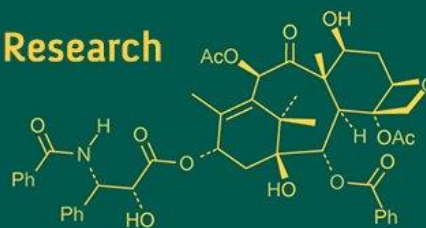


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Influence of sewage sludge and FYM conjugated with RDF (NPK) on growth and yield of green gram (*Vigna radiata* L.)

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Abstract

A field experiment was conducted during the *Zaid* seasons of 2023 and 2024 at the research farm of the Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (Uttar Pradesh), to evaluate the effect of sewage sludge (SS) and farmyard manure (FYM) conjugated with recommended doses of NPK on growth and yield of green gram (*Vigna radiata* L.). The experiment was laid out in a Factorial Randomized Block Design (FRBD) with four levels each of sewage sludge (0, 35, 70, and 105%) and FYM (0, 35, 70, and 105%), resulting in sixteen treatment combinations replicated thrice. The combined application of SS 105% + FYM 105% significantly increased plant height (40.69 cm), effective nodules (21.99 plant⁻¹), dry matter accumulation (26.83 g plant⁻¹), seed yield (1356 kg ha⁻¹), and straw yield (2431 kg ha⁻¹) over the control. The study confirms that integrated organic nutrient management improves soil fertility and productivity of green gram. The study concludes that integrated application of sewage sludge and FYM along with RDF (NPK) is an effective strategy for improving soil fertility, crop growth, and productivity of green gram under Indo-Gangetic plains.

Keywords: Sewage sludge, FYM, NPK, green gram, integrated nutrient management

Introduction

India is predominantly an agricultural country, with nearly 54.6% of its population directly or indirectly dependent on agriculture for livelihood. The agricultural sector contributes about 17-18% to India's Gross Domestic Product (GDP) and plays a vital role in food security and rural development (Ministry of Agriculture & Farmers' Welfare, 2022). However, declining soil fertility due to intensive cultivation, imbalanced fertilizer use, and low organic matter input has become a major constraint to sustainable crop production. Indian soils, particularly in the Indo-Gangetic plains, are often deficient in nitrogen, phosphorus, and micronutrients such as zinc. The soils of Prayagraj region are predominantly sandy loam to loam in texture with low organic carbon and moderate fertility. The combined use of chemical fertilizers, organic manures, and biofertilizers, is considered essential for sustaining soil health and crop productivity. Sewage sludge is a nutrient-rich organic amendment containing macro- and micronutrients and organic matter. Sewage sludge (SS) contains organic matter that initially causes immobilization of N and P by microbes, followed by mineralization that makes nutrients available to plants later. This gives a residual benefit for the next crop and helps reduce chemical fertilizer use (Jatav *et al.*, 2021) [6]. Sewage sludge (SS) improves soil properties like structure, moisture, permeability, cation exchange capacity, nutrient availability and humus content (Marinari *et al.*, 2002; Petersen *et al.*, 2003; Atienza-Martínez *et al.*, 2013) [9, 16, 2]. It can also reduce soil pH and increase electrical conductivity (Pascual *et al.*, 2009) [14]. While FYM improves soil structure, microbial activity, and nutrient availability through slow release. FYM also contains small amounts of micronutrients and heavy metals such as calcium (Ca), magnesium (Mg), sulfur (S), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), and boron (B), heavy metals such as cadmium (0.01-0.57 mg kg⁻¹), lead (0.24-2.35 mg kg⁻¹), and chromium (0.01-0.57 mg kg⁻¹). (Suthar *et al.*, 2012) [21]. Green gram (*Vigna radiata* L.), an important pulse crop, responds well to organic nutrient inputs and biological nitrogen fixation, particularly when inoculated with PSB.

PSB enhance the availability of phosphorus in the soil by solubilizing insoluble phosphate compounds through the production of organic acids, enzymes, and other metabolites. For instance, studies have shown that PSB can effectively solubilize tricalcium phosphate and other inorganic phosphates, thereby increasing the phosphorus content available to plants (Park *et al.*, 2011; Oteino *et al.*, 2015; Saeid *et al.*, 2018) [13, 12, 18]. Therefore, the present study was undertaken to assess the combined effect of sewage sludge and FYM conjugated with NPK on growth and yield of green gram.

