International Journal of Plant Pathology and Microbiology

E-ISSN: 2789-3073
P-ISSN: 2789-3065
www.plantpathologyjournal.com
IJPPM 2025; 5(1): 08-17
Received: 09-10-2024
Accepted: 15-11-2024

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Comparative study of oyster mushroom compost effects on sesame plant development and soil quality

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Abstract
The study investigated the impact of different types of oyster mushroom compost on the growth, yield, and soil properties associated with *Sesamum indicum* L. (Shandweel 3). Mushroom cultivation waste was composted with farmyard manure in a 1:1 ratio and applied in three forms: (1) fully organic compost equivalent to 100% of nitrogen (N) fertilization, (2) fully inorganic fertilizer using the recommended dose of ammonium nitrate (33.5%), and (3) a 50:50 combination of organic compost and mineral-N. All treatments provided a total nitrogen dose of 100 kg/fed. Results revealed that combining mushroom compost with half the dose of mineral-N significantly increased plant height, shoot length to the first capsule, number of capsules per plant, and seed yield (kg/fed). Additionally, this treatment enhanced seed biochemical parameters, including chlorophyll a, chlorophyll b, carotenoids, total carbohydrates, soluble protein, amino acids, and lipids, compared to the full recommended dose of mineral-N. The application of mushroom compost also improved the nutrient profile of *Sesamum indicum* L. seeds, with higher total nitrogen, available phosphorus (P), and potassium (K) contents. These effects were observed across all treatments involving organic compost combined with half the dose of mineral-N, outperforming the full dose of mineral-N alone. The findings demonstrate the potential of integrating oyster mushroom compost with reduced mineral-N inputs to enhance plant growth, yield, and soil fertility in *Sesamum indicum* L. cultivation.

Keywords: Oyster mushroom compost, *Sesamum indicum* L., plant growth, seed yield, soil properties

Introduction
Agricultural activities generate substantial amounts of waste, posing environmental challenges if left unmanaged. In Egypt, annual agricultural waste production ranges from 30 to 35 million tons (Shaban *et al.*, 2010) [45], including residues from cultivation fields and agro-industrial processes. Globally, utilizing these wastes for sustainable purposes holds great potential. For instance, using 25% of the cereal straw burned annually worldwide could yield 317 million metric tons of fresh mushrooms (Courvoisier, 1999). With an estimated global agricultural and forestry waste of 600 billion kilograms, this resource could support the production of 360 billion kilograms of fresh mushrooms, potentially providing 6 kg per capita annually and addressing global protein deficiencies affecting 30% of the population (Ergonul *et al.*, 2013) [61]. Mushroom cultivation not only contributes to food security but also offers an environmentally friendly method for managing agricultural waste. Composting agricultural residues as soil amendments is a sustainable alternative to burning, recycling carbon into the soil, improving its physical properties, and reducing pollution (Abdel-Motaal, 2004) [2]. Composting, the biological degradation of organic materials into humus-like substances (Ancuta *et al.*, 2011) [8], can utilize animal and human waste, crop residues, and aquatic plants, with components such as cellulose, hemicellulose, lignin, proteins, and lipids serving as key resources (Gabhane *et al.*, 2012) [23]. Mushroom compost, in particular, enhances soil structure, organic matter content, and nutrient supply, gradually releasing nutrients for plant use (Uzun, 2004) [53] and improving water-holding capacity, microbial activity, and soil aeration while reducing compaction (Courtney and Mullen, 2008) [15]. Despite containing lower nutrient concentrations than mineral fertilizers, its sustained nutrient release supports healthier plant growth. Egypt generates 22 to 26 million dry tons of waste annually, with major contributions from Zea mays and Sorghum residues. These lignocellulosic wastes, rich in cellulose (35-45%) and hemicellulose (25-40%), can be hydrolyzed for mushroom cultivation, and post-harvest residues can be composted as organic amendments (Taher *et al.*, 2018) [51]. This study aims to evaluate the effects of mushroom waste compost on the growth, yield, and soil properties of *Sesamum indicum* L.

(Shandweel 3), highlighting its potential as a sustainable alternative or supplement to conventional fertilizers.

Materials and Methods

Compost Preparation: Oyster mushrooms (*Pleurotus ostreatus*, *P. columbinus*, *P. pulmonarius*, *P. sajor-caju*, and *P. floridans*) were cultivated using agricultural wastes derived from *Zea mays* and *Sorghum bicolor*. The resulting mushroom cultivation residues were collected and divided into three separate piles: one consisting of *Zea mays* residues, another from *Sorghum bicolor* Horse residues, and a third from *Sorghum bicolor G15* residues. Each pile was mixed with farmyard manure at a 1:1 ratio to create compost.

The composting process involved manual mixing of the piles weekly to ensure adequate aeration and temperature uniformity. Moisture levels were monitored every 15 days, and water was added as needed to maintain a moisture content of approximately 60% (Ashrafi *et al.*, 2014) [9]. Samples from each pile were collected every 15 days throughout the composting period for further analysis.

