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Effect of *Hydrilla Verticillata* derived compost on various growth parameters of chickpea (*Cicer arietinum* L.) crop

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Abstract

The present study was undertaken to evaluate the effect of *Hydrilla verticillata*-derived compost on the growth, nodulation, biomass production, yield and soil microbial population of chickpea (*Cicer arietinum* L.). Different proportions of compost and soil were used, with treatment T1 as the absolute control and treatment T2 having the recommended dose of fertilizer (RDF). The application of *H. verticillata* compost improved the growth and productivity of chickpea compared with the control treatments. Among the various treatments, T7 (50% soil + 50% compost) showed the best performance, recording maximum root length (21.70 cm) and shoot length (55.60 cm), followed by T6 (20.60 and 54.50 cm, respectively). However, a positive effect on nodulation was also observed, with nodule number increasing from 36, 42, 46, 48 and 51 nodules per plant in treatments T3, T4, T5, T6 and T7, respectively, compared with 23 nodules per plant in the RDF containing treatment (T2). Plant biomass also increased substantially with compost application. The maximum fresh and dry weights were recorded in treatment T7 (13.92 and 3.13 g respectively), compared with the absolute control (4.16 and 0.99 g). Similarly, grain yield increased from 13 g pot⁻¹ in treatment T1 to 38 g pot⁻¹ in treatment T7. The compost application also enhanced the soil microbial population. At sowing, T7 recorded the highest bacterial (5.9×10^8 CFU), fungal (0.8×10^3 CFU) and phosphate-solubilizing bacterial (2.8×10^5 CFU) populations, which remained higher after harvest such as 3.9×10^8 , 0.5×10^3 and 1.3×10^5 CFU, respectively. These research findings demonstrated that *H. verticillata*-derived compost significantly enhances chickpea growth, nodulation, biomass production, yield and beneficial microbial populations. The results suggested that compost prepared from *H. verticillata* can serve as an effective organic amendment and provide a sustainable approach for aquatic weed management and improvement of soil fertility and crop productivity.

Keywords: Chickpea, compost, nodulation, biomass, treatments

Introduction

The trajectory of Indian agriculture over recent decades has been shaped predominantly by the imperative to maximize crop yields in order to meet the demands of an expanding population. While these productivity targets have largely been met, growing attention is now being directed towards the quality of the food produced and the ecological sustainability of prevailing agronomic practices. Heavy dependence on synthetic fertilizers, pesticides and herbicides have driven short-term gains in output but this has come at a considerable cost such as deterioration of soil health, reduced biodiversity and elevated public health risks linked to pesticide residue in the food chain (Kashyap *et al.*, 2024; Zhou *et al.*, 2025) ^[1, 2]. Compounding these concerns is the improper disposal of crop residues, most notably the open-field burning of paddy straw, a practice that continues to degrade air quality, diminish soil integrity and contribute to respiratory illness, particularly across the Indo-Gangetic plain (Yadav *et al.*, 2025) ^[3]. Collectively these challenges underscore the need for sustainable, input efficient agricultural strategies capable of sustaining productivity without compromising environmental integrity.

Composting represents an ecologically sound approach for converting agricultural and organic wastes into nutrient-rich biofertilizers, reducing reliance on synthetic agrochemicals while simultaneously addressing waste-management concerns. During composting, complex organic matter is mineralized by microbial communities, primarily bacteria and fungi, which drive the breakdown of lignocellulosic substrates and release plant-available nutrients (Bernal *et al.*, 2009;

Oviedo-Ocaña *et al.*, 2019)^[6, 7]. Composting generally unfolds across four sequential phases *i.e.*, mesophilic, thermophilic, cooling and maturation, each characterized by distinct temperature regimes and microbial community shifts. Bacterial communities, in particular, play a central role in decomposing labile and recalcitrant compounds, with successive dominance of mesophilic (e.g., diverse heterotrophs) and thermophilic (e.g., *Bacillus*, Actinobacteria) taxa influencing the rate and efficiency of organic matter decomposition (Kumari *et al.*, 2024; Wang *et al.*, 2024)^[5, 24]. Enzyme activities such as cellulase, amylase, and protease serve as important indicators of microbial activity and decomposition dynamics, and high microbial diversity in the final compost has been linked to improved nutrient cycling, pathogen suppression, and plant-health benefits (Partanen *et al.*, 2010; Palaniveloo *et al.*, 2020)^[9, 10]. Cattle dung is widely recognized as an effective microbial inoculant in composting systems, given its rich native population of decomposers and its capacity to accelerate the onset of thermophilic activity, thereby shortening overall composting duration and improving the nutrient profile of the finished product.