Materials and Methods

A field experiment was conducted during the *Zaid* seasons of 2023 and 2024 at the research farm of the Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj, Uttar Pradesh, to study the effect of sewage sludge and farmyard manure (FYM) conjugated with NPK on growth and yield of green gram (*Vigna radiata* L.). The experiment was laid out in a Factorial Randomized Block Design (FRBD) with sixteen treatment combinations comprising four levels of sewage sludge (0, 35, 70 and 105%) and four levels of FYM (0, 35, 70 and 105%) which means (0, 7, 14 and 21 ton ha⁻¹) of dose of both SS and FYM along with the recommended dose of NPK fertilizers, replicated three times. The experimental soil was sandy loam in texture, slightly acidic to neutral in reaction (pH 6.89), low in organic carbon (0.37%) and available nitrogen (238.31 kg ha⁻¹), and medium in available phosphorus (21.41 kg ha⁻¹) and potassium (141.4 kg ha⁻¹). Green gram variety used was 'Star-444'. Sewage sludge and FYM were applied as per treatments before sowing, while recommended NPK fertilizers were applied uniformly to all plots. Standard agronomic practices were followed throughout the crop growth period. Observations on growth parameters, nodulation, yield attributes, seed and straw yield were recorded at appropriate stages, and the collected data were statistically analyzed using analysis of variance (ANOVA) appropriate for FRBD.

Results and Discussion

The data presented in Table 1 and 2 clearly demonstrate the significant positive effects of sewage sludge and farmyard manure (FYM) conjugated with NPK on the growth and yield parameters of green gram.

Effect of Sewage Sludge

Application of sewage sludge (SS) had a pronounced and significant effect on growth, nodulation, dry matter accumulation, and yield attributes of green gram during both *Zaid* seasons of 2023 and 2024 (Table 1). A consistent and progressive improvement in all parameters was observed with increasing levels of sewage sludge from SS₀ to SS₁₀₅, indicating the beneficial role of sewage sludge in improving soil fertility and crop performance. Plant height increased significantly with increasing levels of sewage sludge at all growth stages. During *Zaid* 2023, plant height at harvest increased from 36.31 cm under SS_{0%} to 40.49 cm under SS_{105%}, while during *Zaid* 2024 it increased from 36.67 cm to 40.89 cm. Similar increasing trends were observed at 40 and 60 DAS. The positive response can be attributed to the rich nutrient composition of sewage sludge, which supplies

not only essential macronutrients (N, P, K) but also secondary and micronutrients in plant-available forms (Singh & Agrawal, 2008) [19]. The number of trifoliate leaves and branches per plant increased significantly with higher levels of sewage sludge. SS_{105%} recorded the maximum number of trifoliate leaves at harvest (14.97 in 2023 and 15.33 in 2024) and branches per plant (10.73 and 11.31, respectively). This positive effect can be attributed to the nutrient-rich nature of sewage sludge, particularly its high nitrogen, phosphorus, and micronutrient content, which promotes root growth and symbiotic activity of *Rhizobium* (Singh & Agrawal, 2008; Pathak *et al.*, 2009) [19, 15]. Total and effective nodules per plant were significantly influenced by sewage sludge application. During 2023, total nodules increased from 18.66 plant⁻¹ under SS_{0%} to 23.65 plant⁻¹ under SS_{105%}, while effective nodules increased from 13.75 to 20.02 plant⁻¹. Similar trends were recorded during 2024. Dry matter accumulation increased significantly with increasing levels of sewage sludge at all growth stages. At harvest, dry matter accumulation increased from 16.26 g plant⁻¹ under SS_{0%} to 25.59 g plant⁻¹ under SS_{105%} during 2023, and from 15.76 to 23.50 g plant⁻¹ during 2024. This improvement may be attributed to the high nutrient content of sewage sludge, particularly nitrogen and phosphorus, which enhance cell division and elongation in the apical meristems, thereby stimulating branch initiation and growth (Singh & Agrawal, 2008) [19]. Similar results were reported by Kumar *et al.* (2017) [7]. Seed and straw yields were significantly improved by sewage sludge application. The highest seed yield was recorded under SS_{105%} (1112 kg ha⁻¹ in 2023 and 1327 kg ha⁻¹ in 2024), compared to the lowest under SS_{0%}. Straw yield followed a similar trend, with SS_{105%} producing 2386 kg ha⁻¹ in 2023 and 2475 kg ha⁻¹ in 2024. The enhancement in straw yield due to higher levels of SS may be attributed to improved soil fertility, better microbial activity, and sustained nutrient release throughout the crop growth period. These findings are supported by Meena *et al.*, (2020) [10] and Verma *et al.*, (2022) [22], who reported significant increases in vegetative biomass and dry matter yield in pulses with organic nutrient application.

