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Research Article:

Production of organic compost from *Parthenium hysterophorus* and evaluation of its fertilizer value and pathogen suppression potential in onion (*Allium cepa* L.)

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Abstract

This study investigated the fertilizer potential and pathogen suppression capacity of compost produced from *Parthenium hysterophorus* for onion (*Allium cepa* L. cv. 'Pachchai murian') cultivation. *P. hysterophorus* biomass was composted with organic amendments and microbial inoculants using an aerated windrow system for six months. Physicochemical properties of mature composts were analysed, and their effects on onion growth, yield, weed emergence, and disease incidence were evaluated in field-grown bags. The antimicrobial activity of sterilized and unsterilized compost extracts was assessed under *in vitro* conditions against selected fungal and bacterial pathogens. There is a significant difference in the inhibition percentage values in fungi and the clear zone diameter value for bacteria with unsterilized and sterilized compost extracts ($p < 0.05$). The composts largely met Sri Lanka Standards Institution specifications, with few exceptions. Total nitrogen, phosphorus, and potassium contents ranged from 1.40-2.30%, 2.17-15.51%, and 0.93-3.30%, respectively. Compost application reduced weed emergence and disease and pest incidence compared with chemical fertilizer-only and unamended controls. The highest bulb yield (146.43 g/bag and 23.4 g/bag on fresh and dry weight bases) was obtained with a combination of 50% compost and 50% of the recommended nitrogen fertilizer rate. Unsterilized compost extracts of 0.1 g/mL concentration exhibited antifungal activity, with maximum inhibition of 83.33% against *Colletotrichum* sp., whereas sterilized extracts showed lower antifungal activity, reaching a maximum inhibition of 40.47%. Sterilized extract of the same concentration also exhibited antibacterial activity against *Xanthomonas* sp., comparable to the standard antibiotic used as a positive control. These findings suggest that microbial activity and bioactive compounds may contribute to pathogen suppression. The study demonstrates the potential of *P. hysterophorus* compost as an organic fertilizer and a component of integrated weed and disease management in onion cultivation.

Keywords: Antimicrobial activity; Biofertilizer; Invasive weed; *Parthenium hysterophorus;* Sustainable agriculture

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1. Introduction

Growing concern over the adverse environmental and health impacts associated with the prolonged use of synthetic agrochemicals has accelerated the global transition towards sustainable and eco-friendly agricultural practices. Among the emerging alternatives, plant-derived allelochemicals have attracted considerable attention for their potential applications in weed management, pest control, disease suppression, and soil fertility improvement (Badesra et al., 2025; Bhagirath, 2026). Allelopathy refers to biochemical interactions in which plants release secondary metabolites into the environment, influencing the growth, development, and survival of neighbouring organisms (Bhadoria, 2011). Harnessing allelopathic interactions within cropping systems offers an ecologically sound strategy to regulate plant growth and suppress biotic stress factors while minimizing chemical inputs. However, careful management is required to exploit beneficial allelopathic effects without inducing autotoxicity or adverse impacts on crop plants (Hickman et al., 2023).

Parthenium hysterophorus L., an aggressive invasive weed, has emerged as a species of interest due to its strong allelopathic properties and potential utility in sustainable agriculture. Although notorious for its negative effects on biodiversity, livestock, and human health, *P. hysterophorus* contains a diverse array of bioactive compounds capable of modifying soil properties, plant growth, and microbial activity (Kishor et al., 2010). Several studies have reported allelopathic inhibition of economically important plant pathogens by aqueous extracts of *Parthenium* plant parts (Niranjan et al., 2024). Compost derived from *P. hysterophorus* has also been shown to reduce weed populations, an effect attributed to the persistence of allelopathic compounds in decomposed plant residues (Son, 1995). Notably, parthenin, the principal allelochemical of *Parthenium*, is rapidly degraded during decomposition, with a reported half-life (DT_{50}) of approximately 59 h, reducing long-term phytotoxic risks (Belz et al., 2009).

Beyond its phytotoxic effects, parthenin exhibits insecticidal properties and has demonstrated effectiveness against aphids and whiteflies in potato and okra fields (Baig et al., 2022). In addition, the incorporation of *P. hysterophorus* biomass or biochar has been reported to enhance soil pH, nutrient availability, and crop productivity, particularly in acidic soils (Muche et al., 2022). Compost prepared from *Parthenium* has been found to be rich in essential macro- (N, P, K) and micro-nutrients (Fe, Zn, Mn, and Cu), with nutrient concentrations exceeding those of conventional farmyard manure (Chahal et al., 2019). Organic amendments such as compost and manure are also known to improve nutrient assimilation and growth performance in crops, including enhanced nitrogen and phosphorus uptake (Suryawanshi, 2011). Furthermore, phenolic compounds present in composted biomass contribute antioxidant activity and metal chelation under heavy metal stress, thereby improving soil resilience (Parvin et al., 2022).

Although fresh *Parthenium* biomass is known to inhibit seed germination and early seedling growth, composting significantly reduces its phytotoxicity through microbial degradation of allelochemicals (Rajiv et al., 2013). Composting thus provides an effective strategy to detoxify *Parthenium* biomass while retaining beneficial bioactive compounds. Despite its potential, composting of *P. hysterophorus* remains poorly adopted by farmers due to concerns regarding its toxicity and the ecological threats posed by its uncontrolled spread (Gnanavel, 2013). Moreover, comprehensive studies examining the physicochemical characteristics of *Parthenium*-based composts and their effects on soil properties, crop growth, yield, and pathogen suppression remain limited. Pathogen sup-

pression in compost-amended soils may result from the combined action of antagonistic microorganisms and bioactive chemical compounds released during the composting process. Sterilization of compost disrupts microbial communities and alters the concentration and availability of organic compounds responsible for antimicrobial activity, thereby influencing pathogen inhibition mechanisms (Milinkovic et al., 2019). Previous studies have also reported herbicidal effects, reduced pest incidence, and improved crop performance following the application of *Parthenium* green manure, with yields surpassing those obtained using recommended NPK fertilizer rates (Javaid & Shafique, 2010).