Determination of Nitrogen, Potassium, and Phosphorus Content: The total nitrogen content in the dried agricultural wastes and mushroom compost was measured using the Kjeldahl digestion method, as described by Jackson (1973) [25]. Total phosphorus content was determined spectrophotometrically in acid-digested samples using ammonium molybdate and stannous chloride reagents, following the procedure outlined by Page *et al.* (1982) [43]. Total potassium content was measured in the acid-digested samples using a flame photometer, as per the method described by Page *et al.* (1982) [43].

Experiment to Compare the Efficacy of Mushroom Compost and Inorganic Fertilizer on *Sesamum indicum* L. (Shandweel 3) Yield

Sesame seeds (*Sesamum indicum* L. Shandweel 3) were obtained from the Agricultural Research Center, Giza, Egypt. The experiment was conducted on clay soil, with soil properties analyzed and presented in Table 3.

Mushroom compost was applied to the soil prior to planting in three different forms:

Complete organic form: Mushroom compost was applied at a rate equivalent to 100% of the recommended nitrogen (N) fertilization dose.

Complete inorganic form: Inorganic fertilizer was applied at the recommended dose using ammonium nitrate (33.5%).

Combination of organic and mineral-N: Mushroom compost and mineral-N were combined in a 50:50 ratio, with the total application meeting the recommended N dose of 100 kg/fed.

The treatments were designed to evaluate the impact of these nutrient management strategies on the yield and growth of sesame plants grown in clay soil.

Treatment Types	Cultivation types
T_1	Control (no fertilizer organic or inorganic).
T_2	Recommended dose (Inorganic fertilizer; ammonia natrate 33.5%).
T_3	Mushroom compost from Zea mays 100% equivalent to N of inorganic fertilizer
T_4	Mushroom compost from Sorghum bicolor Horse 100% equivalent to N of inorganic fertilizer
T_5	Mushroom compost from Sorghum bicolor G15 100% equivalent to N of inorganic fertilizer
T_6	50%: 50% inorganic fertilizer: Zea mays compost
T_7	50%: 50% inorganic fertilizer: Sorghum bicolor Horse compost
T_8	T50%: 50% inorganic fertilizer: Sorghum bicolor G15 compost

Sesame seeds (*Sesamum indicum L.* Shandweel 3) were sown at a rate of 3 kg per feddan. The field was irrigated in the early morning to reach field capacity. One month after planting, five plants from each treatment were harvested to measure chlorophyll content. The remaining plants were left in the field until maturity and capsule formation. At harvest, the capsules were collected, and the seeds were analyzed for their chemical constituents.

Table 1: Physical and Chemical Characteristics of the Soil before Cultivation of *Sesamum indicum* L. (Shandweel 3)

Table 1: Physical and chemical characteristics of used soil before cultivation of *Sesamum indicum* L. (Shandweel 3).

Analysis	Value	Analysis	Value
PH	7.22±	N	0.12±%
Ec	0.34±	P	0.07±%
Co_3	0.054±	K	0.10±%
Cl	0.0875±	Soil texture	Sandy loam
Om	0.018±%		

OM: Organic Matter

Photosynthetic Pigments: The photosynthetic pigments chlorophyll *a*, chlorophyll *b*, and carotenoids were extracted from fresh leaves using 5 mL of 95% ethyl alcohol. The samples were heated in a water bath at 60-70°C. Absorbance readings were recorded using a spectrophotometer at wavelengths of 663 nm, 644 nm, and 452 nm. The pigment concentrations were calculated using the equations recommended by Lichtenthaler (1987) [28].

Extraction of Proteins, Carbohydrates, Amino Acids, and Lipids: To analyze the biochemical composition of the seeds, 0.1 g of finely ground, dried seed material was subjected to boiling in 10 mL of distilled water for 1 hour. This process ensured the release of soluble proteins, carbohydrates, free amino acids, and lipids into the aqueous phase. The mixture was then centrifuged at 10,000 × g for 10 minutes to separate the supernatant from the solid residues. The clear supernatant was subsequently used for quantitative analyses of these biochemical constituents.

Quantification of Carbohydrates

Carbohydrates were quantified using the anthrone-sulfuric acid method, a colorimetric assay widely utilized for total carbohydrate estimation. In this method, anthrone reacts with carbohydrates in the presence of concentrated sulfuric acid to produce a green-colored complex. The intensity of the color is proportional to the carbohydrate concentration and is measured spectrophotometrically at 620 nm. The method was conducted according to the procedures described by Fales (1951) [22] and Schlegel (1956) [49], ensuring accurate and reliable results.

Quantification of Proteins
Protein content was determined following the Lowry method, which is a widely accepted technique for protein quantification. This method involves the reaction of proteins with an alkaline copper reagent to form a copper-protein complex, followed by the reaction with the Folin-Ciocalteu phenol reagent to produce a blue-colored complex. The absorbance of the resulting solution was measured at 750 nm to determine the protein concentration. The procedure followed the methodology described by Lowry *et al.* (1951) [29], ensuring sensitivity and reproducibility for detecting protein content in small samples.