Effect of Farmyard Manure (FYM)

Farmyard manure (FYM) application exerted a significant influence on growth, nodulation, dry matter accumulation, and yield of green gram during both seasons (Table 1). Increasing levels of FYM resulted in gradual and consistent improvements in all parameters, highlighting the role of FYM in improving soil health and crop productivity. Plant height increased significantly with FYM application. FYM_{105%} recorded the highest plant height at harvest (39.18 cm in 2023 and 39.57 cm in 2024), while FYM₀ recorded the lowest. This improvement can be ascribed to the gradual nutrient release from decomposing organic matter, particularly nitrogen, which is crucial for vegetative growth (Antil & Singh, 2007) [1]. FYM also enhances soil aggregation, moisture retention, and microbial biomass, creating favorable conditions for crop establishment and sustained growth (Hati *et al.*, 2006) [4]. The number of trifoliate leaves and branches per plant also increased with FYM application. FYM_{105%} recorded the maximum number of leaves and branches, indicating improved vegetative growth. The slow and continuous release of nutrients from FYM ensures a steady nutrient supply throughout the crop growth period, resulting in better canopy development.

Nodulation was significantly enhanced with FYM application. FYM_{105%} recorded the highest total nodules (21.96 plant⁻¹ in 2023 and 23.38 plant⁻¹ in 2024) and effective nodules (17.85 and 19.17 plant⁻¹, respectively). The enhancement in nodulation under FYM can be linked to its role in supplying slow-release nutrients and improving soil physical properties such as porosity and aeration (Hati *et al.*, 2006) [4]. Moreover, FYM fosters microbial biomass and enzymatic activity, which benefit nitrogen-fixing bacteria and facilitate nodule development (Antil & Singh, 2007) [1]. Dry matter accumulation increased significantly with increasing FYM levels. At harvest, FYM_{105%} recorded 22.03 g plant⁻¹ in 2023 and 20.50 g plant⁻¹ in 2024, compared to significantly lower values under FYM_{0%}. The positive effect of FYM is likely due to its role in gradually releasing essential macro- and micronutrients, increasing soil organic matter, and enhancing microbial biomass (Hati *et al.*, 2006) [4]. Seed yield increased significantly with FYM application, with FYM_{105%} recording the highest seed yield (964 kg ha⁻¹ in 2023 and 1111 kg ha⁻¹ in 2024). Straw yield followed a similar trend. The consistent increase in straw yield with FYM levels could be due to the gradual mineralization of organic matter, which improved soil physical properties, moisture retention, and microbial activity, ultimately leading to higher vegetative growth. These results are in accordance with the findings of Jat *et al.*, (2019) [5] and Singh *et al.*, (2021) [20].

Effect of Interaction (Sewage Sludge × FYM)

The interaction between sewage sludge and FYM significantly influenced most growth and yield parameters of green gram during both *Zaid* seasons (Table 2). Combined application of SS and FYM proved superior to their individual application, indicating a synergistic effect. Among all treatment combinations, T16 (SS_{105%} × FYM_{105%})

consistently produced the highest values for growth, nodulation, dry matter accumulation, seed yield, and straw yield. During 2023, T₁₆ recorded 41.83 cm plant height, 24.13 total nodules plant⁻¹, 20.85 effective nodules plant⁻¹, 28.22 g plant⁻¹ dry matter accumulation, 1244 kg ha⁻¹ seed yield, and 2612 kg ha⁻¹ straw yield. Similarly, during 2024, T₁₆ recorded the highest seed yield (1468 kg ha⁻¹) and straw yield (2510 kg ha⁻¹). The numerical trends suggest additive benefits when both organic amendments are applied together, possibly due to complementary nutrient supply sewage sludge contributing readily available nutrients, and FYM providing a slow-release nutrient source and improving soil moisture retention (Bolan *et al.*, 2014) [3]. The combined application likely benefits nodulation by providing both readily available nutrients from sewage sludge and sustained nutrient release with improved soil structure from FYM (Bolan *et al.*, 2014) [3]. In contrast, the control treatment (T₁) recorded the lowest values for all parameters in both years. The superior performance of combined application may be attributed to the complementary nutrient release pattern of sewage sludge and FYM. Sewage sludge supplies readily available nutrients during early growth stages, while FYM ensures sustained nutrient release, improves soil physical properties, and enhances microbial activity. This integrated nutrient supply creates a favorable soil environment for root growth, nodulation, nutrient uptake, and yield formation. This positive interaction could be due to the complementary effects of organic amendments, which enhanced nutrient availability, improved soil structure, and promoted root development and biomass accumulation. Similar synergistic effects of organic interactions on biomass yield were reported by Kumar *et al.*, (2020) [8] and Rathore *et al.*, (2023) [17] in green gram and other pulse crops.

