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RESEARCH ARTICLE

USE OF GANGA SLUDGE AS ORGANIC MANURES AND THEIR EFFECT ON THE GROWTH AND YIELD OF PEA (*PISUM SATIVUM*)

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ABSTRACT

This study was focused on the assessment of the efficiency of Ganga sludge-based organic fertilizers on growth and yield parameters of a leguminous crop pea (*Pisum sativum*). The plant parameters like plant height, total biomass (root and shoot), leaf area, total chlorophyll, number of pods per plant and pods weight per plot were investigated during this study. All fertilizer treatments have the potential to affect the growth and yield of pea crops when used singly or in combination. Similarly, effects on the increase in leaf area also showed increased content of total chlorophyll. From these findings, it was concluded that organic fertilizers from sludge and their effects on the growth and yield of peas is an efficient and eco-friendly way to manage Ganga sludge. Apart from peas such experiments should also be carried out on other crops.

KEYWORDS

Ganga sludge, eco-friendly management, organic fertilizers, pea, *Pisum sativum*

1. INTRODUCTION

Organic fertilizers provide the majority of essential plant nutrients, improving actual crop productivity and also leaving beneficial residual effects on succeeding crops (Ghosh et al. 2004). Incorporation of organic fertilizers into soil causes a large and rapid increase in the soil microbial biomass and increases CO2 emissions which ultimately improves soil structure and fertility (Ghoshal and Singh, 1995; Heinze et al., 2010). These environmentally friendly fertilizers are easy to use and available to crops for a longer duration (Jensen et al., 1997; Terhoeven-Urselmans et al., 2009).

The waste from the agriculture sector, food industries, and city compost is a big problem that requires management in an eco-friendly way. The agriculture, food and city compost waste can be used to produce organic fertilizers which can further be used to improve health and overall quality of the soil. However, the management of non-farm wastes of municipal or industrial origin is still a big problem both in economic and environmental terms. This waste is (sewage) produces residual, semi-solid material known as sewage sludge (SS) as a by-product upon treatment. Presently, the sludge is treated with incineration, sanitary burial and composting. Because of health and environmental hazards, burning and burial of sewage sludge is restricted legally (Smith, 2009; Tchounwou et al., 2012). This increased the search for new management solutions for sewage sludge and its use in the agriculture sector has become one of the key areas due to the presence of high organic carbon (OC), nitrogen (N) and phosphorous (P) content (Camargo et al., 2016; Velasco-Munoz et al., 2021). Therefore, present study was undertaken to evaluate the effects of organic fertilizers based on treated sewage sludge of Ganga on the growth and yield of a leguminous crop pea (*Pisum sativum*).

2. MATERIAL AND METHODS

The present experimental was carried out at Experimental farms of the Patanjali Research Institute, Haridwar, India (29° 54′ 49″ N and 77°59′ 51″ E). The climatic conditions of the study area were observed as a maximum temperature of 27°C, minimum temperature of 7°C and annual rainfall of 16.5mm.

2.1 Collection and processing of Ganga sludge samples

The samples of Ganga sludge were collected from the Sludge treatment plant (STP) in Jagjeetpur, Uttrakhand, India and processed at Patanjali Organic Research Institute (PORI) for the production of five different organic fertilizer products based on a patented technology of Patanjali (Patent application number: 202211069280). Five major organic fertilizer products namely, Jaivik Prom , Pori Potash, Dharti ka Chaukidar, Jaivik Poshak and Jaivik Khad were prepared and utilized in field trial experiments.

2.2 Experimental Design and Treatment

The experimental design was framed based on Randomized Block Design (RBD) with six fertilizer treatments and three replications. The sowing of peas (Wonder 10 seed variety) was carried out in field trials with the dimensions as plot size (2×4m) 8m^2 with three biological replicates (R-R 40cm and S-S 10cm). Five different organic fertilizer levels were evaluated in this experiment in 8 treatment combinations as T0 (Control), T1 (Jaivik Prom @ 100 kg/ac), T2 (Pori Potash @100kg/ac), T3 (Dharti ka Chaukidar @10kg/ac), T4 (Jaivik Poshak @7 kg/ac), T5 (Jaivik Khad @80kg/ac), T6 (Jaivik Prom+ Jaivik Khad @50+ 40kg/ac), T7 (Pori Potash + Jaivik Poshak @50+ 3.5kg/ac). Treatment of pea seeds with bio-pesticide (*Trichoderma* and *Pseudomonas* @ 5ml/liter each) was carried out by soaking them overnight before sowing to avoid the attack of any soil-borne pathogen. The test fertilizer treatments were used at each 30 days intervals after sowing.