The aims of this study are

- production of compost
- compost characterization
- evaluation of fertilizer value on *Allium cepa* L.
- antimicrobial activity

Allium cepa L. (onion) is an important crop grown commercially in Jaffna district and in high demand nationwide. Its productivity largely depends on the optimum usage of fertilizers mainly nitrogen (Balemi et al., 2007). Also, it has a short life cycle of 3-4 months.

2. Materials and Methods

2.1 Preparation of Compost Feedstock and Treatments

Above-ground parts of *Parthenium* whole plant except flowers and green leaves with tender stems of *Gliricidia sepium* were collected, chopped into small pieces, and shade-dried to prepare the compost feedstock. Six compost treatments were formulated using different combinations of dried (d) *Parthenium*, green(g) *Parthenium*, green (g) *Gliricidia*, rock phosphate, cow dung, and microbial inoculants.

Three different known species of microbial cultures were used as Microbial Inoculants (MI): *Lactobacillus plantarum* (isolated from fermented cabbage), *Bacillus megaterium* (obtained from a laboratory culture collection) and *Pseudomonas fluorescens*, isolated from rhizosphere soil and screened for phosphate-solubilizing ability using Pikovskaya's agar medium (Gupta et al., 2022; Bashan et al., 2013; Reyes et al., 2006).

2.2 Compost Formulations

1. Compost 1: *Parthenium*(d) and *Parthenium*(g) in 1:1 ratio + MI
2. Compost 2: *Parthenium*(d) and Gliricidia(g) in 1:1 ratio + MI
3. Compost 3: *Parthenium*(d) and *Parthenium*(g) in 1:1 ratio + MI+Rock phosphate (1kg)
4. Compost 4: *Parthenium*(d) and Gliricidia(g) in 1:1 ratio + MI +Rock phosphate (1kg)
5. Compost 5: *Parthenium*(d) and Gliricidia(g) in 1:1 ratio + Rock phosphate (300g) + cowdung (1kg)
6. Compost 6: Standard compost obtained from the District Agriculture Teaching Centre (DATC)

Microbial inoculum (MI) was prepared by mixing equal volumes of 2 x 10^8 cells/mL concentration of each bacterial liquid suspension prepared using reference turbidity solution (0.5 McFarland standard, which corresponds to an approximate concentration of 2 x 10^8 cells/mL). Each pile was inoculated with 30 mL of MI, sprayed evenly across each distinct layer of green and brown plant matter.

2.3 Composting Process

Compost heaps of 1.5 x 1.5 x 1.5 m were constructed. As the performance of composts of different feedstock combinations was compared, to prevent nutrient leaching and runoff by rainwater, composting was done indoors on a cement floor. Feedstocks (25 kg each

dry and green) were arranged in alternate layers Each heap was covered with black polythene to conserve moisture and heat. Moisture content was maintained by sprinkling water every three days, and the piles were turned at two-week intervals to ensure adequate aeration. Composting continued for six months until the dark, uniform-coloured, odourless mature compost was obtained.

2.4 Physicochemical Analysis of Compost

After compost maturation, dark, uniform-coloured, odourless compost samples were air-dried, sieved (2 mm), and analyzed by the Regional Agriculture Research and Development Centre (RARDC), Kilinochchi. Physicochemical parameters including pH, electrical conductivity (EC), moisture content, organic carbon, total nitrogen, available phosphorus, potassium, C: N ratio, and sand percentage were determined using standard analytical procedures.

2.5 Seed Germination Bioassay

The toxicity of composts was evaluated using onion seed (MICIO-1) germination assays. Different compost-amended soils in pots with a 1.5:1 soil-to-compost ratio were prepared in two sets for each treatment, and pots with seeds (10 seeds/pot) on growth medium were kept in a glasshouse; the number of sprouting seeds was recorded in each pot until there was no further increase in sprouting. Germination percentage was calculated to assess the potential phytotoxic effect of compost on seed viability.

2.6 Pot Experiment for Onion Growth and Yield

Onion bulbs (cv. 'Pachchai murian') were planted in polyethylene grow bags filled with compost-amended soil at a 1.5:1 soil-to-compost ratio. Different compost treatments were applied along with recommended fertilizer combinations for 10 onion bulbs in each bag, and two sets were kept for each treatment, which were arranged in a Completely Randomized Design. Growth parameters including plant height, number of leaves, and biomass accumulation, were recorded at regular intervals, while bulb yield was measured at harvest after 4 months of planting bulbs.

2.7 Preparation of Compost Extracts

Aqueous compost extracts (0.1g/mL) were prepared by suspending compost samples in sterile distilled water, followed by shaking and filtration. Portions of the extracts were sterilized by autoclaving, while the remaining extracts were left unsterilized to assess the combined effects of microbial and chemical constituents.

2.8 Antimicrobial Activity Assays

The antimicrobial potential of sterilized and unsterilized compost extracts was evaluated against selected plant pathogens. Antifungal activity against *Fusarium* sp., *Colletotrichum* sp., *Sclerotium* sp., and *Rhizopus* sp. was assessed using the poisoned food technique (Nene & Thapliyar, 2002). The fungal growth medium was poisoned by adding 1 mL compost extract to molten PDA, poured into sterile Petri dishes, and allowed to solidify. Fungal discs of test fungal pathogens of the same diameter were cut from actively growing culture plates and placed at the center of test plates and Control plates without compost extract, and plates were incubated at room temperature for 4-5 days. Radial growth of fungal mycelia was determined by measuring the colony diameter on the surface of the medium. Percentage inhibition of mycelial growth was calculated using the formula:

$$\% \text{ inhibition} = \frac{(\text{diameter of control plate} - \text{diameter of treatment})}{\text{diameter of control}} \text{X100}$$

Antibacterial activity against *Pseudomonas* sp. and *Xanthomonas* sp. was evaluated using the agar well diffusion method (Valgas et al., 2007). Wells with 8 mm diameter were punctured into Nutrient Agar plates with a lawn of test bacteria and 1 mL compost extract was loaded. Zones of inhibition were measured in millimetres after incubating the plates for 48 h at 37°C.

