to diverse climatic conditions, and ability to fix atmospheric nitrogen make it suitable for crop rotation and intercropping systems, enhancing soil fertility and reducing the reliance on synthetic fertilizers. Despite its importance, green gram productivity in India remains low compared to global averages, largely due to environmental stress, poor soil fertility, and sub-optimal agronomic practices. The crop is highly sensitive to planting date, cultivation methods, and soil nutrient availability, which directly influence yield parameters such as plant height, pod number, seed weight, and biological yield. Integrated nutrient management (INM), combining organic and inorganic sources, has been shown to enhance soil fertility, improve nutrient use efficiency, and sustain productivity. Organic amendments such as farmyard manure (FYM), vermicompost, press mud compost, and sludge not only supply macro- and micronutrients but also improve soil structure, microbial activity, and nutrient availability. On the other hand, inorganic fertilizers provide readily available nutrients, particularly nitrogen, phosphorus, and potassium (NPK), which are essential for plant growth and development. However, their excessive and imbalanced use can lead to soil degradation and nutrient losses. Therefore, an integrated approach that combines both nutrient sources is necessary to ensure soil health and sustainable crop production. In this context, the present study was undertaken to evaluate the effect of different nutrient sources on the growth and yield of green gram under pot culture conditions.

2. Materials and Methods

2.1. Experimental Site and Soil Sampling

The study was conducted during June-September 2025 at the Department of Soil Science and Agricultural Chemistry, PGP College of Agricultural Sciences, Namakkal, Tamil Nadu. Soils representing different textural classes (silty clay loam, sandy loam, sandy clay, and clay loam) were collected from selected villages around Namakkal, air-dried, sieved (2 mm), and used for pot culture.

2.2. Experimental Design and Treatments

Table 1: The experiment was laid out and treatment details (Pot Experiment)

Treatment	Treatment Description
T_1	Control (No amendment)
T_2	100% RDF + FYM
T_3	75% RDF + Sludge
T_4	100% RDF + Sludge
T_5	75% RDF + Vermicompost
T_6	100% RDF + Vermicompost
T_7	75% RDF + Press mud compost
T_8	100% RDF + Press mud compost

Each pot was filled with 10 kg of soil, and 10 seeds of green gram (*Vigna radiata* L., var. VBN 11) were sown. After germination, seedlings were thinned to five per pot. Seeds were treated with Azospirillum or Trichoderma viride at 4 g kg^{-1} prior to sowing. Soil moisture was maintained at 60-70% of field capacity throughout the experiment.

2.3. Data Collection

Growth parameters such as plant height, number of leaves, leaf area, and biomass accumulation were recorded at different growth stages. Yield parameters including dry matter production, number of pods per plant, pod length, seeds per pod, 100-seed weight, grain weight, and straw yield were recorded at harvest.

2.4. Soil and Nutrient Analysis

Soil nutrient dynamics were studied at 5, 10, 15, 20, and 45 days after sowing. Available nitrogen was estimated by the Kjeldahl method, phosphorus by molybdenum blue colorimetry, and potassium by flame photometry.

Observations and Yield Attributes

Growth Observations

Growth of green gram was significantly influenced by the different nutrient sources. Treatments receiving integrated nutrient management showed higher plant height, leaf area, and biomaJss accumulation compared to control. Among the treatments, T_4 (100% RDF + Sludge) recorded the tallest plants and maximum leaf area, followed by T_6 (100% RDF + Vermicompost) and T_2 (100% RDF + FYM). The control (T_1) consistently showed the lowest growth values.

Yield Attributes

Yield attributes such as number of pods per plant, seeds per pod, pod length, 100-seed weight, plant dry weight, biomass production, and test weight varied significantly among treatments

2.5. Statistical Analysis

All data were analyzed using analysis of variance (ANOVA) under CRD, and treatment means were compared at a 5% level of significance. Graphical representations were prepared to illustrate nutrient release and treatment effects.