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2.3 Measurement of plant parameters

For analysis, nine plants were randomly selected from each treatment and their replicates. Plant height (cm), total biomass (root and shoot) per plant (gm), leaf area (cm^2), number of pods per plant, pods weight (gm) per plant and pods weight per plot were measured at 30 and 60 days after sowing. The total chlorophyll content was measured with the help of the SPAD meter and expressed as the SPAD meter value. The number of nodules produced after 30 days of sowing was also observed visually.

2.4 Data Analysis

Data obtained after analyses of each parameter are presented as mean± standard deviation (SD) of three replicates and were analyzed with the help of student t-test ($P \leq 0.05$) for the comparison with the control.

3. Results

3.1 Effect of organic fertilizers on plant parameters

Results of the present study were expressed in terms of the effects of organic fertilizers on plant parameters (plant height, total biomass (root and shoot), leaf area, total chlorophyll number of pods per plant and pod weight per plot. After a comparison of results, it was observed that all fertilizer treatments have the potential to affect the growth and yield of pea crops (Figure 1 and 2).

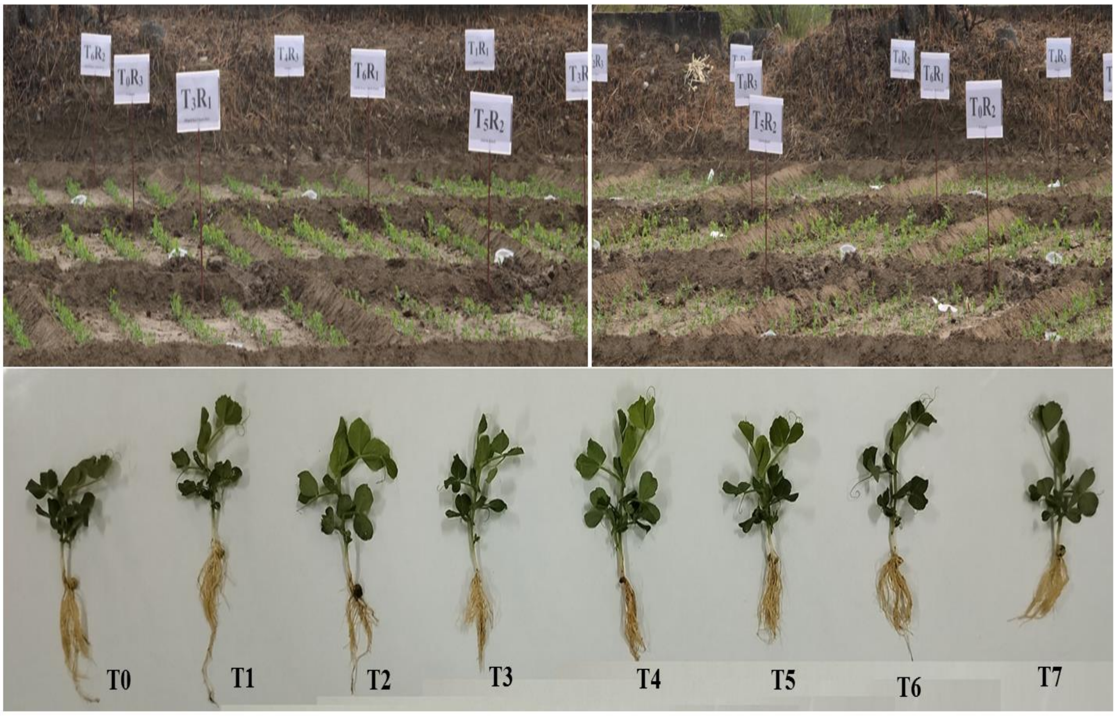

Figure 1: Field trial on peas crop in the field (Upper), comparison of parameters after 30 days of sowing (lower)