2.9 Statistical Analysis

All the estimates tabulated were mean values. Statistical analysis was carried out using Minitab 17.0. The data were analyzed using one-way ANOVA, where Tukey's multiple comparison tests were used to determine significant differences at $p<0.05$.

3. Results and Discussion

The differential antimicrobial responses observed between unsterilized and sterilized compost extracts demonstrate that both microbial activity and chemically persistent allelocompounds play complementary roles in pathogen suppression. According to the results (Table 1), all composts have EC values exceeding the recommended limits. Despite the higher EC, the composts contained elevated concentrations of essential macronutrients (N, P, and K), which are advantageous for plant growth and soil fertility enhancement. Among the treatments, Composts 3 and 4 recorded substantially higher phosphorus levels compared to the other composts, presumably due to the combined application of rock phosphate with phosphate-solubilizing bacteria. Compost 5 also exhibited higher phosphorus content

Table 1: Physicochemical analytical report of composts (mean ± SEM).

Parameter	SLSI standard	Compost 1	2	3	4	5
pH	6.5-8.5	7.60±0.06^{a}	7.62±0.07^{a}	7.46±0.09^{c}	7.53±0.02^{b}	7.54±0.01^{b}
Electrical conductivity (dS/m)	0.5-3	12.06±0.01^{a}	8.54±0.01^{b}	8.40±0.02^{c}	4.90±0.08^{e}	7.54±0.01^{d}
Total phosphorus (P_2O_5, % dry wt.)	>0.5 %	2.26±0.02^{d}	2.17±0.04^{d}	10.09±0.11^{b}	15.51±0.01^{a}	5.36±0.005^{c}
Total potassium (K_2O, %dry wt.)	>1 %	3.30±0.11^{a}	2.38±0.02^{b}	1.96±0.47^{c}	0.93±0.005^{d}	1.76±0.01b^{c}
Total Nitrogen (% dry wt.)	>1%	2.24±0.03^{b}	2.30±0.01^{a}	1.74±0.02^{d}	1.40±0.01^{e}	2.07±0.01^{c}
Moisture content (%fresh wt.)	<25 %	11.9±0.005^{c}	17.1±0.01^{b}	19.8±0.02^{a}	11.3±0.01^{d}	7.20±0.30^{e}
Organic carbon (% dry wt.)	>20 %	58.23±0.12^{a}	55.25±0.06^{b}	40.65±0.06^{d}	30.55±0.01^{e}	45.37±0.10^{c}
Carbon to nitrogen ratio (C:N)	10-25	26±0.30^{a}	24.02±0.05^{b}	23.36±0.55^{c}	21.82±0.56^{d}	21.92±0.05^{d}
Sand content (%)	<20 %	5.28±0.00^{e}	8.18±0.05^{d}	8.98±0.01^{c}	14.17±0.06^{b}	15.3±0.07^{a}

Treatments bearing the same letters for mean values did not differ significantly at $p < 0.05$. SEM – Standard Error of Mean

than Composts 1 and 2, which may be attributed to the presence of naturally occurring phosphate-solubilizing microorganisms in the added cow dung that solubilize the added rock phosphate (Behera & Ray, 2021). Rock phosphate (RP) is a natural source of inorganic phosphorus. It is insoluble in water and releases phosphorus very slowly over time. It is converted into a plant-available form of phosphorus by phosphate-solubilizing bacteria during composting. Therefore, supplementation with rock phosphate feeds microbes, which speed up the breakdown of organic matter and reduce the time to reach maturity and stability (Moharana & Biswas, 2016). Other physicochemical parameters, including moisture content, organic carbon, carbon-to-nitrogen (C:N) ratio, and sand percentage, also satisfied the SLSI standards. C:N value of compost 1 exceeding the standard may be due to excess carbon-to-nitrogen due to the lack of greens and the sole source of high lignocellulosic Parthenium, which breaks down very slowly and locks up carbon and increases the C:N ratio (Okolo & Abongo, 2014).