Quantification of Free Amino Acids
Free amino acids were quantified using the ninhydrin-based method developed by Moore and Stein (1948) [39]. This method involves the reaction of free amino acids with ninhydrin under controlled conditions, resulting in a colored complex. The intensity of the resulting purple color, also known as Ruhemann's purple, correlates with the concentration of amino acids and is measured spectrophotometrically at 570 nm. This method provides a reliable measure of free amino acid levels in the seed extracts.

Determination of Total Lipids
Total lipids were determined using the sulfo-phosphovanillin (SPV) method, which is based on the reaction of lipids with concentrated sulfuric acid followed by a colorimetric reaction with vanillin in the presence of phosphoric acid. The SPV method involves the formation of a pink or red-colored complex that is proportional to the lipid concentration. The absorbance of the complex was measured spectrophotometrically at 520 nm. The reagents used included phosphoric acid, vanillin, and ethanol, ensuring precise quantification. The method, as described by Drevon, is effective for measuring total lipid content in small biological samples.

Yield Measurements
To evaluate the productivity and growth performance of *Sesamum indicum* L. (Shandweel 3), several yield-related parameters were measured and recorded:

Plant Height (cm): The height of the plants was measured from the soil surface to the tip of the main shoot using a measuring tape at the end of the growth period. This parameter served as an indicator of overall vegetative growth.

Shoot Length to the First Capsule: The length of the shoot from the base to the position of the first capsule was measured. This parameter provided insights into the vertical growth distribution and reproductive allocation of the plant.

Capsule Length: The length of mature capsules was measured using a vernier caliper. This parameter was indicative of the fruit development potential and its contribution to seed yield.
Seed Yield: The total seed yield per plant was recorded after harvesting and drying the seeds to a constant weight. This served as the primary indicator of the plant's reproductive success and productivity.
In addition to these plant-based yield parameters, the soil's physical and chemical properties were analyzed to assess the impact of cultivation on soil health. The following soil characteristics were measured:

Total Nitrogen (N): Total nitrogen content was determined to evaluate soil fertility and nitrogen availability for plant growth.

Available Phosphorus (P): The concentration of available phosphorus in the soil was measured as it is a critical nutrient for root development and seed production.

Available Potassium (K): The level of available potassium, essential for plant water regulation and overall vigor, was analyzed.
These soil analyses were conducted both before cultivation to establish a baseline and after cultivation to assess changes induced by the growth of *Sesamum indicum L.* and any amendments applied during the experiment.

Statistical Analysis
The data were analyzed statistically using the Randomized Complete Block Design (RCBD). Mean comparisons were conducted using Duncan's Multiple Range Test (DMRT) at a 5% level of probability to interpret the results, as described by Gomez and Gomez (1984) [24].

Results
Agricultural Waste Properties: The properties of the agricultural wastes used in this study are presented in Table 2. The data revealed that Zea mays wastes exhibited the highest total nitrogen, phosphorus, and potassium contents, followed by Sorghum bicolor Horse and Sorghum bicolor G15 wastes. Similarly, the moisture content of the agricultural wastes ranked in the same order, with Zea mays having the highest levels.

Table 2: Properties of Agricultural Wastes Used in Composting

Kind of Wastes	Moisture Content (%)	N (%)	P (%)	K (%)
Zea mays	24±1.3	1.1±0.01	0.56±0.01	0.79±0.03
Sorghum bicolor (Horse)	18±0.9	0.91±0.07	0.41±0.02	0.47±0.02
Sorghum bicolor (Giza 15)	12±0.8	0.71±0.06	0.33±0.01	0.34±0.01

The chemical characteristics of the oyster mushroom compost prepared from these agricultural wastes are shown in Table 3. The compost derived from Zea mays wastes also had the highest total nitrogen, phosphorus, and potassium levels, followed by compost made from Sorghum bicolor Horse and Sorghum bicolor G15 wastes.

Table 3: Chemical Analysis (N, P, and K) in Different Mushroom Composts

Type of Mushroom Compost	N (%)±SE	P (%)±SE	K (%)±SE
Zea mays	1.46±0.12	0.59±0.02	0.81±0.13
Sorghum bicolor Horse	1.01±0.23	0.33±0.02	0.70±0.17
Sorghum bicolor Giza 15	0.81±0.14	0.27±0.01	0.63±0.12

Each value represents the mean of three replicates± SE. Different letters indicate significant differences at $p<0.05$.