Table 2: Details of different nutrient sources used for pot Experiment

S. No.	Particulars	Pot Experiment
1	Crop	Green gram (*Vigna radiata* L.) - Variety VBN 11
2	Experimental design	Completely Randomized Design (CRD) with 8 treatments and 3 replications
3	Season	Adipattam (Kharif), June-September 2025
4	Location	Department of Soil Science and Agricultural Chemistry, PGP College of Agricultural Sciences, Namakkal, Tamil Nadu
5	Soil used	Different textures - silty clay loam, sandy loam, sandy clay, clay loam
6	Pot size and filling	Earthen pots filled with 10 kg air-dried soil (2 mm sieved)
7	Seed rate & sowing	10 seeds per pot, later thinned to 5 seedlings
8	Seed treatment	*Azospirillum* or *T. viride* @ 4 g kg^{-1} of seed
9	Moisture management	Soil moisture maintained at 60-70% field capacity
10	Observations recorded	Plant height, number of leaves, leaf area, biomass, yield attributes
11	Nutrient analysis methods	N - Kjeldahl digestion P - Molybdenum blue colorimetry K - Flame photometry

3. Results and Discussion

Growth Parameters

Growth of green gram was significantly influenced by nutrient sources (Table 3). Among the treatments, T_4 (100% RDF + Sludge) and T_6 (100% RDF + Vermicompost) recorded superior plant height, leaf area, and biomass accumulation compared to other treatments. The lowest growth was observed in the control (T_1). The beneficial effect of sludge and vermicompost may be attributed to their higher nutrient availability and improved soil microbial activity, which enhanced root development and nutrient uptake. Similar positive effects of organic amendments on legume growth have been reported by Meena *et al*. (2016) [1] and Yubaraj *et al*. (2016) [2].

Yield Attributes

Yield attributes such as number of pods per plant, pod length, seeds per pod, and 100-seed weight showed significant variation among treatments (Table 2). T_7 (75% RDF + Press Mud Compost) recorded the maximum number of pods per plant (75.3), while T_8 (100% RDF + Press Mud Compost) registered the highest seeds per pod (14.0). The maximum test weight was observed in T_6 (100% RDF + Vermicompost). These results suggest that integrated nutrient management (INM) improved pod setting and seed development due to better synchronization of nutrient release with crop demand. (Table.3)

Biomass and Dry Matter Accumulation

Biomass production was significantly higher in integrated treatments (Table.3) compared to control. T_8 (100% RDF + Press Mud Compost) produced the highest total biomass (28.52 g plant^{-1}), while control (T_1) showed the lowest. Dry matter accumulation followed a similar trend. These findings corroborate earlier studies by Jat *et al*. (2012) [3], who observed higher biomass production in green gram with combined application of FYM and NPK.

Nutrient Dynamics

Nutrient release patterns revealed that nitrogen, phosphorus, and potassium availability increased steadily up to 20 days after sowing and then declined. Among the treatments, T_4 (100% RDF + Sludge) consistently maintained higher levels of N, P, and K throughout the crop growth period, followed by T_6 (100% RDF + Vermicompost) and T_2 (100% RDF + FYM). This indicates that sludge not only supplied nutrients directly but also improved nutrient mineralization in soil, resulting in sustained availability. These results are in line with Barral *et al*. (2021) [4], who reported that sludge application enhances nutrient release and availability in soils.

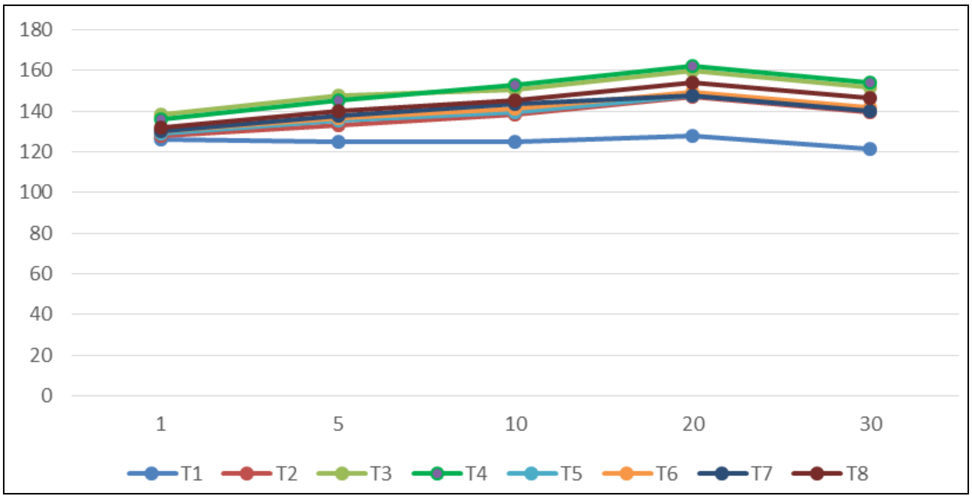
Overall Treatment Performance

Overall, T_4 (100% RDF + Sludge) was the most effective treatment, showing superior performance in growth, yield attributes, and nutrient dynamics, followed by T_6 (100% RDF + Vermicompost) and T_2 (100% RDF + FYM). The integration of organic amendments with recommended fertilizer dose improved nutrient use efficiency and soil fertility compared to sole fertilizer application.