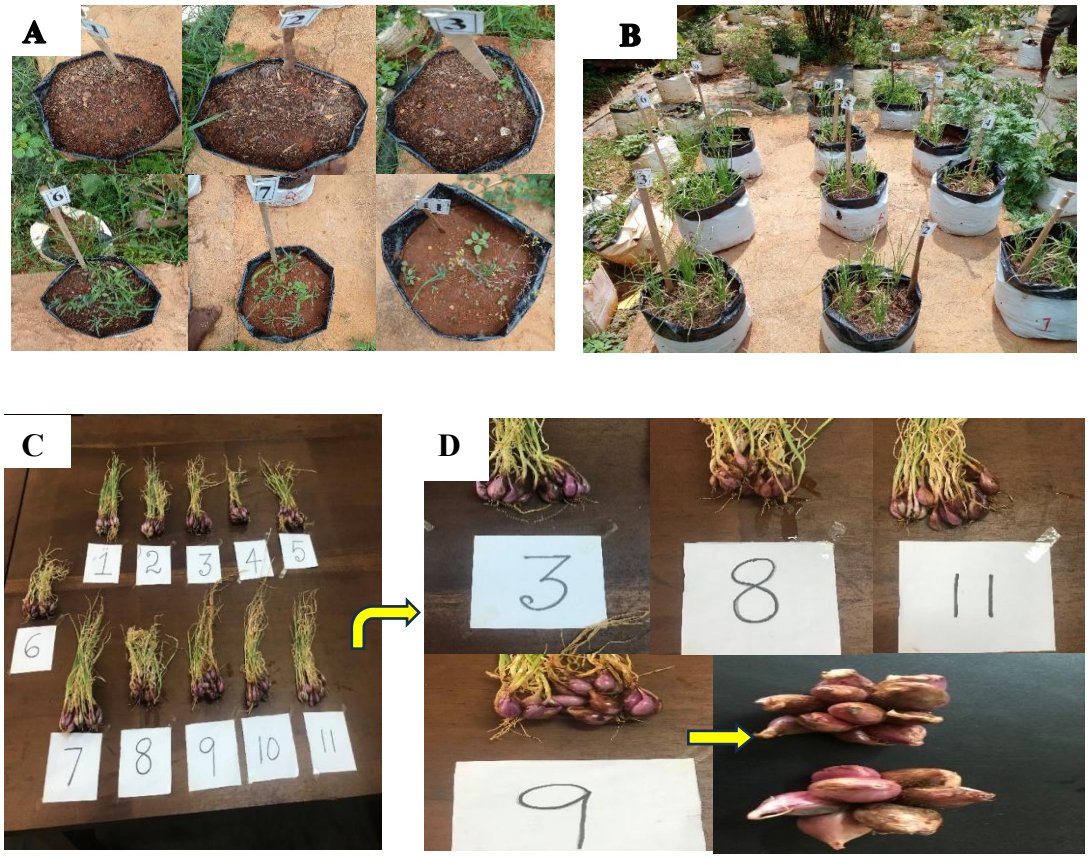

Figure 1. Effect of *Parthenium* compost amendment on onion growth and bulb yield. *(A)* Slow emergence and absence of weeds in Parthenium compost–amended soil (bags 1–3). *(B)* More than 90% germination of bulbs observed in all treatments. *(C)* Harvested bulbs from different treatments. *(D)* Cluster of onion bulbs (12 bulbs) produced from a single planted bulb in bag 9.

These observations are supported by previous findings demonstrating that increased soil organic matter enhances water-holding capacity, improves soil structure, facilitates nutrient exchange, buffers against extreme pH fluctuations, and increases nutrient availability to plants (Sonwane & Ustad, 2016). Application of *Parthenium* compost did not induce any adverse allelopathic effects on onion bulb development. Although a slight delay in seed germination and seedling emergence was observed during the early stages in bags amended with *Parthenium*-only compost, germination exceeded 90% across all treatments over time. The initial growth suppression associated with *Parthenium* composts gradually diminished, likely due to the microbial degradation of residual allelochemicals following incorporation into the soil. Soils amended with *Parthenium*-based compost consistently exhibited lower weed density and reduced disease and pest incidence compared with treatments receiving chemical fertilizer alone and untreated control (Figure 1). These results suggest that *Parthenium* compost retains biologically active compounds with herbicidal and pesticidal properties even after composting, contributing to integrated weed and pest suppression**.** The cumulative growth performance scores were highest in Treatments 9 and 10 (Table 2). Treatment 9 produced the highest fresh and dry bulb yields (146.43 and 23.40 g/bag, respectively) (Table 3 and Figure 2). Although Treatment 10 recorded the second-highest cumulative growth score, its bulb yield was lower than that of Treatment 9. This increased bulb yield is mainly attributed to the improved nutrient availability from the added compost rather than the non-nutritional factors like free from disease and vigour of plant. Vigorous, disease-free plants absorb nutrients efficiently. Compost improves soil structure, nutrient release timing and water-holding capacity necessary for plant growth. Treatments 8 and 10, in which *Parthenium* green

Table 2: Scoring of growth performance indicators and biotic stress-causing factors affecting *Allium cepa* in different compost-amended soils

Growth performance parameters	Treatments										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Initial germination & emergence	4	1	2	4	1	4	4	4	1	5	2
Germination %	5	5	5	5	5	5	5	5	5	5	4
Weed emergence	1	1	1	1	1	5	4	1	1	2	3
Free from disease occurrence	4	4	4	2	3	4	1	2	5	5	1
Vigour & health	4	4	4	2	3	4	2	2	5	5	1
Bulb yield (dry wt./bag)	2	3	4	4	4	3	3	3	5	3	2
Total Scores (excluding the scores for initial germination and weed emergence)	15	16	17	13	15	16	11	12	**20**	**18**	08

1 - very poor, 2 – poor, 3 - average, 4 – good, 5 – outstanding

Table 3: Effect of different soil amendments on the yield and percentage moisture content of bulbs of *Allium cepa.*

Treatment		Fresh wt.(g)	Dry wt.(g)	Moisture content (%)
1	Composts made	51.23±0.01^{k}	7.20±0.005^{k}	85.95±0.03^{a}
2		93.28±0.41^{f}	13.88±0.01^{g}	85.12±0.01^{b}
3		107.40±0.02^{c}	17.72±0.01^{c}	83.50±0.01^{d}
4		105.77±0.05^{d}	17.43±0.01^{d}	83.52±0.01^{d}
5		112.66±0.06^{b}	18.28±0.01^{b}	83.77±0.005^{d}
6	Compost from DATC	91.09±0.52^{g}	13.97±0.04^{f}	84.66±0.58^{c}
7	Chemical fertilizer only	97.13±0.005^{e}	14.57±0.01^{e}	85.00±0.10^{b}
8	Green *Parthenium* only	80.75±0.06^{h}	12.68±0.03^{h}	84.30±0.01^{c}
9	50% Compost+ 50% Chemical fertilizer	146.43±0.04^{a}	23.40±0.01^{a}	84.02±0.01c^{d}
10	50 % Green Parthe.+50% Chem-ical fertilizer	77.61±0.00^{i}	11.30±0.02^{i}	85.44±0.01a^{b}
11	Control (soil without any addition)	63.28±0.01^{j}	9.90±0.02^{j}	84.36±0.03^{c}