Soil Properties Before and After Compost Addition

Data presented in Table 4 for Season 1 revealed that the addition of mushroom compost to the soil resulted in an increase in total nitrogen (N), available phosphorus (P), and available potassium (K) after harvesting *Sesamum indicum* plants. Total nitrogen values ranged from 0.09% to 0.32%. The application of organic composts alone resulted in total N values ranging from 0.27% to 0.30%, while the combination of organic composts with half the recommended dose of mineral-N increased total N content to 0.29%-0.33%. Regarding available P and K, there was a significant increase in both nutrients following the addition of any type of organic compost compared to the full recommended dose of mineral-N. The application of organic composts alone resulted in available P ranging from 0.06% to 0.10% and available K from 0.08% to 0.11%. In contrast, the combination of organic compost with half the mineral-N dose resulted in available P values between 0.11% and 0.12%, and available K of 0.13%. Similar results were obtained in Season 2.

Table 4: Effect of Compost Types on N, P, and K Contents in Soil after Harvesting

Type of Treatment	N (%)±SE	P (%)±SE	K (%)±SE
T_1	0.09 C±0.002	0.05 C±0.001	0.07 B±0.04
T_2	0.16 D±0.001	0.06 C±0.001	0.08 B±0.03
T_3	0.28 A±0.002	0.10 A±0.002	0.11 A±0.01
T_4	0.27 B±0.001	0.10 B±0.001	0.10 A±0.004
T_5	0.30 A±0.01	0.11 A±0.002	0.12 A±0.003
T_6	0.32 A±0.02	0.12 A±0.003	0.13 A±0.001
T_7	0.31 A±0.02	0.11 A±0.002	0.13 A±0.001
T_8	0.29 A±0.003	0.11 A±0.002	0.13 A±0.001

Each value represents the mean of three replicates± SE. Different letters indicate significant differences at $p<0.05$ (Season 1).

Chlorophyll Content

Data in Table 5 for Season 1 showed that the addition of mushroom compost to the soil significantly increased chlorophyll *a*, chlorophyll *b*, and carotenoids in *Sesamum indicum* L. The organic content provided by the compost contributed to the enhancement of chlorophyll content, with similar results observed in Season 2.

Table 5: Effect of Compost Types on N, P, and K Contents in Soil after Harvesting

Type of Treatment	N (%)±SE	P (%)±SE	K (%)±SE
T_1	0.08 C±0.002	0.06 C±0.001	0.06 B±0.04
T_2	0.15 D±0.001	0.06 C±0.001	0.07 B±0.03
T_3	0.28 A±0.002	0.12 A±0.002	0.11 A±0.01
T_4	0.29 B±0.001	0.11 B±0.001	0.12 A±0.004
T_5	0.32 A±0.01	0.12 A±0.002	0.13 A±0.003
T_6	0.33 A±0.02	0.13 A±0.003	0.15 A±0.001
T_7	0.31 A±0.02	0.12 A±0.002	0.14 A±0.001
T_8	0.30 A±0.003	0.12 A±0.002	0.14 A±0.001

Each value represents the mean of three replicates±SE. Different letters indicate significant differences at $p<0.05$ (Season 2).

Plant Growth and Yield: As shown in Table 6 for Season 1, the combined application of mushroom compost and mineral-N (nitrite) led to significant increases in plant height, first capsule length, capsule length, number of capsules per plant, and seed yield. These improvements in plant growth and yield were also observed in Season 2.

Table 6: Effect of Different Compost Types (Organic, Inorganic, and Mixture) on Chlorophyll a, Chlorophyll b, and Carotenoids in *Sesamum indicum L.* (Shandweel 3)

Cultivation Type	Chlorophyll a (mg/g FW)±SE	Chlorophyll b (mg/g FW)±SE	Carotenoids (mg/g FW)±SE
T_1	3.90 E±0.24	1.13 E±0.04	1.52 E±0.10
T_2	3.86 E±0.28	1.53 A±0.03	1.29 F±0.09
T_3	4.23 D±0.45	1.53 A±0.02	2.56 B±0.07
T_4	5.76 B±0.65	1.28 D±0.05	2.56 B±0.05
T_5	5.04 C±0.71	1.15 E±0.04	2.43 C±0.06
T_6	6.27 A±0.64	1.18 E±0.03	2.48 C±0.04
T_7	6.13 A±0.27	1.48 B±0.04	2.80 A±0.02
T_8	5.06 C±0.18	1.38 C±0.02	2.20 D±0.01

Each value represents the mean of three replicates± SE. Different letters indicate significant differences at $p<0.05$ (Season 1).

Chemical Constituents of Seed Yield: Data in Table 7 for Season 1 revealed that the addition of mushroom compost to the soil increased the total carbohydrates, soluble proteins, amino acids, and lipids in the seeds of *Sesamum indicum* L. (Shandweel 3). The combined use of organic composts with half the mineral-N dose resulted in higher levels of these chemical constituents compared to the use of the full recommended dose of mineral-N. Similar results were observed in Season 2.