Rice (*Oryza sativa*) is one of the principal staple crops cultivated in Asia, generating large quantities of rice straw that pose a significant management challenge in Indian states such as Punjab and Haryana (Singh, 2018; Singh & Patel, 2022)^[11, 12]. Rather than burning, this residue can instead be diverted towards composting, yielding organic fertilizer that reduce environmental impacts and enhance soil fertility. A parallel opportunity exists in the management of invasive aquatic weed, particularly *Hydrilla verticillata* (waterthyme), which proliferates aggressively in fresh water bodies and irrigation channels, requiring frequent removal (Zhu *et al.*, 2017)^[4]. Rather than treating hydrilla as a mere nuisance, it can be valorized as a composting feedstock because of its relatively high nitrogen and nutrient content (Safitri *et al.*, 2019; Shrivastava & Srivastava, 2021)^[13, 14]. Composting hydrilla has additionally been shown to reduce heavy metal contamination while improving soil health and supporting plant growth, and its fibrous structure is expected to enhance porosity within the compost pile, favouring aerobic decomposition and minimizing the malodorous byproducts associated with aerobic decomposition. Combining hydrilla with paddy straw is therefore expected to yield a complementary substrate because paddy straw contributes a carbon rich, structurally stable base, while hydrilla supplies additional nitrogen and readily degradable biomass, together improving aeration, nutrient balance and microbial activity relative to either material composted alone.

Chickpea (*Cicer arietinum* L.) is an important leguminous crop grown in arid and semi-arid regions, valued for its high protein content, dietary fiber, and ability to fix atmospheric nitrogen through symbiotic rhizobial associations (Fukagawa & Ziska, 2019; Rath *et al.*, 2022)^[15, 16]. However, chickpea productivity is often constrained by suboptimal soil fertility, limited water holding capacity, and inadequate microbial activity in degraded agricultural soils. Compost derived from diverse microbial communities has been demonstrated to improve soil health, nutrient availability, and disease-suppressive capacity, thereby enhancing legume growth and yield (Rath *et al.*, 2022)^[15]. Despite these advances, the specific effects of hydrilla-based compost, particularly when combined with rice straw, on chickpea growth, nodulation, and associated soil microbial properties remain poorly understood. In particular, it remains unclear whether hydrilla-based compost of this composition can match or exceed the performance of conventional organic amendments in supporting early vegetative growth, root and nodule development and overall plant vigor in chickpea.

The present study therefore investigates the effect of hydrilla and paddy straw-based compost, prepared using cattle dung as a microbial source, on the growth parameters of chickpea under representative Indian agro-climatic conditions. We hypothesize that this compost combination will enhance chickpea growth and nodulation relative to conventional practice, owing to the complementary nutrient and structural properties of its constituent materials. In doing so, this study aims to establish a sustainable, low input strategy for improving chickpea productivity, while concurrently reducing dependence on synthetic fertilizers, mitigating the environmental burden of paddy straw burning and offering productive use for an otherwise problematic invasive aquatic weed.

The present investigation was carried out in Soil Microbiology Laboratory (Lab. No. 225), Department of Microbiology, CCS Haryana Agricultural University, Hisar (India).

Materials and Methods

Evaluation of compost quality and its impact on growth of chick pea crop

The capacity of pot was calculated by weighing the empty pot and then pot with soil. The capacity was measured by subtracting the weight of empty pot from the weight of pot with soil. The pots used in the experiment were found to be of 5Kg capacity and then soil was filled as per the requirements of the treatments. The compost was prepared using paddy straw, hydrilla and cattle dung (1.5:1.5:1.0) with 2% of microbial consortia containing *Aspergillus oryzae*, *Aspergillus niger*, *Streptomyces* spp. and *Bacillus* spp.