Nitrogen dynamics (Graph 1.)

This chapter presents the findings from the experiment, which examined the nutrient dynamics in soil following the application of various amendments, including Farmyard Manure (FYM), Vermicompost, Pressmud, and Sludge, alongside different doses of Recommended Dose of Fertilizer (RDF). The study primarily focused on the availability and release of Nitrogen (N), Phosphorus (P), and Potassium (K) over a 30-day period, with soil samples analysed at intervals of 1, 5, 10, 20, and 30 days.

4.1 Nitrogen Dynamics



Graph 1: Nitrogen

4.1.1 Nitrogen Release over Time

Nitrogen release increased gradually across all treatments until day 20, after which it started to decrease slightly. T_1 (Control) showed lower Nitrogen release compared to the amended treatments, which emphasizes the role of amendments in enhancing nutrient availability. T_2 (100% RDF + FYM) demonstrated moderate Nitrogen release, peaking around day 20, reflecting the organic nature of FYM, which tends to release Nitrogen gradually. T_4 (100% RDF + Sludge) had the highest Nitrogen release, with a significant increase from day 5 to day 20, maintaining a good level of availability throughout the experiment. T_6 (100% RDF + Vermicompost) also exhibited good Nitrogen release, though not as substantial as T_4, with a similar peak on day 20. The treatments with 75% RDF, such as T_3 (75% RDF + Sludge), T_5 (75% RDF + Vermicompost), and T_7 (75% RDF + Pressmud), showed relatively lower Nitrogen release than their 100% RDF counterparts, indicating that a full RDF dose enhances nutrient availability.

4.1.2 Nitrogen Dynamics Interpretation

The treatment T_4 (100% RDF + Sludge) demonstrated a strong ability to release and maintain Nitrogen, making it an ideal choice for promoting Nitrogen availability in soils. T_2 (100% RDF + FYM) and T_6 (100% RDF + Vermicompost) provided substantial Nitrogen release but were surpassed by the efficiency of T_4 in maintaining consistent Nitrogen levels.

The findings highlight that while all amended treatments improved Nitrogen availability, Sludge combined with 100% RDF had the most significant impact on sustained Nitrogen release.

4.2.1 Phosphorus Release over Time

Phosphorus availability remained stable until day 20, after which it increased significantly in all treatments. The treatment T_4 (100% RDF + Sludge) again demonstrated the highest Phosphorus release, especially between day 15 and day 30. T_8 (100% RDF + Pressmud) followed closely, showing a considerable increase in Phosphorus availability after day 15, although it remained slightly lower than T_4. T_2 (100% RDF + FYM) and T_6 (100% RDF + Vermicompost) showed moderate Phosphorus release, with T_2 performing slightly better in this aspect. Treatments with 75% RDF, such as T_3 (75% RDF + Sludge), provided moderate Phosphorus release but were less effective than the 100% RDF treatments.

4.2.2. Phosphorus Dynamics Interpretation

The treatments T_4 (100% RDF + Sludge) had the most sustained and substantial Phosphorus release, indicating its effectiveness in improving Phosphorus availability. T_8 (100% RDF + Pressmud) showed improvement, though it was slightly less effective than Sludge. T_2 (100% RDF + FYM) and T_6 (100% RDF + Vermicompost) performed well, though the results suggest that Sludge is more efficient in maintaining higher Phosphorus levels in the soil.

4.3.1 Potassium Release over Time

Potassium release increased significantly after day 20 across most treatments. T_4 (100% RDF + Sludge) led in Potassium release, showing a consistent increase up to day 30. T_2 (100% RDF + FYM) and T_6 (100% RDF + Vermicompost) also exhibited good Potassium release, though they were slightly lower compared to T_4. T_8 (100% RDF + Pressmud) showed some improvement in Potassium availability but did not match the performance of Sludge. Treatments with 75% RDF, while effective, generally showed lower Potassium availability compared to the treatments with 100% RDF.