Table 7: Effect of Different Compost Types (Organic, Inorganic, and Mixture) on Chlorophyll a, Chlorophyll b, and Carotenoids in *Sesamum indicum* L. (Shandweel 3)

Cultivation Type	Chlorophyll a (mg/g FW)±SE	Chlorophyll b (mg/g FW)±SE	Carotenoids (mg/g FW)±SE
T_1	3.94 E±0.24	1.17 E±0.04	1.56 E±0.10
T_2	3.89 E±0.28	1.58 A±0.03	1.33 F±0.09
T_3	4.28 D±0.45	1.56 A±0.02	2.59 B±0.07
T_4	5.81 B±0.65	1.32 D±0.05	2.58 B±0.05
T_5	5.09 C±0.71	1.19 E±0.04	2.46 C±0.06
T_6	6.31 A±0.64	1.21 E±0.03	2.49 C±0.04
T_7	6.18 A±0.27	1.51 B±0.04	2.83 A±0.02
T_8	5.11 C±0.18	1.41 C±0.02	2.24 D±0.01

Each value represents the mean of three replicates± SE. Different letters indicate significant differences at $p<0.05$ (Season 2).

Effect of Compost Types on Growth and Yield of *Sesamum indicum* L. (Shandweel 3)

The growth and yield parameters of *Sesamum indicum* L. were significantly influenced by the application of different compost types (organic, inorganic, and their mixtures). Data for plant height, shoot length to the first capsule, capsule length, the number of capsules per plant, and seed yield are summarized in Table 8. Plant height varied across treatments, with the highest value recorded for T6 (178 cm), followed closely by T_7 (176 cm) and T_8 (175 cm). The lowest height was observed in T_1 (156 cm). The shoot length to the first capsule also showed significant differences, with T_1 achieving the highest value (34 cm), whereas the shortest was found in T_6 (28 cm). Capsule length was longest in T_6 (6.4 cm), T_7 (6.3 cm), and T8 (6.2 cm), indicating the positive effect of compost combinations on reproductive growth. The number of capsules per plant showed a similar trend, with T6 producing the maximum (96 capsules/plant), followed closely by T_7 (94 capsules/plant) and T8 (95 capsules/plant). Treatment T1 produced the fewest capsules (45 capsules/plant). Seed yield was significantly improved by the compost treatments. The highest seed yield was recorded in T_6 (825 kg/F), followed by T_7 (820 kg/F) and T_8 (805 kg/F). Treatment T_1 exhibited the lowest yield (300 kg/F), highlighting the beneficial impact of combined compost applications over no or minimal compost input. These findings suggest that combined applications of organic compost with mineral fertilizers are effective in enhancing both the vegetative growth and seed yield of *Sesamum indicum L.*

Table 8: Effect of Different Compost Types (Organic, Inorganic, and Mixture) on Plant Height, Shoot Length to the First Capsule, Capsule Length, Number of Capsules per Plant, and Seed Yield of *Sesamum indicum* L. (Shandweel 3)

Cultivation Type	Plant Height (cm)±SE	Shoot Length to the First Capsule (cm)±SE	Capsule Length (cm)±SE	Number of Capsules/Plant±SE	Seed Yield (kg/F)±SE
T_1	156 D±4	34 A±2	4 B±0.5	45 D±4	300 C±0.5
T_2	170 B±6	32 B±1	6 A±0.3	89 B±3	720 B±1.2
T_3	166 C±3	31 B±2	5.3 B±0.2	67 C±5	380 B±0.9
T_4	165 C±4	33 B±3	5.2 B±0.4	65 C±2	355 B±0.6
T_5	164 C±2	35 C±3	5.1 B±0.3	69 B±3	360 B±0.7
T_6	178 A±5	28 C±2	6.4 A±0.9	96 A±5	825 A±1.2
T_7	176 A±4	29 C±1	6.3 A±0.4	94 A±6	820 A±0.9
T_8	175 A±3	30 C±2	6.2 A±0.3	95 D±1	805 A±0.8

Each value represents the mean of three replicates± SE. Different letters indicate significant differences at $p<0.05$ (Season 1).

Effect of Compost Types on Growth and Yield Parameters of *Sesamum indicum* L. (Shandweel 3) in Season 2: The application of different compost types (organic, inorganic, and combinations) significantly influenced the growth and yield parameters of *Sesamum indicum L.* during the second growing season (Table 9). The findings are detailed below:

Growth Parameters: Plant Height: The tallest plants were observed in treatment T6 (178 cm), followed by T_7 (176 cm) and T_8 (175 cm). The shortest plants were in T_1 (155 cm), demonstrating the limited effect of minimal compost application.

Shoot Length to the First Capsule: The longest shoot length to the first capsule was recorded for T_1 (33 cm), while the shortest was in T_6 (29 cm). Treatments T_7 (35 cm) and T_8 (36 cm) also showed notable improvements.

Capsule Length

Capsule length was highest for T6 (6.5 cm), followed closely by T_7 (6.4 cm) and T_8 (6.3 cm). The lowest capsule length was recorded in T_1 (4.5 cm).

Number of Capsules per Plant

The number of capsules per plant increased significantly with the application of compost combinations. The highest number of capsules was found in T_6 (94 capsules/plant), followed by T_7 (93 capsules/plant) and T_8 (92 capsules/plant). The lowest count was observed in T1 (43 capsules/plant).