Table 1: Effect of sewage sludge and FYM conjugated with RDF (NPK) on growth and yield of green gram in *Zaid* seasons of 2023 and 2024

Zaid seasons of 2023																
Treatment	Plant height (cm)			Total nodules per plant	Effective nodules per plant	No. of trifoliate leaves			Number of branches per plant			Dry matter accumulation (gm)			Seed yield (kg ha-1)	Straw yield (kg ha-1)
	At 40 DAS	At 60 DAS	At harvest			At 30 DAS	At 60 DAS	At harvest	At 40 DAS	At 60 DAS	At harvest	At 40 DAS	At 60 DAS	At harvest		
Effect of Sewage sludge																
SS 0	13.36	35.95	36.31	18.66	13.75	7.75	15.94	9.10	1.38	7.12	7.34	2.90	15.06	16.26	710	1705
SS 35	15.51	37.66	38.04	20.60	16.04	9.35	17.66	11.17	1.74	7.83	8.08	3.62	17.80	19.22	836	1962
SS 70	16.97	38.80	39.19	22.35	18.19	10.40	19.44	13.35	2.25	8.87	9.14	4.66	20.01	21.61	923	2123
SS 105	18.73	40.09	40.49	23.65	20.02	11.79	20.76	14.97	3.02	10.41	10.73	6.20	23.69	25.59	1112	2386
SEm±	0.14	0.32	0.32	0.18	0.15	0.09	0.16	0.11	0.02	0.07	0.08	0.04	0.17	0.18	7.72	17.47
CD at 5%	0.40	0.92	0.93	0.53	0.43	0.25	0.46	0.31	0.06	0.21	0.22	0.12	0.48	0.52	22.31	50.46
Effect of FYM																
FYM 0	15.24	37.34	37.71	20.45	15.93	9.27	17.75	11.31	1.94	8.24	8.49	4.02	17.97	19.41	815	1884
FYM 35	15.84	38.13	38.51	21.28	16.90	9.62	18.34	12.03	2.05	8.45	8.71	4.24	18.62	20.11	877	2028
FYM 70	16.47	38.25	38.63	21.56	17.31	9.93	18.66	12.48	2.13	8.62	8.89	4.41	19.57	21.13	925	2089
FYM 105	17.01	38.79	39.18	21.96	17.85	10.47	19.05	12.77	2.28	8.91	9.19	4.70	20.40	22.03	964	2175
SEm±	0.14	0.32	0.32	0.18	0.15	0.09	0.16	0.11	0.02	0.07	0.08	0.04	0.17	0.18	7.72	17.47
CD at 5%	0.40	0.92	0.93	0.53	0.43	0.25	0.46	0.31	0.06	0.21	0.22	0.12	0.48	0.52	22.31	50.46
Zaid seasons of 2024																
Effect of Sewage sludge																
SS 0	18.34	36.13	36.67	19.56	14.19	8	16.44	10.61	1.42	7.20	7.42	2.99	14.6	15.76	768	1844
SS 35	19.21	37.85	38.42	21.7	16.85	9.83	18.55	12.29	1.82	8.01	8.26	3.8	16.91	18.27	933	2189
SS 70	19.79	39.00	39.58	24.01	19.44	11.11	20.78	14.04	2.41	9.18	9.46	4.98	18.67	20.16	1070	2383
SS 105	20.45	40.29	40.89	25.26	21.88	12.88	22.69	15.33	3.3	10.97	11.31	6.77	21.76	23.5	1327	2475
SEm±	0.16	0.32	0.32	0.19	0.16	0.09	0.17	0.11	0.02	0.08	0.08	0.04	0.16	0.17	8.94	19.24
CD at 5%	0.47	0.92	0.94	0.56	0.46	0.27	0.49	0.33	0.06	0.22	0.23	0.12	0.45	0.49	25.82	55.58