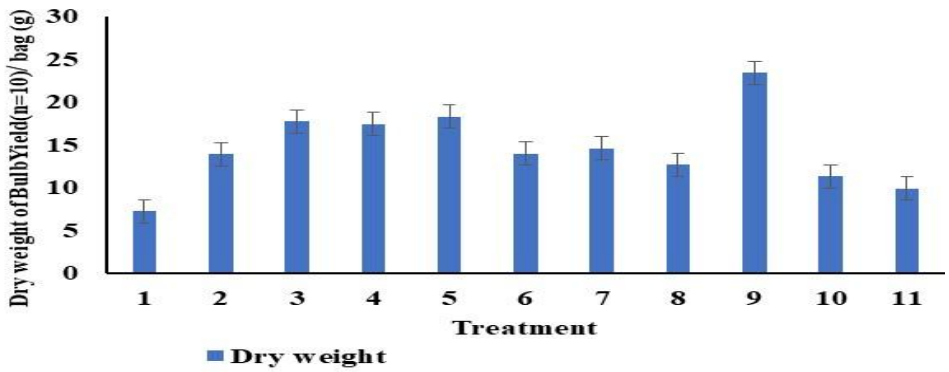

Figure 2: Effect of integrated Parthenium compost on the yield of *Allium cepa*.
Treatments bearing the same letters for mean values did not differ significantly at $p < 0.05$.

Leaf manure was incorporated, producing lower bulb yields than treatments amended with *Parthenium* compost supplemented with rock phosphate. This difference may be attributed to the higher and more balanced nutrient availability in compost relative to green leaf manure, as well as the enhanced phosphorus supply mediated by microbial inoculant activity.

Bulbs cultivated under integrated compost and chemical fertilizer applications at a 1:1 ratio exhibited significantly higher fresh and dry bulb weights, highlighting the synergistic effects of organic amendments and inorganic nutrient supplementation on onion productivity. When a combined form of organic compost and inorganic chemical fertilizer is used, nutrient availability to crops is improved by balancing the immediate delivery

of mineral nutrients with the slow, steady supply by mineralization of organic matter. Matching the release and availability of nutrients with the actual growth and uptake demands of the plant over time through this nutrient synchronization optimize the plant's physiological function and is a viable approach for cost-efficient and environmentally sustainable soil fertility management by reducing the fertilizer application rate.

Onion seed germination was lower in compost-amended treatments (10–65%) than in the control (92%) (Table 4). This response may be attributed to the presence of residual allelochemicals, including alkaloids and other organic compounds, that persist in the compost despite the composting process. Across all compost formulations, pH values range from 7.46 to 7.62, which falls within the desirable range for agricultural applications. However, electrical conductivity (EC) values exceeded recommended limits, likely due to the elevated salinity of the water used during compost preparation (Gondek et al., 2020). or due to indoor composting on a cement floor where there is no leaching by rainwater and the possibility of accumulation of dissolved ions released from feedstock trapped within compost by cation exchange capacity. As the water used for composting has an EC value of 0.673 dS/m, composting on a cement floor may be one of the reasons for the higher EC value.

Table 4: Percentage germination of cold-shocked onion seeds in pots with different compost-amended soil and Green Manure (GM)

Treatment	% Germination
Compost 1	50[d]
Compost 2	40[f]
Compost 3	30[g]
Compost 4	10[i]
Compost 5	45[e]
Compost 6	65[b]
Seeds put for germination after 2-3 wks. of GM addition	12[h]
Seeds put for germination after 2-3 days of GM addition	50[c]
Control	92[a]

Seed germination percentage was higher in pots where green *Parthenium* biomass was incorporated 2–3 days before sowing compared to pots amended with green *Parthenium* well in advance of sowing. Fresh Parthenium has been shown to reduce seed germination due to the release of allelochemicals than composted *Parthenium* (Rajiv et al., 2013). In contrast, seed germination study with *Parthenium* green manure addition showed less inhibition on seed gemination may be due to shorter period between incorporation and sowing that may have limited the extent of allelochemical release by degradation of plant tissue and thereby reducing allelopathic stress on onion seed viability.

The effects of sterilized and unsterilized compost extracts on the radial growth of Sclerotium sp., Rhizopus sp., Fusarium sp., and Colletotrichum sp. are illustrated in Figure 3. Unsterilized extracts showed greater inhibition of fungal growth than sterilized extracts, with the highest inhibition against Colletotrichum sp. (83.33%), followed by Fusarium sp. (76.19%) and Sclerotium sp. (58.33%); inhibition of Rhizopus sp. was minimal (1.00%) (Table 5 and Figure 4).