Figure 2: Comparison of root nodules production in peas plants treated with different treatments after 30 days of sowing

3.2 Total Biomass (shoots and roots)

After 30 days of sowing (DAS) the highest percentage of biomass (shoot) was observed in the case of pea plant shoots treated with treatment Jaivik Prom (T1) (11.882±0.532%), which was followed by a combination of Pori Potash + Jaivik Poshak treatment (T7) (11.826±0.130%). Other treatments (except T2 and T4) also showed significant effects of treatments on the shoot biomass of peas crop. The percentage of biomass (shoot) was observed in the range of 11.778±0.812 to 10.780±0.618%. In the case of roots, the highest %age of biomass was observed in the case of plants treated with T7 (7.898±0.635), and T6 (7.600±0.283). It was observed in the range of 7.287±0.660 to 6.554±0.631% in rest of the treatments used in the present study.

The shoot biomass (%age) after 60 days of sowing were found most prevalent in treatment T4 (24.026±1.024%) and T7 (23.094±1.531%). This effect was also found significant in the case of other treatments (21.989±1.595 -21.566±1.394%). Similarly, the effect on root biomass (%age) was found highest in pea plants treated with T7 (27.650±0.742), which was followed by treatments T6 (26.368±0.634), T4 (25.487±0.020), T3 (24.374±1.871), T5 (22.219±0.142), T1 (21.824±1.477) and T2 (20.268±0.014) (Table 1&2 and Figure 3&4).

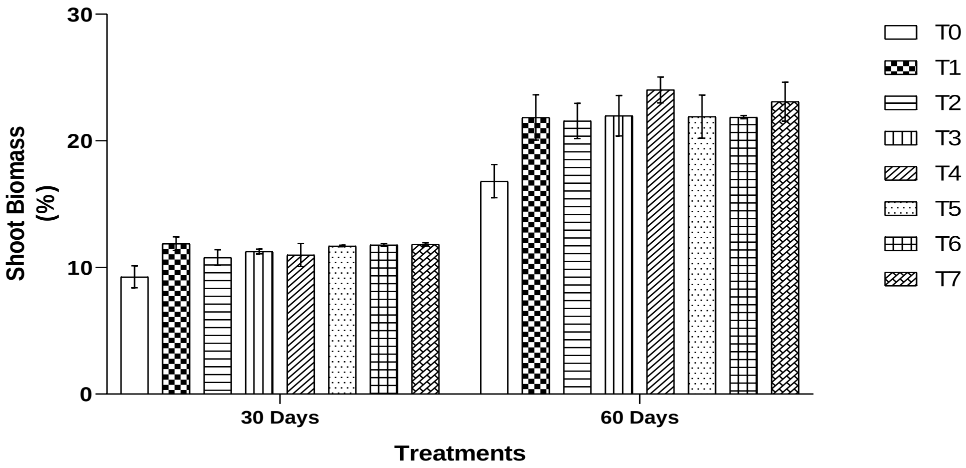

Figure 3: Comparative effects of different treatments on shoot biomass of pea plants after 30 and 60 days of sowing