To assess the effect of compost application on chickpea growth and yield, the following treatments were established:

T1: Soil (Control)

T2: Soil + RDF (Control)

T3: 90% soil + 10% compost (w/w)

T4: 80% soil + 20% compost (w/w)

T5: 70% soil + 30% compost (w/w)

T6: 60% soil + 40% compost (w/w)

T7: 50% soil + 50% compost (w/w)

Each treatment was arranged in a Completely Randomized Design (CRD) with appropriate replications. The compost was thoroughly mixed with soil at the specified ratios prior to pot filling and sowing. The RDF was applied as per standard agronomic recommendations in the respective treatment.

Chickpea seeds (HC-5) were first imbibed in distilled water for 4-5 hours to initiate the germination process. After soaking, the seeds were air-dried for 20-30 minutes at room temperature. The seeds were then sown (4 seeds/ pot) in triplicates at a depth of 2.5 cm and 8cm distance, in the prepared pots.

Following are the parameters that were observed in the crop.

1. Root and shoot length

Root and shoot length of the plants were measured after harvesting with the help of a measuring scale in centimetre (cm) after placing the plant straight on a plain black cloth.

2. Nodule number

Nodule numbers were counted at the 50% flowering stage of chickpea crop. To count nodules one of the replicates from the set was used. The plants were taken out of the pot, trying to take the roots intact, as much length as we can. The nodules were counted manually.

3. Root and shoot fresh weight (just after harvesting)

Just after harvesting the root and shoot of the plant were weighed

with the help of a weighing balance. Average of the replicates was taken as the

4. Root and shoot dry weight

Root and shoot dry weight were taken after oven drying the plants. The weight was recorded regularly till it became constant.

5. Crop yield

Crop yield was determined by counting seed number and average seed weight per pot.

Microbial count analysis

Total culturable microbial populations were quantified at two phenological stages (sowing and harvest) using selective growth

media:

1. Nutrient Agar (NA) for total bacteria count
2. Potato Dextrose Agar (PDA) for fungal colonies
3. Pikovskaya's Agar (PVK) for phosphate-solubilizing bacteria

Results

Evaluation of compost for its effect on growth of chick pea (*Cicer arietinum* L.)

To evaluate the compost quality, the compost was introduced to chickpea crop in different ratio with soil as different treatments. The effect of compost on various growth parameters of chickpea is described in the Table 1.

Table 1: Effect of compost on yield and yield attributes of chickpea crop under pot house conditions

Treatment	Root length (cm)	Shoot length (cm)	Nodules/pot	Fresh weight (g)	Dry weight (g)	Yield (g/pot)
T1	15.80±0.196 ^e	44.90±0.458 ^d	20±0.262 ^f	4.16±0.015 ^f	0.99±0.003 ^f	13±0.026 ^g
T2	16.20±0.033 ^e	46.80±0.681 ^c	23±0.024 ^e	4.43±0.083 ^f	0.85±0.006 ^g	18±0.029 ^e
T3	18.39±0.007 ^d	48.50±0.604 ^c	36±0.339 ^d	5.03±0.050 ^e	1.15±0.009 ^e	15±0.262 ^f
T4	19.10±0.297 ^c	48.10±0.925 ^c	42±0.874 ^c	8.37±0.062 ^d	1.59±0.009 ^d	23±0.467 ^d
T5	20.20±0.241 ^b	51.60±0.645 ^b	46±0.958 ^b	10.51±0.158 ^c	2.41±0.030 ^c	25±0.401 ^c
T6	20.60±0.020 ^b	54.50±0.172 ^a	48±0.999 ^b	12.03±0.151 ^b	2.58±0.042 ^b	37±0.193 ^b
T7	21.70±0.104 ^a	55.60±0.088 ^a	51±1.115 ^a	13.92±0.217 ^a	3.13±0.026 ^a	38±0.437 ^a
C.D. @ 5%	0.514	1.774	2.346	0.381	0.069	0.953
SE(m)	0.168	0.579	0.766	0.124	0.022	0.311

*Data indicate mean ± SD of triplicate experiment, significant difference of $p < 0.05$. The means with similar letter(s) in each column did not differ significantly from each other.