4.3.2 Potassium Dynamics Interpretation

The treatment T_4 (100% RDF + Sludge) was highly effective in maintaining consistent Potassium release, suggesting that Sludge not only supports Nitrogen and Phosphorus availability but also contributes to Potassium availability in soils. T_2 (100% RDF + FYM) and T_6 (100% RDF + Vermicompost) provided notable Potassium release but at slightly lower levels than Sludge. T_8 (100% RDF + Pressmud) contributed to Potassium availability, but its performance was not as pronounced as Sludge's in this context.

4.4 Overall Comparison of Treatments

The overall comparison of the treatments reveals that T_4 (100% RDF + Sludge) consistently outperformed other treatments in releasing and maintaining the availability of Nitrogen, Phosphorus, and Potassium. The treatment T_2 (100% RDF + FYM) and T_6 (100% RDF + Vermicompost) were also effective in releasing nutrients but did not match the efficiency of T_4. T_8 (100% RDF + Pressmud), while demonstrating good results, showed slightly lower nutrient release compared to Sludge, particularly in terms of Nitrogen and Potassium availability. Treatments with 75% RDF, including T_3 (75% RDF + Sludge) and T_7 (75% RDF + Pressmud), were beneficial but produced lower nutrient availability compared to the treatments with 100% RDF, highlighting the significance of applying the full RDF dose for maximizing nutrient release.

4.5 Implications for Soil Health and Nutrient Management

The treatment T_4 (100% RDF + Sludge) proved to be the most effective in ensuring consistent nutrient availability across all three major nutrients (N, P, K). This indicates that Sludge, when combined with 100% RDF, is an excellent option for enhancing soil fertility and promoting sustainable agricultural practices. T_2 (100% RDF + FYM) and T_6 (100% RDF + Vermicompost) were also viable treatments, providing gradual and sustained nutrient release, though they were slightly less effective than Sludge. The use of T_8 (100% RDF + Pressmud), while beneficial, provided lower overall nutrient release compared to Sludge but is still an effective option for soil fertility management. T_1 (Control) exhibited lower nutrient availability, emphasizing the necessity of incorporating soil amendments to improve and maintain soil fertility.

In conclusion, Sludge combined with 100% RDF (T_4) has proven to be the most effective treatment for maintaining the availability of essential nutrients such as Nitrogen, Phosphorus, and Potassium. This result highlights the potential of Sludge as an excellent soil amendment that can enhance nutrient release and improve soil health, supporting sustainable agriculture.

Nutrient dynamics study

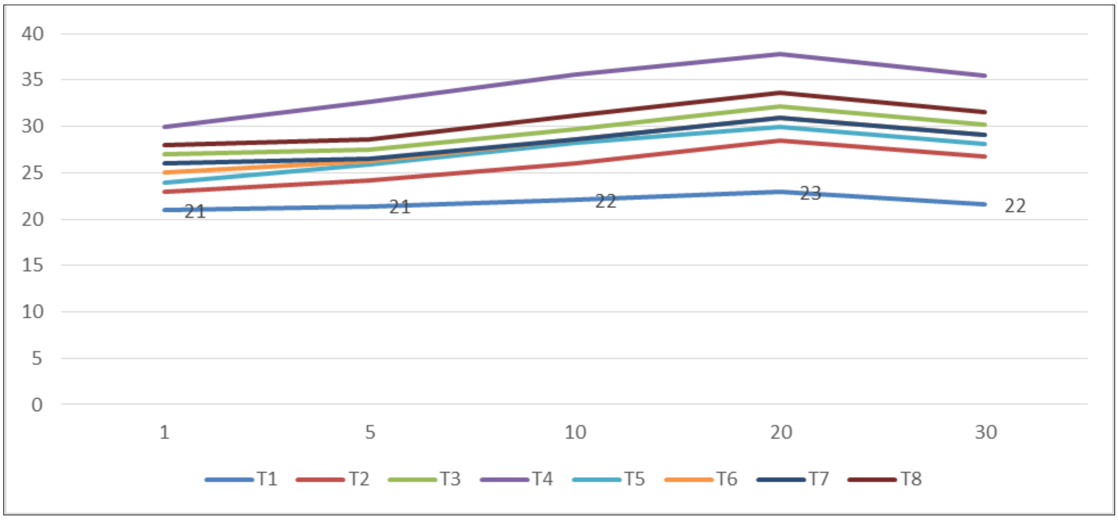
Soil fertility is a critical component of sustainable agriculture, directly affecting crop productivity and ecosystem health. Nutrient dynamics in the soil, including the processes of mineralization, immobilization, and leaching, play a crucial role in determining the availability of essential nutrients like nitrogen (N), phosphorus (P), and potassium (K). Organic amendments, such as FYM, vermicompost, pressmud, and distillery sludge, are increasingly being used to enhance soil fertility, but their effects on nutrient dynamics need to be understood comprehensively Lal, R. (2015) [5].