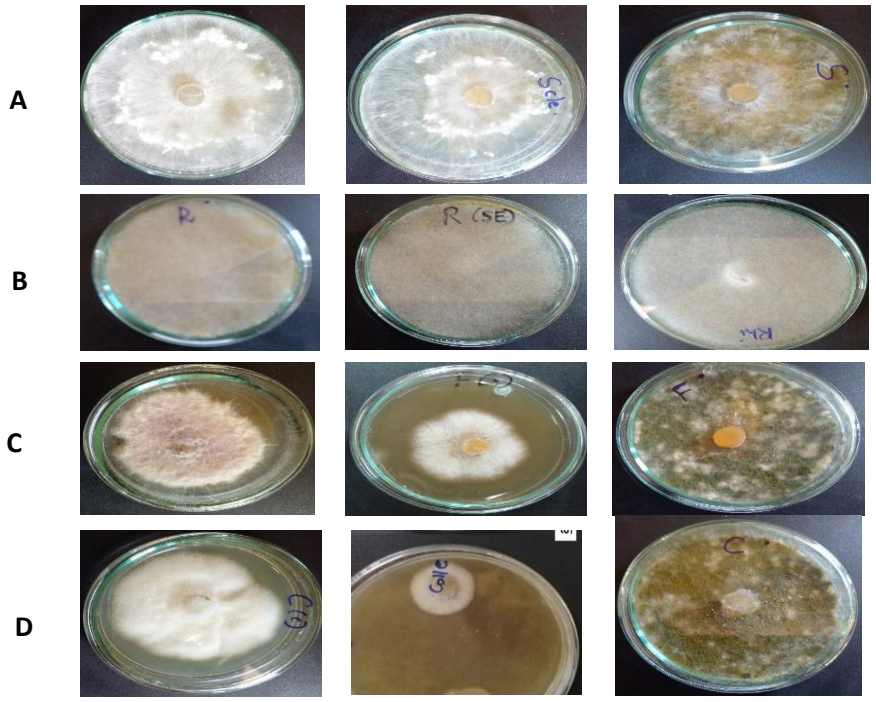

Figure 3: Radial growth of fungal mycelia on PDA plates poisoned with sterilized, unsterilized compost extract and control without any added extract. *(A) Sclerotium* sp., *(B) Rhizopus* sp., *(C) Fusarium* sp. *(D) Colletotrichum* sp.

Table 5. Effect of compost extracts on the fungal growth inhibition percentage. Mean values that do not share a letter are significantly different.

Plant pathogenic fungi	Mean diameter of fungal radial growth (mm) & % inhibition				
	Control	Unsterilised extract	% Inhibition	Sterilized extract	% Inhibition
Fusarium sp.	42	10.00±0.01	76.19±0.01^{b}	25.00±0.05	40.47±0.56^{a}
Colletotrichum sp.	60	10.00±0.00	83.33±0.01^{a}	50.00±0.01	16.66±0.01^{c}
Sclerotium sp.	60	25.00±0.12	58.33±0.52^{c}	45.00±0.05	25.00±0.05^{b}
Rhizopus sp.	70	69.30±0.00	1.00±0.00^{d}	70.00±0.00	0.00±0.00^{d}

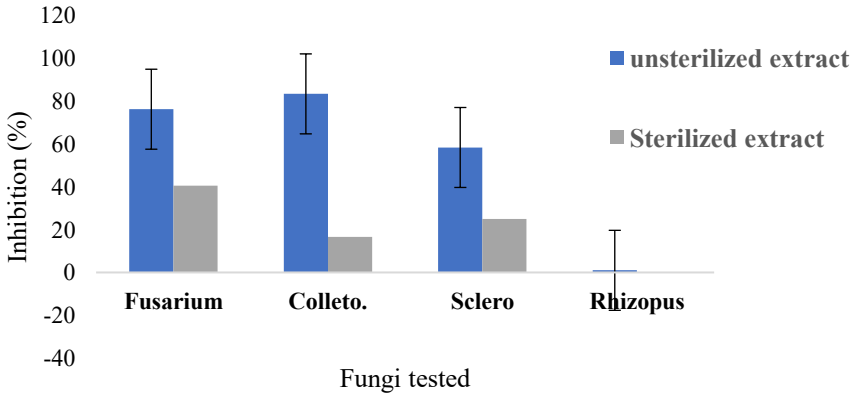

Figure 4: Effect of compost extracts on the fungal growth inhibition.

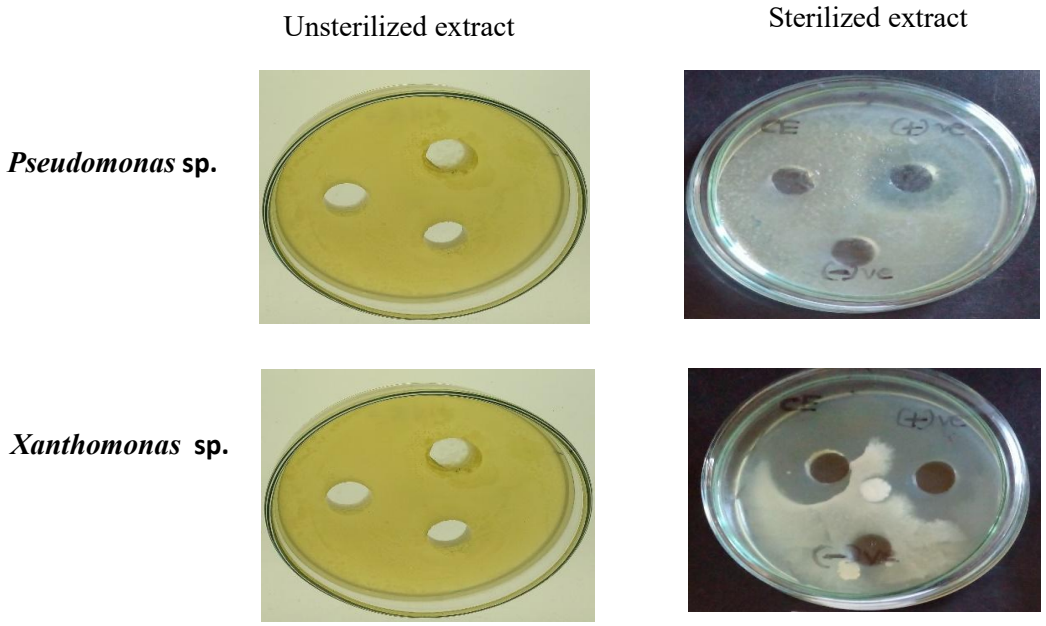

Figure 5: Effect of compost extracts on the inhibition of plant pathogenic bacteria.