	Degree of freedom	Sum of squares	Mean square	F value	P value
Treatments	6	3225.381	537.563	27.853	<0.01
Parameters	5	34311.741	6862.348	355.557	<0.01
Treatments × Parameters	1	69183.167	69183.167	3584.571	<0.01

Effect of compost on root and shoot length of the plant

The root and shoot length of the chickpea crop was analysed and found that the treatment T7 (21.70 cm and 55.60 cm, respectively) was having a significant effect on the crop followed by treatment T6 (20.60 cm and 54.50 cm respectively). The root length of T5 and T6 was comparatively similar (20.20 cm and 20.60 cm,

respectively). According to the observations, root length of treatments increased with increase in the concentration of the compost in the soil. The roots of the compost treated plants were much healthier and fibrous as compared to the controls (T1 and T2) (Fig. 1).

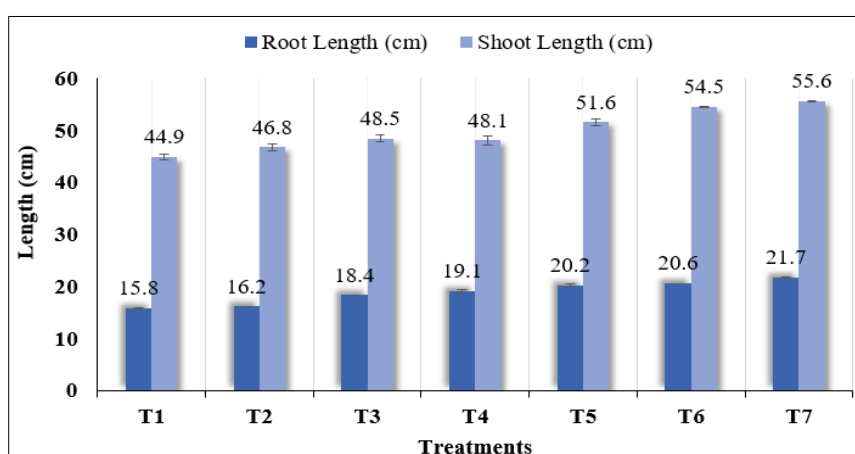


Fig 1: Effect of different treatments on root and shoot length of chickpea crop under pot house conditions

It was observed that the shoot was taller in all the compost treated plants (T3, T4, T5, T6 and T7), compared to the controls (T1 and T2). It was found that there was a significant increase in the shoot length of the plant with increase in the ratio of the compost in the soil. The treatments (T3 and T4), didn't show a markable difference in the shoot length (48.50 cm and 48.10 cm,

respectively) but the treatments with high ratio of compost (T5, T6 and T7) showed a significant difference in the shoot length of the plant, measured as 51.60, 54.50 and 55.60 cm, respectively. Even the increase in biomass and branches was observed in the compost treated plants (Fig. 2 and 3).

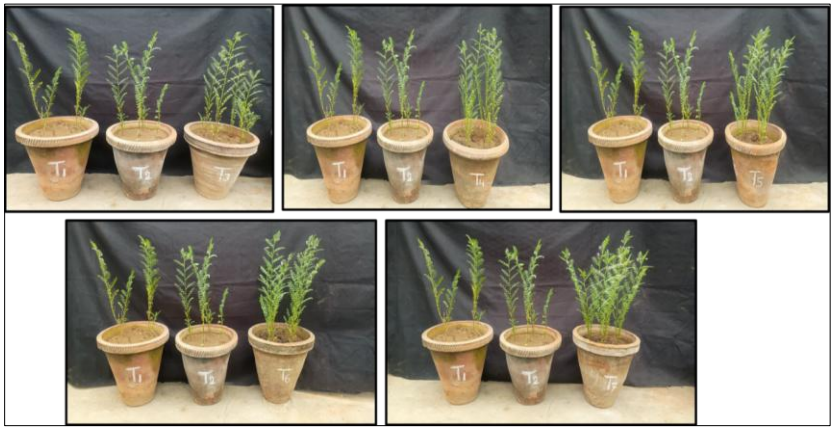


Fig 2: Effect of different treatments on plant biomass of chickpea crop under pot house conditions



Fig 3: Effect of different treatments on shoot length of chickpea crop under pot house conditions after 30 days of showing

Effect of compost on nodules of the plant

The nodules were counted in roots of the plant at 50% flowering stage. A positive impact of compost was observed on the nodule formation of chickpea crop. The treatments with different concentration of compost (T3, T4, T5, T6 and T7) showed a significant increase in the nodule number (36, 42, 46, 48 and 51 nodules/plant, respectively) with increase in compost

concentration in the soil. The maximum nodule number was observed in T7 (51 nodules/plant) whereas T1 was having least number of nodules i.e., 20 nodules/plant. The treatment with RDF (T2) was showing 23 nodules/plant, that is higher than the absolute control (T1) but very low from the compost treatments (Fig. 4 and 5).