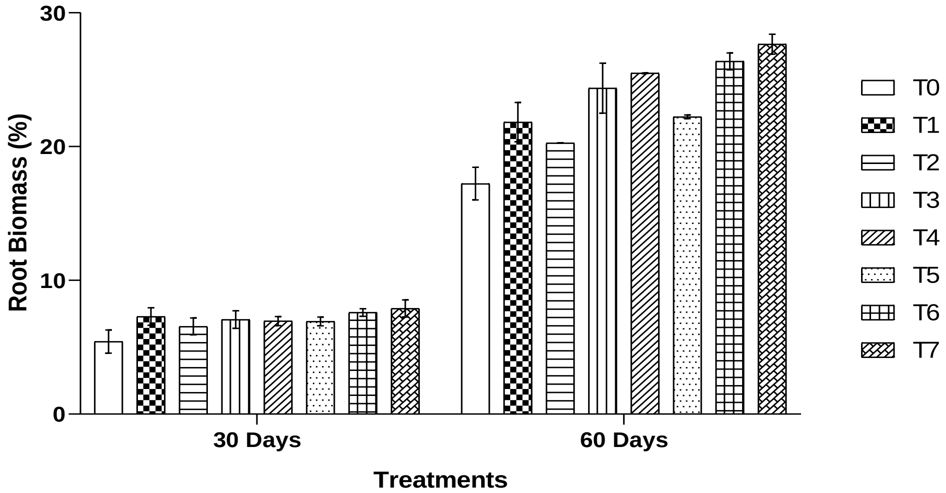

Figure 4: Comparative effects of different treatments on root biomass of pea plants after 30 and 60 days of sowing

3.3 Plant height

The highest shoot length was observed in the case of treatment T5 (17.111±0.502 cm), it was found highest in treatment T7 (11.611±0.419cm) in the case of roots. When the shoot length in the rest of the treatments was observed in the range of 16.111±0.678 to 14.556±0.347cm; it was observed as 11.222±0.347 to 9.778±0.084cm in the case of roots.

The length of the shoot was observed to be highest in the case of treatment T7 (126.889±7.943) and T4 (71.222± 1.881), while it was observed in a range of 69.222± 1.674 to 59.222± 0.500cm. Similarly, the root length was found maximum in treatment T6 (15.111±1.072), followed by T4 (14.778±1.836), T7 (14.444±0.694), T5 (14.556±0.072), T3 (14.111±0.770), T2 (13.778±1.219) and T1 (13.778±1.836). Like in the case of 30 DAS, the effects of all treatments on plant height (shoot and root) were found significant. In the case of shoot length, the effects of treatments T5, T6 and T7 were highly significant ($p \leq 0.01$), while it was found significant ($p \leq 0.50$) in treatments T2, T4, T6 and T7 (Table 1 and 2 and Figure 5 and 6).

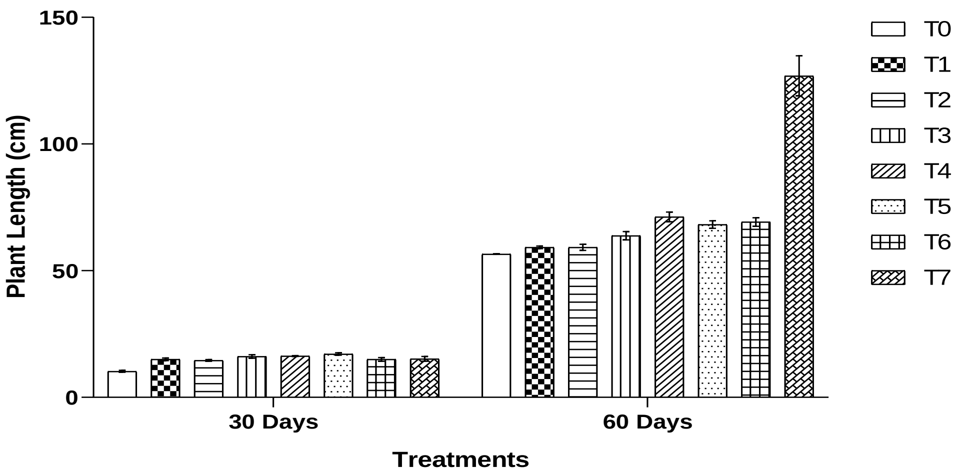

Figure 5: Comparative effects of different treatments on plant (shoot) length of pea plants after 30 and 60 days of sowing