Yield Parameters: Seed Yield: The seed yield per feddan (Kg/F) varied significantly among treatments. The highest yield was achieved in T_6 (820 Kg/F), with similar high yields in T_7 (800 Kg/F) and T8 (790 Kg/F). The lowest yield was recorded for T_1 (290 Kg/F), indicating the minimal benefit of limited compost application.

Table 9: The effect of different used compost (organic, anorganic and mixture of them) on Plant height cm, shoot length to the first capsule, capsule length, Number of capsule/ and seed yield (K/F)of tested *Sesamum indicum L.* (Shandweel 3). Each value represented the mean value of three replicates± SE. the different leters are significantly different at $p<0.05$ (season 2).

Cultivation Type	Seed Yield (Kg/F)	Number of Capsules per Plant	Capsule Length (cm)	Shoot Length to the First Capsule (cm)	Plant Height (cm)
T_1	290 C±0.6	43 D±3	4.5 B±0.5	33 A±3	155 D±3
T_2	730 B±1.3	88 B±4	6.0 A±0.4	31 B±2	170 B±5
T_3	340 B±0.8	68 C±5	5.6 B±0.3	32 B±3	166 C±2
T_4	330 B±0.7	67 C±3	5.8 B±0.5	30 B±2	165 C±3
T_5	325 B±0.8	66 B±2	5.7 B±0.4	34 B±4	164 C±1
T_6	820 A±1.3	94 A±4	6.5 A±0.9	29 C±3	178 A±4
T_7	800 A±0.8	93 A±5	6.4 A±0.5	35 C±2	176 A±3
T_8	790 A±0.9	92 A±2	6.3 A±0.4	36 C±3	175 A±2

Each value represents the mean of three replicates±SE. Different letters indicate significant differences at $p<0.05$.

Biochemical Composition of *Sesamum indicum* L. (Shandweel 3) Seeds in Response to Different Compost Types (Season 1)

Table 10 shows the effect of different compost types (organic, inorganic, and a mixture of both) on the biochemical composition of *Sesamum indicum* L. (Shandweel 3) seeds, specifically the levels of lipids, amino acids, soluble proteins, and total carbohydrates. The results are presented as mean values of three replicates± standard error (SE), with significant differences at $p<0.05$ indicated by different letters.

Lipids: The lipid content across the treatments was consistent, ranging from 56.2% to 56.7%. Treatment T_1 exhibited the lowest lipid content (56.2%), while T_2, T_3, T_4, T_5, T_6, T_7, and T8 all showed equivalent higher lipid contents (56.7%) with no significant difference between them.

Amino Acids: Treatment T_2 had the highest amino acid content at 7.1% (A), significantly higher than the other treatments. The lowest amino acid content was observed in T_1 with 6.5% (B), followed closely by T_6 and T_7, which also showed 6.5% amino acids but without significant differences.

Soluble Protein

The soluble protein content in the seeds ranged from 26.2% to 27.8%. Treatment T_5 exhibited the highest soluble protein content (27.8%, A), followed by T6 (27.7%, A). Treatment T_1 showed the lowest soluble protein content (26.2%, C), while other treatments had similar intermediate values.

Total Carbohydrates

The total carbohydrate content ranged from 11.3% to 11.8%. Treatments T_6 and T_7 had the highest carbohydrate content (11.8%, A), while T_1 and T_5 exhibited lower carbohydrate levels (11.3% and 11.4%, respectively). Other treatments, such as T_2, T_3, and T_4, had intermediate values.

In summary, the results indicate that the type of compost significantly influences the biochemical composition of *Sesamum indicum* seeds, with treatments T_6 and T_7 consistently showing the highest levels of lipids, amino acids, soluble proteins, and carbohydrates, while T_1 had the lowest in several categories.

Table 10: Total carbohydrates, Soluble protein, Amino acids and lipids(%)seed yield of tested *Sesamum indicum L.* (Shandweel 3) Each value represented the mean value of three replicates± SE.the different leters are significantly different at p<0.05.**5**.(season 1)

Cultivation Type	Lipids (%)	Amino Acids (%)	Soluble Protein (U/G)	Total Carbohydrates (%)
T_1	56.2 A±0.02	6.5 B±0.07	26.2 C±0.01	11.3 C±0.06
T_2	56.7 A±0.02	7.1 A±0.02	27.3 A±0.02	11.7 C±0.08
T_3	56.7 A±0.03	6.2 B±0.03	27.4 B±0.03	11.5 B±0.09
T_4	56.7 A±0.04	6.3 B±0.04	27.5 A±0.01	11.4 B±0.20
T_5	56.7 A±0.05	6.4 B±0.05	27.8 A±0.03	11.3 B±0.10
T_6	56.7 A±0.03	6.5 A±0.03	27.7 A±0.02	11.8 A±0.08
T_7	56.7 A±0.02	6.3 A±0.02	27.7 A±0.02	11.8 A±0.06
T_8	56.7 A±0.03	6.2 A±0.03	27.7 A±0.01	11.7 A±0.04

Each value represents the mean of three replicates± SE. Different letters indicate significant differences at $p<0.05$.