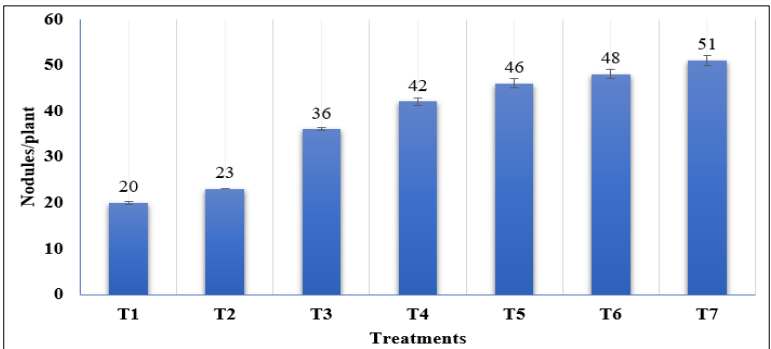


Fig 4: Effect of various treatments on Nodules/plant of Chickpea crop under pot house conditions

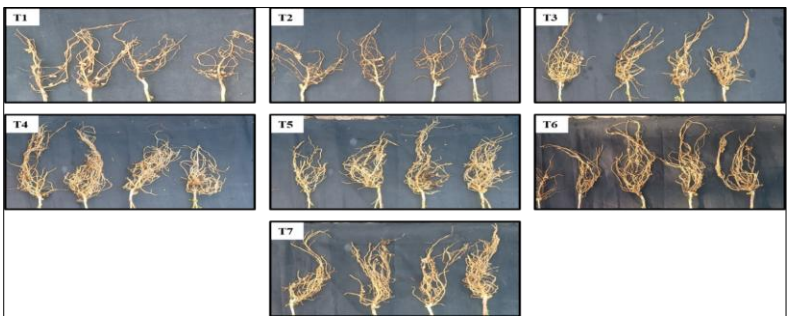


Fig 5: Roots of chickpea plant showing nodules at 50% flowering stage of different treatments

Effect of compost on fresh and dry weight of chickpea plant

A very significant difference was observed in the fresh and dry

weight of the plant, treated with compost as compared to normal soil and soil with RDF.

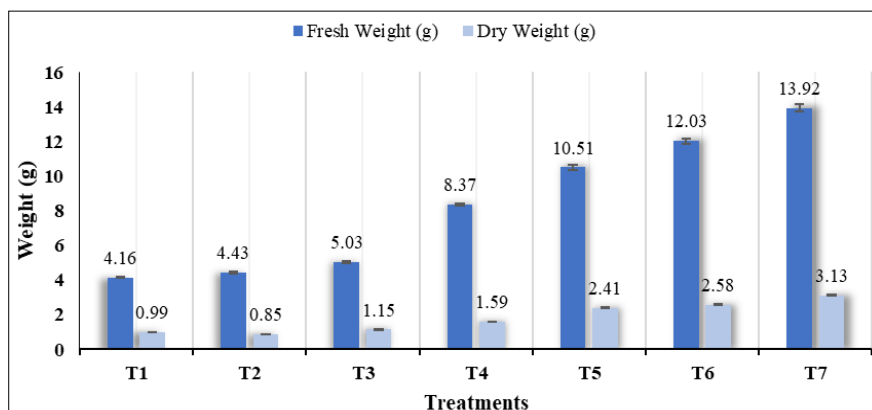


Fig 6: Effect of different treatments on fresh and dry weight of chickpea crop under pot house conditions