Effect of FYM																
FYM 0	19.04	37.52	38.09	21.58	16.8	9.78	18.69	12.38	2.05	8.45	8.71	4.25	17.08	18.45	918	2090
FYM 35	19.45	38.32	38.89	22.34	17.92	10.2	19.44	12.96	2.18	8.71	8.98	4.51	17.55	18.95	999	2201
FYM 70	19.51	38.44	39.02	23.22	18.47	10.6	19.89	13.27	2.28	8.92	9.2	4.72	18.32	19.79	1070	2278
FYM 105	19.78	38.98	39.57	23.38	19.17	11.24	20.45	13.66	2.45	9.27	9.55	5.07	18.98	20.5	1111	2321
SEm+	0.16	0.32	0.32	0.19	0.16	0.09	0.17	0.11	0.02	0.08	0.08	0.04	0.16	0.17	8.94	19.24
CD at 5%	0.47	0.92	0.94	0.56	0.46	0.27	0.49	0.33	0.06	0.22	0.23	0.12	0.45	0.49	25.82	55.58

Table 2: Interaction effect of sewage sludge and FYM conjugated with RDF (NPK) on growth and yield of green gram in *Zaid* seasons of 2023 and 2024

Treatment	Plant height (cm)			Total nodules per plant	Effective nodules per plant	No. of trifoliate leaves			Number of branches per plant			Dry matter accumulation (gm)			Seed yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
	At 40 DAS	At 60 DAS	At harvest			At 30 DAS	At 60 DAS	At harvest	At 40 DAS	At 60 DAS	At harvest	At 40 DAS	At 60 DAS	At harvest		
Zaid seasons of 2023																
T ₁	11.71	34.98	35.33	16.79	11.69	6.58	14.77	7.77	1.25	6.88	7.09	2.65	13.95	15.07	591	1417
T ₂	13.11	35.92	36.28	19.13	14.21	7.44	16.19	9.33	1.36	7.08	7.30	2.87	14.91	16.11	720	1727
T ₃	13.84	36.08	36.44	19.19	14.35	8.23	16.25	9.47	1.38	7.12	7.34	2.91	15.40	16.63	752	1805
T ₄	14.77	36.82	37.19	19.53	14.77	8.76	16.55	9.85	1.51	7.38	7.61	3.17	15.95	17.23	779	1870
T ₅	14.84	36.92	37.29	20.13	15.44	9.16	17.16	10.52	1.70	7.76	8.00	3.55	16.42	17.73	790	1897
T ₆	15.37	37.82	38.20	20.19	15.54	9.18	17.22	10.64	1.70	7.76	8.00	3.55	16.67	18.01	800	1921
T ₇	15.77	37.95	38.33	20.73	16.25	9.36	17.82	11.41	1.71	7.78	8.02	3.57	18.97	20.49	869	2000
T ₈	16.04	37.96	38.34	21.33	16.93	9.71	18.44	12.10	1.83	8.02	8.27	3.81	19.14	20.67	883	2030
T ₉	16.37	38.42	38.80	21.73	17.40	10.11	18.79	12.52	1.96	8.28	8.54	4.07	19.64	21.21	898	2065
T ₁₀	16.57	38.88	39.27	22.33	18.09	10.29	19.40	13.22	2.16	8.68	8.95	4.47	19.90	21.49	909	2092
T ₁₁	17.37	38.95	39.34	22.46	18.40	10.31	19.59	13.60	2.38	9.12	9.40	4.91	20.11	21.72	933	2147
T ₁₂	17.57	38.96	39.35	22.86	18.86	10.88	20.00	14.07	2.51	9.38	9.67	5.17	20.38	22.01	952	2190
T ₁₃	18.04	39.02	39.41	23.13	19.21	11.24	20.27	14.42	2.83	10.02	10.33	5.81	21.87	23.62	980	2155
T ₁₄	18.32	39.88	40.28	23.46	19.76	11.56	20.56	14.94	2.96	10.28	10.60	6.07	22.99	24.83	1078	2372
T ₁₅	18.91	40.02	40.42	23.86	20.25	11.83	20.96	15.44	3.05	10.46	10.79	6.25	23.78	25.69	1145	2404
T ₁₆	19.65	41.42	41.83	24.13	20.85	12.51	21.24	15.07	3.25	10.86	11.20	6.65	26.13	28.22	1244	2612
SEm+	0.28	0.64	0.64	0.36	0.30	0.17	0.32	0.22	0.04	0.15	0.15	0.08	0.33	0.36	15.45	34.94
CD at 5%	NS	NS	NS	NS	0.86	0.50	NS	0.63	0.11	0.43	NS	0.23	0.97	1.04	44.62	100.93
Zaid seasons of 2024																
T ₁	17.84	35.15	35.68	17.35	11.92	6.71	15.07	9.46	1.28	6.91	7.13	2.70	13.68	14.77	619	1486
T ₂	18.32	36.10	36.64	19.92	14.64	7.66	16.68	10.85	1.40	7.17	7.39	2.96	14.48	15.64	779	1871
T ₃	18.40	36.26	36.81	20.42	14.85	8.52	16.82	10.91	1.43	7.22	7.44	3.01	14.88	16.07	819	1965
T ₄	18.78	37.00	37.56	20.55	15.36	9.11	17.21	11.20	1.57	7.50	7.74	3.30	15.34	16.57	856	2053
T ₅	18.83	37.10	37.66	20.90	16.10	9.55	17.90	11.80	1.77	7.91	8.15	3.70	15.74	17.00	872	2092
T ₆	19.29	38.01	38.58	20.94	16.26	9.60	18.01	11.86	1.78	7.92	8.16	3.71	15.94	17.22	886	2127
T ₇	19.36	38.14	38.71	22.31	17.14	9.87	18.80	12.45	1.80	7.97	8.22	3.77	17.83	19.26	976	2245
T ₈	19.36	38.15	38.72	22.66	17.91	10.27	19.50	13.05	1.94	8.24	8.49	4.03	18.14	19.59	996	2292
T ₉	19.60	38.61	39.19	23.25	18.46	10.73	19.94	13.40	2.08	8.52	8.79	4.32	18.29	19.75	1018	2342
T ₁₀	19.83	39.07	39.66	23.56	19.25	10.95	20.65	14.00	2.30	8.96	9.24	4.76	18.69	20.19	1037	2354
T ₁₁	19.87	39.14	39.73	24.55	19.76	11.07	21.04	14.18	2.56	9.47	9.77	5.27	18.81	20.31	1098	2405
T ₁₂	19.87	39.15	39.74	24.67	20.30	11.71	21.52	14.58	2.70	9.76	10.07	5.56	18.89	20.40	1125	2430
T ₁₃	19.90	39.22	39.80	24.82	20.72	12.13	21.87	14.85	3.05	10.47	10.79	6.27	20.61	22.26	1162	2440
T ₁₄	20.34	40.08	40.68	24.96	21.54	12.60	22.41	15.13	3.23	10.81	11.15	6.62	21.09	22.78	1291	2453
T ₁₅	20.41	40.22	40.82	25.60	22.14	12.93	22.91	15.53	3.33	11.03	11.37	6.83	21.76	23.50	1388	2498
T ₁₆	21.13	41.63	42.25	25.65	23.12	13.87	23.56	15.80	3.60	11.57	11.93	7.37	23.56	25.44	1468	2510
SEm+	0.32	0.64	0.65	0.39	0.32	0.18	0.34	0.23	0.04	0.15	0.16	0.09	0.31	0.34	17.83	38.49
CD at 5%	NS	NS	NS	NS	0.92	0.53	NS	0.66	0.12	0.44	NS	0.25	0.90	0.97	51.64	111.17