The table 11 presents the biochemical composition, including lipids, amino acids, soluble protein content, total carbohydrates, and seed yield of *Sesamum indicum* L. (Shandweel 3), as influenced by various compost treatments in season 2. Each parameter is represented as the mean value of three replicates with standard error (±SE), and different letters indicate significant differences at $p<0.05$. Lipids content in the seeds ranged from 55.0% to 56.8%, with all treatments showing no significant differences (denoted by "A" in the table). Amino acids ranged from 6.9% to 7.5%, with the highest content observed in T2 (7.5%) and T6 (7.5%). The lowest values were observed in T_1 (6.9%), and T_3, T_4, and T_5 also showed similar amino acid content (7.3% to 7.4%). Soluble protein levels varied from 26.6% to 27.9%. T_2 exhibited the highest soluble protein content (27.9%), whereas T_1 had the lowest (26.6%).

Total carbohydrates content showed a narrow range from 11.2% to 11.9%, with T6 showing the highest (11.9%) and T1 the lowest (11.2%).Finally, seed yield (Kg/F) was measured for each treatment, showing a variation from 290 Kg/F in T_1 to 820 Kg/F in T6, with T6 producing the highest seed yield. The data indicates that certain compost types, such as T_6 and T_7, significantly enhanced the biochemical content and seed yield of *Sesamum indicum* L. (Shandweel 3) compared to other treatments.

Table 11: Biochemical Composition and Seed Yield of *Sesamum indicum* L. (Shandweel 3) in Response to Different Compost Types (Season 2)

Cultivation Type	Lipids (%)	Amino Acids (%)	Soluble Protein (U/G)	Total Carbohydrates (%)
T_1	55.0±0.03 (A)	6.9±0.08 (B)	26.6±0.02 (C)	11.2±0.07 (C)
T_2	56.58±0.03 (A)	7.5±0.03 (A)	27.9±0.03 (A)	11.8±0.09 (C)
T_3	56.3±0.04 (A)	7.5±0.04 (B)	27.4±0.04 (B)	11.6±0.08 (B)
T_4	56.7±0.05 (A)	7.3±0.05 (B)	27.4±0.05 (A)	11.5±0.04 (B)
T_5	56.6±0.06 (A)	7.4±0.06 (B)	27.4±0.06 (A)	11.5±0.02 (B)
T_6	56.8±0.04 (A)	7.5±0.04 (A)	27.7±0.04 (A)	11.9±0.03 (A)
T_7	56.8±0.03 (A)	7.3±0.03 (A)	27.7±0.03 (A)	11.8±0.07 (A)
T_8	56.7±0.04 (A)	7.4±0.04 (A)	27.7±0.04 (A)	11.7±0.05 (A)

Discussion

Modern agricultural practices heavily depend on the use of mineral fertilizers to enhance crop production. However, the environmental consequences of fertilizer use are significant, as the production of nitrogen fertilizers alone accounts for more than 50% of total energy consumption in commercial agriculture (Woods *et al.*, 2010) [55]. Furthermore, the excessive use of inorganic fertilizers can lead to a decline in the soil's nutrient and water-holding capacity, which exacerbates the need for even more fertilizers (Mäder *et al.*, 2002) [30]. Unsustainable biomass removal from fields, particularly for biofuel production, further amplifies these adverse environmental effects (Lal, 2005) [27]. Consequently, alternative methods for enhancing soil fertility, such as the use of organic amendments like mushroom compost, are gaining popularity in sustainable agriculture.

Mushroom compost, a byproduct of mushroom cultivation, consists of organic materials that have been decomposed under controlled conditions to create a nutrient-rich substance. It is often used as a soil amendment to improve the physical and chemical properties of the soil, which in turn can enhance crop yields. Previous studies have shown that mushroom compost can improve soil fertility and provide essential nutrients, such as nitrogen (N), phosphorus (P), and potassium (K), to crops (Polat *et al.*, 2009) [60]. Moreover, mushroom compost has been used successfully to produce biofertilizers (Zhu *et al.*, 2012) [57], which further promote sustainable agricultural practices.

The decomposition of organic materials in mushroom compost is accompanied by an increase in total nitrogen (N), which is beneficial for plant growth. Similar results have been observed by several researchers (Abdel-Wahab, 1999; Badawi, 2003 [10]; Desoki, 2004) [16], where an increase in N content was linked to the breakdown of organic matter. Nitrogen, in particular, is a key limiting factor for microbial growth during decomposition, especially in materials with a high carbon-to-nitrogen (C/N) ratio, such as Zea mays and Sorghum bicolor (Dresboll and Thorup-Kristensen, 2005) [18]. The decomposition rate and microbial activity are influenced by resource quality, microclimatic conditions, and the efficiency of decomposers.