According to the observations the fresh weight of the two treatments as control (T1 and T2) was found to be 4.16 and 4.43 g/plant, respectively whereas the dry weight was recorded as 0.99 g/plant (T1) and 0.85 g/plant (T2) which was found to be very low compared to other treatments. The fresh weight of the compost treatments varied in the range (5.03-13.92), with T3 (5.03g), T4 (8.37g), T5 (10.51g), T6 (12.03g) and T7 (13.92g) whereas the dry weight varied from 1.15-3.13g/plant, with T3 (1.15g), T4 (1.59g), T5 (2.41g), T6 (2.58g) and T7 (3.13g). The maximum fresh and dry weight was observed in treatment T7 (50% soil +

50% compost). Results showed an increasing trend in the fresh and dry weight of plant with increase in the concentration of compost in soil, confirming the nutritional quality of compost in comparison to the soil and RDF (Fig. 6).

Effect of compost on yield of chickpea plant

The yield of the crop was observed under pot house conditions and measured in grams per pot with seven different treatments (T1-T7) (Fig. 7 and 8).

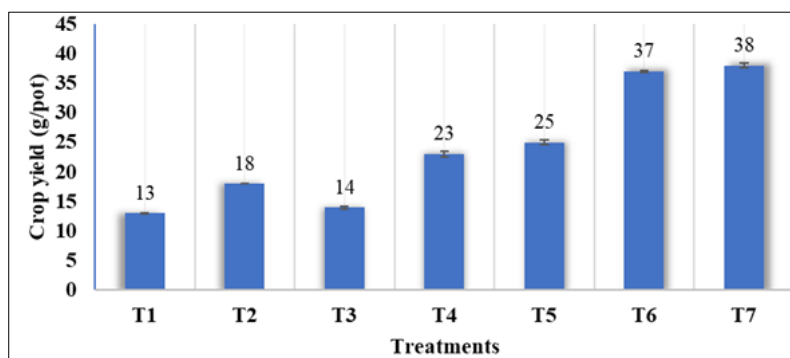


Fig 7: Effect of various treatments on yield of chickpea crop under pot house conditions

It was found that the absolute control (T1) was having minimum yield (13g/pot) among all the treatments followed by the treatment with 10% compost and 90% soil (T3) and treatment with RDF (T2) i.e., 15g/pot and 18g/pot. However, the treatments with higher concentration of compost were showing a very high

and significant increase in the per pot yield (T4: 23g, T5: 25g, T6: 37g and T7: 38g), justifying the positive effect of compost on plant yield.



Fig 8: Effect of different treatments on yield of chickpea plants under pot house conditions

Microbial count

The bacterial, fungal and PSB (phosphate solubilizing bacteria) count was analyzed at the time of sowing and after harvesting the

chickpea crop (Table 2). It was observed that at the time of sowing the number of colonies were higher as compared to the colonies in the soil after harvesting the crop.

Table 2: Effect of various treatments on the microbial population of rhizospheric soil of chickpea crop at the time of sowing and after harvesting

Treatment	Microbial count at the time of sowing			Microbial count after harvesting		
	Bacterial count (CFUg ⁻¹ soil)	Fungal count (CFUg ⁻¹ soil)	PSB count (CFUg ⁻¹ soil)	Bacterial count (CFUg ⁻¹ soil)	Fungal count (CFUg ⁻¹ soil)	PSB count (CFUg ⁻¹ soil)
T1	0.7x10 ⁸	0.3x10 ³	1.1x10 ⁵	0.4x10 ⁸	0.1x10 ³	0.3x10 ⁵
T2	0.9x10 ⁸	0.2x10 ³	1.3x10 ⁵	0.6x10 ⁸	0.1x10 ³	0.7x10 ⁵
T3	1.8x10 ⁸	0.2x10 ³	1.3x10 ⁵	1.1x10 ⁸	0.2x10 ³	0.7x10 ⁵
T4	2.9x10 ⁸	0.7x10 ³	2.2x10 ⁵	1.7x10 ⁸	0.5x10 ³	1.1x10 ⁵
T5	4.7x10 ⁸	0.5x10 ³	2.5x10 ⁵	2.3x10 ⁸	0.3x10 ³	0.8x10 ⁵
T6	5.3x10 ⁸	0.8x10 ³	2.3x10 ⁵	3.2x10 ⁸	0.3x10 ³	1.2x10 ⁵
T7	5.9x10 ⁸	0.8x10 ³	2.8x10 ⁵	3.9x10 ⁸	0.5x10 ³	1.3x10 ⁵