The antibacterial activity of compost extracts varied between sterilized and unsterilized treatments. *Pseudomonas* sp. exhibited only slight inhibition, whereas *Xanthomonas* sp. was more sensitive to the sterilized compost extracts (Figure 5). In contrast, unsterilized compost extracts did not show measurable inhibition of bacterial growth. These results suggest that suppression of bacterial pathogens may be largely associated with the presence of heat-stable chemical constituents rather than with live microbial antagonists present in the compost, supported by the finding that autoclaving of extract had less effects on the antibacterial properties (Hashemi et al., 2008). Pathogen inhibition in compost-amended systems is commonly attributed to antimicrobial metabolites produced by microorganisms and/or allelochemicals released from plant biomass during composting. Comparable trends have been reported for composts derived from horticultural waste, where sterilization altered antimicrobial efficacy by modifying the availability of (decreasing or increasing) bioactive compounds (Milinkovic et al., 2019).

Unsterilized compost extracts were more effective than sterilized extracts in suppressing fungal pathogens, while sterilized extracts exhibited greater antibacterial activity, indicating the involvement of both biological and chemical mechanisms in pathogen suppression. Among the fungal pathogens investigated, *Rhizopus* responded differently, and its inhibition was almost absent even with the unsterilized compost extract. This may be due to its higher rate of growth than the rate of inhibition due to its resistance to antifungal substances in the *Parthenium* compost extract, and it overcomes the inhibitory factor and continues to expand its colony. Similar drug resistance by fungi was reported in a previous study (Perlin. et al., 2015). Reduced disease incidence was observed in plants grown in compost-amended soils in grow bags, supporting the potential of *Parthenium*-based composts as a component of integrated disease management strategies (Rai & Suthar, 2020; Kumar et al..2025). Separating the flowerless plants from plants with flowers is not possible for large-scale composting, as *Parthenium* usually exists in all different life stages simultaneously. Farmers are reluctant to use *Parthenium* compost due to the allelopathic nature of incompletely decomposed plant matter, causing crop damage. Long-term application of Parthenium compost may alter the microbes and chemistry of soil.

4. Conclusions

This study demonstrates that this invasive allelopathic weed can be effectively transformed into a value-added biofertilizer through composting, particularly when combined with beneficial microbes and supplementary organic materials. Physicochemical analyses confirmed the nutrient-rich nature of compost, which promoted healthy onion growth and provided biocontrol against fungal and bacterial pathogens. Based on the experimental results, the integrated nutrient management (50% compost and 50% chemical fertilizer) is the most effective way of using organic compost. *Parthenium* compost treatment outperformed both the chemical-only fertiliser treatment and the unamended control treatment, showing the Parthenium compost's standalone efficacy over synthetic alternatives.

To optimize benefits and minimize allelopathic effects, *Parthenium* biomass should be harvested before flowering, composted with microbial inoculants for at least six months, with a long thermophilic phase before use in amendments. Sustainable management of *Parthenium* through composting offers an economical and eco-friendly strategy for weed control while producing an effective organic fertilizer. Creating awareness regarding proper composting methods and its fertilizer value is essential. Future studies should investigate the long-term effects of *Parthenium* compost on different crops and soil ecosystems under field conditions. The exact dosage for diverse crops that maximises yield without phytotoxicity, and the development of bioformulations for commercialisation, should also be studied.

Conflict of interest

The authors declare that they have no competing interests.

Author contribution

K. Niranjan: conducted the research and wrote the original draft Manuscript; P. N. Yapa: Supervision, manuscript correction, and R. Kapilan: Supervision and editing. All authors have read and agreed to publish the version of the manuscript.

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Data availability statement

The datasets generated and/or analysed during the current study are available from the authors upon reasonable request.

References

Badesra, S., Manuja, S., Sharma, G. D., Shivalika, Mali, S., & Kumari, S. (2025). Allelopathy based weed management: Advances and challenges. *Vigyan Varta, 6*(4), 231–233.

Baig, B., Yousaf, S., Iqbal, J., Jee, H., Naz, A., & Bilal, M. (2022). Characterization and quantification of active compounds in *Parthenium hysterophorus* for development of a bio-herbicide to reduce reliance on synthetic herbicides. *Journal of Hunan University (Natural Sciences), 49*(10), 1691–1704.

Balemi, T., Pal, N., & Saxena, A. K. (2007). Response of onion (*Allium cepa* L.) to combined application of biological and chemical nitrogenous fertilizers. *Acta Agriculturae Slovenica, 89*(1), 107–114. https://doi.org/10.2478/v10014-007-0013-y

Bashan, Y., Kamnev, A. A., & de-Bashan, L. E. (2013). Tricalcium phosphate is inappropriate as a universal selection factor for isolating and testing phosphate-solubilizing bacteria that enhance plant growth: A proposal for an alternative procedure. *Biology and Fertility of Soils, 49*(4), 465–479. https://doi.org/10.1007/s00374-012-0737-7

Behera, S. S., & Ray, R. C. (2021). Bioprospecting of cowdung microflora for sustainable agricultural, biotechnological and environmental applications. *Current Research in Microbial Sciences, 2*, Article 100018. https://doi.org/10.1016/j.crmicr.2020.100018

Belz, R. G., van der Laan, M., Reinhardt, C. F., & Hurle, K. (2009). Soil degradation of parthenin—Does it contradict the role of allelopathy in the invasive weed *Parthenium hysterophorus* L.? *Journal of Chemical Ecology, 35*, 1137–1150. https://doi.org/10.1007/s10886-009-9698-1

Bhadoria, P. B. S. (2011). Allelopathy: A natural way towards weed management. *American Journal of Experimental Agriculture, 1*(1), 7–20. https://doi.org/10.9734/AJEA/2011/002

Bhagirath, G. (2026). Role of allelopathy in enhancing soil microbial activity, nutrient cycling, and weed suppression. *International Journal on Science and Technology, 17*(2). https://doi.org/10.71097/IJSAT.v17.i2.10614

Chahal, H. S., Singh, S., Dhillon, I. S., & Kaur, S. (2019). Effect of integrated nitrogen management on macronutrient availability under cauliflower (*Brassica oleracea* var. *botrytis* L.). *International Journal of Current Microbiology and Applied Sciences, 8*(4), 1623–1633.