Nutrient dynamics of N

The nutrient release and nutrient dynamics of fertilized containers shows notable variation in nutrient availability when compared with the absolute control (T_1). Application of soil amendments also registered a significant impact on nutrient dynamics. Among the different treatments/ amendments distillery sludge from sugar industry recorded the highest nutrient availability over all the other amendments. Sludge application recorded 10.8 per cent increased N availability over T_2 (100 % NPK + FYM) even at 30 days after incubation that indicates the availability of N at slower rate which can support the crop growth until flowering stage. Similar nutrient release from amendments was reported by Barral *et al.*, 2021 [4]. Though, it is on par with application of press mud application the N release was comparatively higher in sludge application though out the experiment.

Nutrient dynamics of P

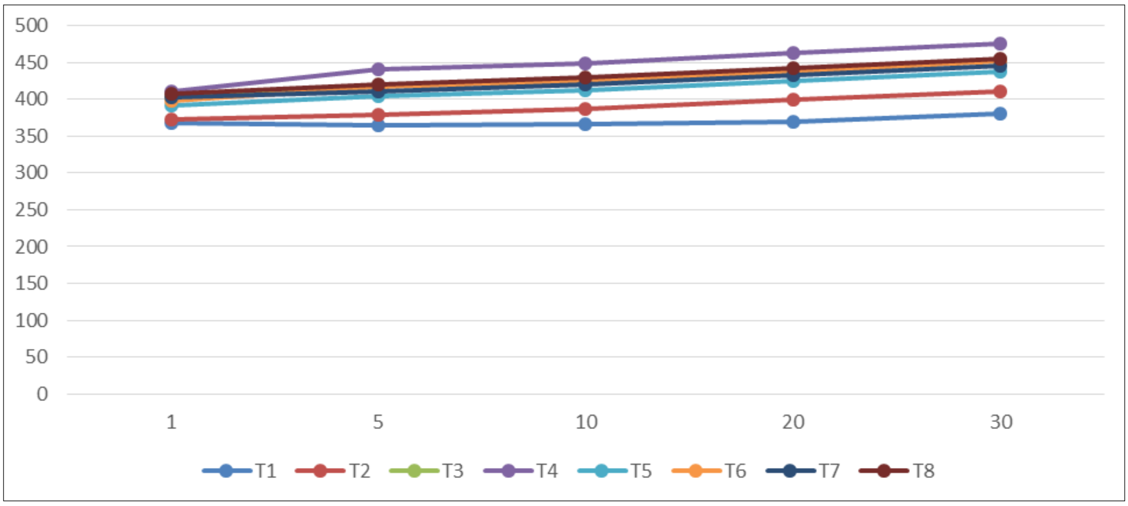
Like N the release of P also revealed that the application of amendments has significant influence over the P release. The P availability was higher with the treatment applied with sludge over other treatments. The percent increase over press mud application is 11.1 per cent. This might be due to the application of sludge which possess higher amount P in it (Barral *et al.*, 2021) [4].



Graph 2: Phosporus

Nutrient dynamics of K

Contrarily the availability of K exists till the last sampling date. Similar to N and P the treatment received the sludge recorded the highest K availability which may be due to the release of lattice K (red soil) and release of K from sludge. However, the press mud applications also reveals the significant improvement of soil K (Barral *et al.*, 2021) [4].