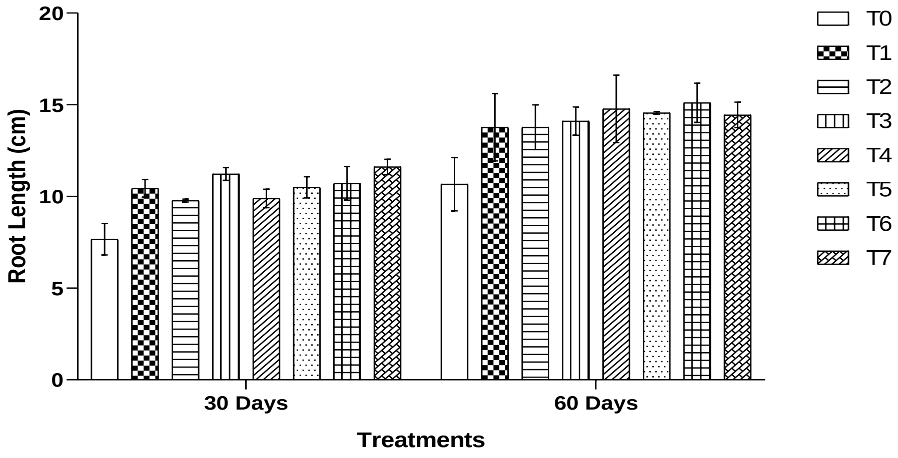

Figure 6: Comparative effects of different treatments on root length of pea plants after 30 and 60 days of sowing

3.4 Root nodules

The maximum numbers of root nodules were observed in the case of pea plants treated with T7 followed by T2, T5, T1, T3 and T4. This clearly showed the positive effects of organic fertilizers on the growth and development of roots and associated nodules and of course overall plant growth (Figure 2).

3.5 Leaf area

The total leaf area was observed highest in the case of treatment T5 (6.333±0. 651 cm^2) which was followed by T7 (5.633±0.644 cm^2), T6 (5. 033±0.802 cm^2), T3 (4.933±0.909cm^2), T2 & T4 (4.833±0.365 and cm^2 4.833±0.065 resp.), T1 (4.967±0.872 cm^2) after 30 days of sowing.

After 60 days of sowing, the leaf area was found maximum in the case of pea plants treated with treatment T7 (13.639±1.454 cm^2). The leaf area in plants with other tenements was observed as T6 (10.211±0.864 cm^2), T5 (10.187±1.149 cm^2), T4 (10.111±1.228 cm^2), T1 (9.671± 0.541 cm^2), T3 (9.517± 0.486 cm^2) and T2 (8.700± 0.470 cm^2) (Table 1&2 and Figure 7).

3.6 Total chlorophyll

Total chlorophyll was observed highest in the case of cm^2 T7 (43.900±1.224), T5 (43.711±2.682) and T6 (43.133±0.583). It was found high in T1 (42.078±0.185), followed by T3 (40.900±0.896), T4 (40.544±0.812) and lowest in T2 (39.544±2.922) after 30 days of sowing. The effect of treatment T3 was not significant in comparison to control.

The chlorophyll content after 60 days of sowing was found highest in the case of plants growing with treatment T7 (49.533±1.320). Total chlorophyll was also observed significantly high in the case of T6 (48.622±1.426) and T5 (48.044±1.672). It was observed in the medium range of 45.978±1.153 (T3) and 45.922±0.594 (T4), while lowest in the case of T1 (43.556±1.481) and T2 (42.889±0.983). The effects of all treatments (except T2) on total chlorophyll were found highly significant (Table 1 and 2 and Figure 7).

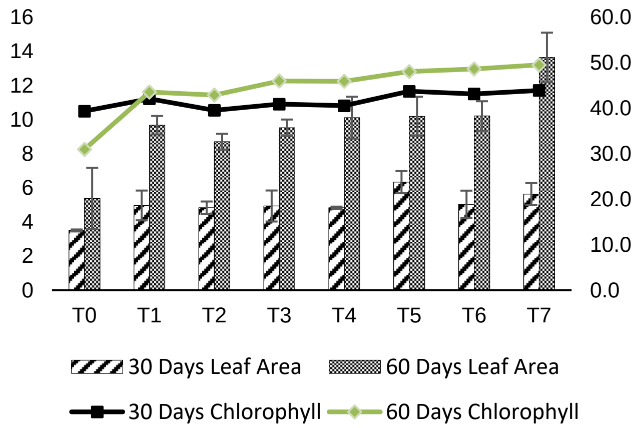

Figure 7: Comparative effects of different treatments on leaf area and total chlorophyll of pea plants after 30 and 60 days of sowing

3.7 Number of pods per plant

The effects of organic fertilizers on the number of pods per plant were evaluated after 60 days of sowing as no pod formation was taking place on the 30th day of sowing. The average number of pods was found highest in the case of pea plants under the treatment of T7 & T6 (11.444±0.857 & 11.444±0.547 respectively). This number was also found variable in pea plants growing under other treatments. It was observed in the average range of 10.667±0.606 to 7.111± 0.439 pods per plant (Table 1 and 2).