Conclusion

The study clearly demonstrates that both application of sewage sludge and farmyard manure (FYM) conjugated with recommended NPK had a significant and positive influence on growth, nodulation, dry matter accumulation, and yield of green gram during the *Zaid* seasons of 2023 and 2024. Increasing levels of sewage sludge and FYM resulted in consistent improvement in all observed parameters compared to the control. Sewage sludge application proved more effective than FYM in enhancing plant height, nodulation, dry matter accumulation, seed yield, and straw yield. The highest level of sewage sludge (SS_{105%}) and FYM (FYM_{105%}) recorded maximum values for growth attributes,

dry matter accumulation, seed yield, and straw yield during both seasons, indicating its ability to supply readily available nutrients and improve soil fertility. The combined application of sewage sludge and FYM at their highest levels (SS_{105%} × FYM_{105%}) consistently produced the highest plant height, nodulation, dry matter accumulation, seed yield, and straw yield in both years. This treatment combination proved superior due to the complementary effects of sewage sludge and FYM, where sewage sludge supplied nutrients rapidly during early growth stages and FYM ensured sustained nutrient availability throughout the crop growth period. Overall, the results of the study indicate that integrated application of sewage sludge and FYM along

with recommended NPK is an effective and sustainable nutrient management strategy for enhancing productivity of green gram. The combined use of SS_{105%} and FYM_{105%} can be recommended for green gram cultivation under similar agro-climatic conditions, provided the sewage sludge is safe and within permissible limits of heavy metals.

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