Gnanavel, I. (2013). *Parthenium hysterophorus* L.—A major threat to natural and agroecosystems in India. *Science International, 1*(5), 124–131.

Perlin, M., Weindorf, D. C., Thiel, C., & Kleinheinz, G. (2020). Soluble salts in compost and their effects on soil and plants: A review. *Compost Science & Utilization, 28*(2), 59–75. https://doi.org/10.1080/1065657X.2020.1772906

Gupta, R., Kumari, A., Sharma, S., Alzahrani, O. M., Noureldeen, A., & Darwish, H. (2022). Identification, characterization and optimization of phosphate solubilizing rhizobacteria (PSRB) from rice rhizosphere. *Saudi Journal of Biological Sciences, 29*(1), 35–42. https://doi.org/10.1016/j.sjbs.2021.09.075

Hashemi, S. R., Zulkifli, I., Zunita, Z., & Somchit, M. N. (2008). The effect of selected sterilization methods on antimicrobial activity of aqueous extract of herbal plants. *Journal of Biological Sciences, 8*(6), 1072–1076.

Hickman, D. T., Comont, D., Rasmussen, A., & Birkett, M. A. (2023). Novel and holistic approaches are required to realize allelopathic potential for weed management. *Ecology and Evolution, 13*, Article e10018. https://doi.org/10.1002/ece3.10018

Javaid, A., & Shafique, S. (2010). Seasonal pattern of seed dormancy in *Parthenium hysterophorus* L. *Pakistan Journal of Botany, 42*(1), 497–503.

Kishor, P., Ghosh, A. K., Singh, S., & Maurya, B. R. (2010). Potential use of *Parthenium* (*Parthenium hysterophorus* L.) in agriculture. *Asian Journal of Agricultural Research, 4*(4), 220–225.

Kumar, M., Kaur, P., Taneja, T., Singh, R., Koul, A., & Sharma, A. K. (2025). Weeds having antifungal activity against pathogenic fungi: From an ethnomedicinal perspective. *Studies in Fungi, 10*, Article e031.

Milinković, M., Lalević, B., Jovičić-Petrović, J., Golubović-Ćurguz, V., Kljujev, I., & Raičević, V. (2019). Biopotential of compost and compost products derived from horticultural waste—Effect on plant growth and plant pathogens' suppression. *Process Safety and Environmental Protection, 121*, 299–306. https://doi.org/10.1016/j.psep.2018.09.024

Moharana, P. C., & Biswas, D. R. (2016). Assessment of maturity indices of rock phosphate enriched composts using variable crop residues. *Bioresource Technology, 222*, 1–13. https://doi.org/10.1016/j.biortech.2016.09.097

Muche, M., Molla, E., Mohammed, S., Sintie, E., & Hassen, A. (2022). Evaluating slow pyrolysis of *Parthenium hysterophorus* biochar: Perspectives to acidic soil amelioration and growth of selected wheat (*Triticum aestivum*) varieties. *The Scientific World Journal, 2022*, Article 8181742. https://doi.org/10.1155/2022/8181742

Nene, Y. L., & Thapliyal, P. N. (2002). *Fungicides in plant disease control*. Oxford & IBH Publishing.

Niranjan, K., Kapilan, R., & Yapa, P. N. (2024). Composition and antimicrobial activity of different plant parts of *Parthenium hysterophorus* L. *Tropical Agricultural Research, 35*(1), 84–93.

Okolo, E. G., & Abongo, B. O. (2014). Challenges of soil health management by small-holder farmers in Western Kenya: The C:N (carbon: nitrogen) ratio context in composting. *International Journal of Science and Research, 3*(11), 877–883

Parvin, K., Nahar, K., Mohsin, S. M., Mahmud, J. A., Fujita, M., & Hasanuzzaman, M. (2022). Plant phenolic compounds for abiotic stress tolerance. In M. Hasanuzzaman, G. J. Ahammed, & K. Nahar (Eds.), *Managing plant production under changing environment* (pp. 193–237). Springer. https://doi.org/10.1007/978-981-16-5059-8_8

Perlin, D. S., Shor, E., & Zhao, Y. (2015). Update on antifungal drug resistance. *Current Clinical Microbiology Reports, 2*, 84–95.

Rai, R., & Suthar, S. (2020). Composting of toxic weed: Nutrient changes, the fate of faecal coliforms, and biopesticidal property assessment. *Journal for Research in Applied Science and Engineering Technology, 8*, 953–960.

Rajiv, P., Rajeshwari, S., Hiranmai Yadav, R., & Rajendran, V. (2013). Vermiremediation: Detoxification of parthenin toxin from *Parthenium* weeds. *Journal of Hazardous Materials, 262*, 489–495. https://doi.org/10.1016/j.jhazmat.2013.08.075

Reyes, I., Valery, A., & Valduz, Z. (2006). Phosphate-solubilizing microorganisms isolated from rhizospheric and bulk soils of colonizer plants at an abandoned rock phosphate mine. *Plant and Soil, 287*(1–2), 69–75. https://doi.org/10.1007/s11104-006-9061-z

Son, T. T. N. (1995). *Bioconversion of organic wastes for sustainable agriculture* [Doctoral dissertation, Tamil Nadu Agricultural University].

Sonwane, N., & Ustad, I. (2016). Biological control of *Parthenium hysterophorus* and its utilization as biocompost. *World Journal of Pharmaceutical Research, 5*(5), 884–886.

Suryawanshi, D. S. (2011). Utilization of weed biomass as an organic source in maize. *Life Science Bulletin, 8*(1), 10–12.

Valgas, C., de Souza, S. M., Smânia, E. F. A., & Smânia, A. (2007). Screening methods to determine antibacterial activity of natural products. *Brazilian Journal of Microbiology, 38*, 369–380. https://doi.org/10.1590/S1517-83822007000200034