3.8 Pods weight per plant and plot

The effect of organic fertilizers was found significantly high in treatment T6 & T7 (36.122± 1.175 & 36.366± 1.033 resp.) which was followed by T4, T3, T5, T2 and T1 (35.863± 0.280 - 23.693± 1.339). In the case of pods per plant, the results of the pods' weight per plot were also found in treatments T6 & T7. The highest yield in T7 was observed at 6.813± 0.963 kg and 6.687± 0.179 Kg in treatment T6. In other treatments, the yield per plot was observed in the range of 5.403± 0.294 to 4.230± 0.409. The effects of treatments T5, T6 and T7 on pods weight per plot were highly significant, while, it was significant in the rest of the treatments (Table 1 and 2).

4. Discussion

The use of organic manures showed a significant impact on yield and other attributes of crops including pea. The use of sludge in the production of beneficial organic fertilizers has been suggested by several researchers in their research. In a technology developed by BARC, the treated and dried sewage is crushed and exposed to a 10 kGy radiation dose which helps in the killing of pathogens in the sludge and makes it safer for use. The addition of BIO- NPK microorganisms converted this material into a useful bio-fertilizer (Krishijagran, 2019). In the Mediterranean region, 40% of sewage sludge is used as a soil organic amendment due to its high organic matter content (Milieu Ltd. 2010). The potential use of sewage sludge as fertilizer has been reviewed in detail (Lamastra et al., 2018). Similarly, the management and application of sewage sludge as sustainable fertilizer was advocated (Sugurbekova et al., 2023).

The significant residual effects of the organic fertilizers on the yield of the succeeding winter wheat were observed by (Diacono and Montemurro, 2010). It was also revealed from the same study that organic fertilizers normally release nutrients slowly, which showed significant positive long-term effects. These observations support the efficacy of organic fertilizers used in the present study on growth and yield of different crops including peas (Jannoura et al., 2013). The positive effects on root and shoot biomass and plant length after 30 and 60 days of sowing revealed the long-term efficacy of all organic fertilizers. The variable numbers of root nodules produced after 30 days of sowing also justified the variability in biomass and overall length of the pea plant. Because root nodules serve as nitrogen sources for plants and enhance their overall growth and development, they might be responsible for variable plant growth characteristics (Jaiswal, et al., 2021; Etesami, 2022). Like in plant growth, increased leaf area was also observed in all plants treated with different organic fertilizer treatments. The increased leaf area also justified the increase in total chlorophyll content in all treatments 30 and 60 days after sowing Such findings were

Table 1: Effect of organic fertilizers on plant characteristics of peas after 30 days of sowing

Treatment	Shoot biomass (%age)	Root biomass (%age)	Plant length (cm)		Leaf area (cm²)	Chlorophyll
			Shoot	Root		
T_0	9.259±0.863	5.426±0.866	10.278±0.398	7.667±0.856	3.500±0.058	39.356±1.600
T_1	11.882±0.532*	7.287±0.660*	15.000±0.528*	10.444±0.481	4.967±0.872*	42.078±0.185*
T_2	10.780±0.618	6.554±0.631	14.556±0.347*	9.778±0.084*	4.833±0.365*	39.544±0.922*
T_3	11.260±0.190*	7.074±0.658*	16.111±0.678*	11.222±0.347*	4.933±0.909*	40.900±0.896*
T_4	10.987±0. 911	6.957±0.339*	16.333±0.180**	9.889±0.503*	4.833±0. 065*	40.544±0.812*
T_5	11.701±0.053*	6.925±0.327*	17.111±0.502**	10.500±0.577*	6.333±0. 651**	43.711±2.682*
T_6	11.778±0.112*	7.600±0.283*	15.000±0.732*	10.722±0.918*	5. 033±0.802*	43.133±0.583*
T_7	11.826±0. 130*	7.898±0.635	15.222±0.953*	11.611±0.419*	5. 633±0.644 *	43.900±1.224**