It was also found that there was an increase in the bacterial, fungal [refer to Annexure 1 (A7)] and PSB count, with increase in the compost concentration in the soil before harvesting. Similar observations were found in case of post harvesting data of microbial count. The maximum microbial count (bacterial, fungal and PSB) was found in treatment T7 (50% soil + 50% compost) i.e., 5.9x10⁸, 0.8x10³ and 2.8x10⁵ respectively, at the time of sowing and 3.9x10⁸, 0.5x10³ and 1.3x10⁵ respectively, after harvesting as compared to other treatments. The least colony count (bacteria and PSB) was observed in the treatment (T1) i.e., 0.7x10⁸ and 1.1x10⁵ whereas, treatments (T2 and T3) showed minimum fungal colonies (0.2x10³) at the time of sowing. After harvesting least bacterial, fungal and PSB count (0.4x10⁸, 1x10³ and 0.3x10⁵ respectively) was observed in absolute control (T1).

Discussion

The present research demonstrates that co-composting *Hydrilla verticillata* with paddy straw, using cattle dung as a microbial inoculant, produced a compost capable of significantly enhancing chickpea growth and nodulation compared to conventional chemical fertilizers as control. This improvement can be attributed primarily to the complementary nutrient profiles of the two feedstocks: paddy straw, though an abundant and otherwise problematic carbon-rich residue, is inherently nitrogen-deficient, while hydrilla's high nitrogen content helped correct this imbalance and establish a more favourable carbon-to-nitrogen ratio for microbial decomposition. The addition of cattle dung likely further accelerated this process by introducing active bacterial communities, consistent with its established role as a natural microbial inoculant in composting systems. Matured compost quality was evaluated by its impact on growth of chick pea crop. The effect of increasing compost concentration on plant growth was clearly seen across all the parameters (root length, shoot length, nodulation, biomass accumulation and yield). As compost percentage increased from T3 (90% soil + 10% compost) to T7 (50% soil + 50% compost), a progressive increase in growth parameters was observed, demonstrating positive impact of compost enriched soil on the crop. Increase in root and shoot length shows better soil structure, enhanced nutrient availability, proper aeration, improved microbial activity and water holding capacity in compost treatments as compared to controls (Hasanuzzaman *et al.* 2023) [17]. Higher nodulation in the treated plants indicated that compost have positive influence on nutrient availability, balanced pH, root proliferation and increased microbial interactions in the rhizosphere. Enhanced biomass and yield confirm that the compost is having a long-term beneficial effect on plant

productivity. A similar observation was made by Khan *et al.* (2021) [19], they examined effect of different phosphate fertilizers and organic manures on nutrient uptake, growth, yield, chlorophyll and protein content of chickpea and found that the combined use of P fertilizers and manures along with growth promoting bacteria is effective in growth and yield of chickpea. Similar results were reported by Hussein *et al.* (2025) [18] in the fenugreek. In their investigation, the increase in plant parameters [yield (233.37 to 580.64 g/plant), shoot dry weight (0.086 to 0.290 g/plant), root dry weight (0.02 to 0.11 g/plant) etc.] was observed after application of vermicompost as compared to control. In our study, soil microbial count was strongly influenced by application of the type and level of nutrient source (compost, soil and RDF). At the time of sowing lowest microbial count was observed in T1 (Soil), showing limited nutrient ability and organic carbon. However, it was observed that by the application of RDF (T2) there was a slight increase in the bacterial and PSB count as compared to treatment T1. In contrast, compost showed a clear dose dependent increase in microbial population. Even after harvesting the beneficial microbial count was more in the soil of compost treatments as compared to RDF and control. Mekenova *et al.* (2023) [20] observed effect of various types of compost treatments (Compo-MIX, Agrarka, Agro-MIX, Trichodermin-KZ, Poultry manure (5t/ha), Poultry manure (10t/ha), Poultry manure (15t/ha) and control) on ammonifiers and mineral nitrogen fixing bacteria colonization in barley rhizosphere at the time of sowing, tillering and after crop maturity. They found that bacteria colonization is better in all the compost treatments as compared to control and is way too maximum in treatment containing Trichodermin-KZ.

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