Graph 3: Potassium

Table 3: Effect of different soil textures on growth, yield and quality parameters of green gram

Treatments	No. of Clusters hill^{-1}	Length of pod (cm)	No. of Pods hill^{-1}	No. of Seeds pod^{-1}	100 seed weight (g)	Plant dry weight (g)	Biomass Production (g plant^{-1})	Test weight (g)
T_1	4.55	7.6	24.2	11.5	3.25	12.82	11.94	28.83
T_2	4.80	7.8	37.4	12.2	3.32	12.84	20.43	29.10
T_3	4.98	7.5	40.9	11.8	3.24	14.62	21.25	29.13
T_4	5.60	7.6	56.8	12.3	3.25	12.24	23.64	29.60
T_5	7.04	7.6	31.4	12.3	3.25	11.66	26.26	29.70
T_6	7.99	7.7	49.4	12.0	3.28	12.32	27.22	30.43
T_7	8.74	7.6	75.3	12.0	3.24	11.69	28.32	29.83
T_8	9.35	7.9	38.3	14.0	3.21	15.60	28.52	29.93
Mean	6.63	7.66	44.34	12.14	3.25	13.22	23.45	6.63
SEd	1.64	3.77	2.00	0.01	0.50	22.53	1.69	0.54
CD (5%)	2.07	7.40	4.99	0.03	1.12	15.72	4.22	1.35

Table 4: Nutrient dynamics of pot culture experiment using green gram:

S. No	Day -5			Day -10			Day-15			Day -20			Day -45		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T_1	126	21	368	125	21	365	125	22	366	128	23	370	122	22	381
T_2	128	23	372	133	24	379	138	26	387	147	28	399	139	27	411
T_3	136	27	402	148	28	418	151	30	426	160	32	439	152	30	452
T_4	138	30	411	146	33	440	153	36	449	162	38	462	154	36	476
T_5	129	24	392	135	26	404	140	28	412	148	30	424	140	28	437
T_6	130	25	397	137	26	417	141	29	425	149	31	438	142	29	451
T_7	130	26	403	138	27	411	143	29	419	148	31	432	140	29	445
T_8	132	28	408	140	29	420	146	31	429	154	34	442	147	32	455
CD (0.05)	2.290	NS	16.9	9.001	7.412	12.487	9.001	7.412	8.369	11.329	6.924	7.462	7.932	4.714	5.157

Summary and Conclusion

The study evaluated the effect of different organic amendments (FYM, Vermicompost, Pressmud, Sludge) in combination with Recommended Dose of Fertilizer (RDF) on the growth, yield, and nutrient dynamics of green gram under pot culture conditions. Soils from different villages varied in texture from clay loam to sandy loam, with pH ranging from 7.8 to 8.6 and generally low nitrogen content but high potassium content.

Growth parameters like plant height, number of clusters, pods per hill, seeds per pod, 100-seed weight, plant dry weight, biomass, and test weight varied significantly across treatments. The T_4 (100% RDF + Sludge) treatment consistently recorded the highest values for yield parameters, followed by T_2 (100% RDF + FYM) and T_6 (100% RDF + Vermicompost).

Nutrient dynamics showed that nitrogen, phosphorus, and potassium release increased steadily up to day 20, with T_4 outperforming all other treatments in maintaining higher and sustained nutrient availability. Treatments with 75% RDF showed lower nutrient release compared to 100% RDF combinations. Sludge application resulted in about 10-11% higher nutrient availability compared to FYM or Pressmud.

The experiment clearly demonstrated that 100% RDF combined with Sludge (T_4) is the most effective treatment for enhancing growth, yield, and nutrient availability in green gram. Sludge provided sustained release of N, P, and K throughout the crop growth period, supporting better plant performance and soil fertility improvement.

FYM and Vermicompost, when combined with 100% RDF, also improved crop growth and nutrient dynamics, though slightly less than Sludge. Pressmud was beneficial but less effective than other amendments.

The findings highlight that applying full RDF along with suitable organic amendments, particularly Sludge, can significantly improve green gram productivity and soil health, making it a promising practice for sustainable agriculture.

The soils obtained from Belukurichi village, Bommasanudram village registered highest growth and yield of green gram as compare to Akkiampatti village and Kalappanayaikenpatti village were found moderate growth and yield. Similar findings were realized by Shanmugasundaram and Savithri (2000) [6]. Sandy loam soils of Mettupalayam had low soil fertility, possibly due to high fractions of sand and unbalanced concentrations of NPK in the soils.

The study revealed that soil's physical and chemical characteristics, along with fertility status, influence the production of Green gram. The interaction of soil texture and crops can be utilized for maximum gain by technological interventions and good agricultural practices. The growth and yield parameters of Green gram irrespective verities were found maximum under sole cropping compared to intercropping with soil textures However, contrary the growth and yield parameters of Clay loam soil texture were found maximum pod yield of green gram.

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