Mean ± standard deviation of nine replicates. * Significant (p≤0. 50); ** Highly significant (p≤0.01)

Table 2: Effect of organic fertilizers on plant characteristics of peas after 60 days of sowing

Treatment	Shoot biomass (%age)	Root biomass (%age)	Plant length (cm)		Leaf area (cm²)	Chlorophyll	No. of pods per plant	Pods weight per plant (gm)	Pods weight per plot (Kg)
			Shoot	Root					
T_0	16.807±1.303	17.230±1.221	56.556± 0.131	10.667±1.453	5.378± 1.801*	30.944±0.687	6.556± 0.018	23.693± 1.339*	2.153±0.529
T_1	21.845±1.782*	21.824±1.477*	59.222± 0.500*	13.778±1.836	9.671± 0.541*	43.556±0.481**	8.111± 0.481*	28.362± 0.965*	5.403±0.294**
T_2	21.566±1.394*	20.268±0.014*	59.222± 1.235*	13.778±1.219*	8.700± 0.470*	42.889±0.983*	7.111± 0.439	25.919± 0.907	4.230±0.409*
T_3	21.989±1.595*	24.374±1.871*	63.778± 1.632**	14.111±0.770	9.517± 0.486*	45.978±1.153**	9.667± 0.882*	32.811±1.957*	5.303±0.938*
T_4	24.026±1.024**	25.487±0.020*	71.222± 1.881**	14.778±1.836*	10.111±1.228*	45.922±0.594**	9.889± 0.439**	35.863± 0.280**	5.373±0.200**
T_5	21.911±1.703*	22.219±0.142*	68.222± 1.500**	14.556±0.072	10.187±1.149*	48.044±1.672**	10.667± 0.606**	31.652± 1.804*	5.267±0.470**
T_6	21.872±0.122*	26.368±0.634**	69.222± 1.674**	15.111±1.072*	10.211±0.864*	48.622±1.426**	11.444± 0.547**	36.122± 1.175**	6.687±0.179**
T_7	23.094±1.531*	27.650±0.742**	126.889± 7.943**	14.444±0.694*	13.639±1.454*	49.533±1.320**	11.444± 0.857**	36.366± 1.033**	6.813±0.963**

Mean ± standard deviation of nine replicates. * Significant (p≤0. 50); ** Highly significant (p≤0.01)

Most of recearcher observed in previous studies which depicted the influence of chlorophyll content and leaf area index on the growth of Pigeonpea (Hamblin et al., 2014; Nagaraj et al., 2019). The effects of organic fertilizers on the final yield of the crop were also observed in several studies (Cen et al., 2020; Kominko et al., 2022). As in the present study, organic fertilizers exhibited a positive impact on the number of pea pods per plant and per plot. A study carried out by Parewa et al. also revealed that suitable organic nutrient management practices can enhance the yield of wheat and other crops (Parewa et al., 2019).

The previous findings also advocated an environment-friendly approach of organic farming and supported the effects of sludge-based organic fertilizers on the growth and yield of many crops like Spinach, Raspberry, wheat and many more observed in several studies that highlighted the importance of this eco-friendly way of sludge management (Balkrishna et al., 2023; Balkrishna et al., 2024 a,b,c and d; Parwada et al., 2020; Koutroubas et al., 2014; Angin et al., 2017; Zhang et al., 2023).

5. Conclusion

It is concluded from the present study that the production of organic fertilizers from sludge is an efficient and eco-friendly way to manage Ganga sludge. Moreover, the effects of sludge-based organic fertilizers on the growth, development and yield of pea plants also advocated the significance of this eco-friendly approach of sludge management. Therefore, the production of organic fertilizers from Ganga sludge and their effects on the growth and yield of Pea (*Pisum sativum*) are quite encouraging and these organic fertilizers should also be examined on other crops.

Conflicts Of Interest

The signing authors of this research work declare that they have no potential conflict of personal or economic interest with other people or organizations that could unduly influence this manuscript.

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