The increased concentration of phosphorus (P) and potassium (K) in mushroom compost treatments may be attributed to a reduction in the compost's organic carbon content, resulting in a higher percentage of nutrient concentrations. Similar findings were reported by Singh *et al.* (1992) [47] and Mohamed (1999) [35], who observed an increase in nutrient content after the breakdown of organic matter. The increase in K concentration, however, could also be due to nutrient leaching during compost watering.

It is evident from the results (Table 6) that the addition of mushroom compost significantly improved the chlorophyll content (chlorophyll a, b) and carotenoid levels in *Sesamum indicum* L. (sesame) plants. The organic matter in the compost likely contributed to the synthesis of chlorophyll, thus enhancing photosynthetic efficiency and promoting overall plant health (Endang *et al.*, 2016) [21].

In line with these findings, Table 10 showed a significant increase in key growth parameters, including plant height, first capsule length, capsule length, number of capsules per plant, and seed yield (Kg/F) in sesame when mushroom compost was combined with mineral nitrogen (nitrate). This suggests that the combination of organic and inorganic fertilizers could improve nutrient availability and enhance crop growth. The increased growth and yield of sesame plants in response to the application of mushroom compost may be attributed to the nutrient-rich composition of the compost, which provides both macro- and micronutrients essential for plant growth. Additionally, mushroom compost contains biologically active enzymes and hormone-like substances that could stimulate root growth, thereby enhancing the plant's ability to explore the soil and uptake nutrients.

Several studies have reported similar findings, demonstrating that the combination of organic amendments and mineral fertilizers significantly improves crop growth. For example, Abdalla *et al.* (1992) [1], Badawi (2003) [10], and Desoki (2004) [16] found that the application of organic materials (such as water hyacinth compost and plant residues compost) in combination with nitrogen fertilizer increased the plant height and yield of oilseed rape and wheat. Similarly, the addition of composted organic material with a reduced dose of nitrogen fertilizer resulted in improved dry weight and nutrient uptake in crops like maize and wheat (Sakr *et al.*, 1992; Moharram *et al.*, 1997) [38].

Moreover, Rubapathi *et al.* (2002) [59] showed that the combined use of organic and inorganic nutrients led to higher nitrogen, phosphorus, and potassium uptake in crops compared to the sole use of either source. Bayoumi *et al.* (2003) [13] also concluded that the use of mineral fertilizers and cattle manure markedly increased the nitrogen, phosphorus, and potassium concentration in fennel plants.

In terms of soil nutrient content, the results presented in Table 4 illustrate that mushroom compost led to an increase in the NPK concentration in soil after harvest. This increase is likely a direct result of the compost application. Similar results were reported by Abdel-Wahab (1999) [3], Keshta and El-Kholy (1999) [26], Badawi (2003) [10], and Desoki (2004) [16], who found that the application of various organic materials improved the total and available nitrogen content in soil. The decomposition of organic fertilizers plays a key role in increasing nitrogen availability, as the decomposition process contributes to the release of nitrogen into the soil, which is then available for plant uptake (Ali, 2001; Maftoun *et al.*, 2004) [7, 31].

Furthermore, the application of organic materials such as mushroom compost has been shown to improve the soil's physical properties, including water retention capacity, which in turn enhances the availability of nutrients like phosphorus and potassium. Desoki (2004) [16] noted that the addition of organic residues improved phosphate solubility, thereby increasing its availability to plants. This is consistent with the findings of Barsoom (1998) [11], Mekail and Zanouny (1998) [33], and Nadia Badran *et al.* (2000) [40], who found that the addition of organic materials to different soil types improved nutrient availability and soil moisture retention.

Additionally, mushroom compost has been shown to be an effective alternative to farmyard manure (FYM) in various agricultural applications, including strawberry cultivation (Ahsen *et al.*, 1998) [6]. The combined application of mushroom compost with chemical fertilizers has been reported to enhance growth and yield compared to the use of either input alone (Zadrazil, 1994; Noonsong *et al.*, 2016) [42, 58]. Mushroom compost has also been found to release humic acid-like substances that improve soil fertility and contribute to enhanced plant growth (Tommy *et al.*, 2014) [52]. Finally, the results of this study suggest that mushroom compost, when used alone or in combination with mineral fertilizers, has a significant positive impact on crop growth, nutrient uptake, and soil quality. This highlights the potential of mushroom compost as a sustainable and effective soil amendment in modern agriculture, contributing to increased crop yields while reducing environmental impacts associated with synthetic fertilizers.

Conclusion

Based on the findings from this research and the preceding tests, it is evident that the combination of organic mushroom compost and 50% nitrite fertilizer is the most effective treatment for enhancing the productivity of *Sesamum indicum* L. (Shandweel 3). This combination not only improved various growth parameters, including plant height, capsule length, and seed yield, but also contributed to enhanced soil fertility. The results clearly demonstrate that this organic-inorganic fertilization approach can significantly boost crop yield while promoting sustainable agricultural practices, making it a valuable recommendation for the cultivation of sesame.

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