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RESEARCH ARTICLE

Effect of effective microorganism for the recycling of crop wastes and dry land weeds

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Abstract

The study, conducted during 2015-16, aimed to evaluate the effectiveness of pit and bed methods in composting selected crop residues and weed biomass. The waste materials, viz., coconut leaf stalk with leaflets, mixed crop residues, mixed dryland weeds, banana plant and kapok seed pod without cotton were chosen based on their local availability, decomposition potential and nutrient content. Ten treatments were tested, incorporating 50 kg of cow dung and 500 g of urea per ton of waste, with and without effective microorganisms at 1 liter per ton. The composting process was monitored for temperature variations, nitrogen content, carbon content and decomposition efficiency. Composting efficiency was influenced by factors such as the nature of crop residue, C:N ratio, moisture, temperature and aeration. Results indicated that the bed method facilitated faster decomposition than the pit method, primarily due to improved aeration, which enhanced microbial activity. Treatments with Efficient Microorganisms (EM) showed accelerated decomposition and better compost. The findings emphasize the importance of selecting appropriate composting techniques based on residue characteristics. Efficient composting not only transforms crop residues into nutrient-rich compost but also improves soil quality, contributing to sustainable agricultural practices. This study provides insights into optimizing composting methods for effective crop residue management.

Keywords: bed method; C:N ratio; crop residue composting; effective microorganisms; pit method

Introduction

Composting is an effective method of solid waste management in which the organic fraction of waste undergoes biological decomposition under controlled conditions to reach a stable state. This stabilized compost can be safely handled, stored and applied to soil without causing environmental harm. With the increasing accumulation of crop residues and dryland weeds, improper disposal practices such as burning, contribute to air pollution and the loss of valuable organic matter. Recycling these residues through composting offers a sustainable solution by converting waste into a nutrient-rich soil amendment, besides improving the soil fertility and structure. However, conventional composting methods are often slow, requiring months to achieve full decomposition (1). India generates over 500 metric tonnes of crop residues annually, encompassing a wide range of by-products such as coconut leaf stalks, banana plants, kapok seed pods and various weed biomasses from dryland farming systems (2). A substantial proportion of these residues remains underutilized or is burned, leading to significant nutrient loss and environmental concerns. Given the rising cost of chemical fertilizers and the growing emphasis on sustainable farming practices, there is a compelling need to convert these organic materials into nutrient-rich composts that can supplement or partially replace synthetic fertilizers. The transformation of agricultural and weed residues into organic manures offers a promising pathway for improving soil health, enhancing nutrient cycling and reducing input costs. Among various composting approaches, pit composting is commonly adopted for its ability to retain moisture and minimize nutrient leaching, especially in water-scarce regions. In contrast, the bed method provides better aeration, facilitating enhanced microbial activity and faster decomposition, making it suitable for areas with good water availability and space constraints (3).

The integration of EM into composting practices has further expanded the potential for rapid and efficient breakdown of organic matter (4). These microbial consortia accelerate decomposition and improve the nutrient profile of the final compost product. Given the diversity and abundance of agricultural residues in India and the need for sustainable nutrient sources, this study was undertaken to explore efficient decomposition methods that can convert locally available biomass into valuable organic amendments, ultimately contributing to soil fertility and sustainable crop production.

Materials and Methods

The study considered the pit and bed method of composting in decomposing selected crop residues and dryland weeds using EM and urea. The experiment was carried out at the Agricultural Research Station, Virudhachalam, during 2016-17. Residues of mixed dryland weeds were utilized for composting. Weed residues such as *Cynodon dactylon* (Bermudagrass), *Pancicum repens* (Knotgrass) and *Amaranthus* spp. were utilized. This weed biomass was chopped into small pieces of 2 to 5 cm in length. 500 kg of residues were utilized for each composting. Effective microbial (EM) inoculum and urea were added to the compost as per the treatment schedule. EM was prepared using a traditional fermentation process. Fresh papaya (500 g) and pumpkin (500 g) were cut into small pieces after removing their skin. Jaggery (500 g) was dissolved in 20 L of water in a mud pot. A handful of fertile soil collected from a crop field was added to introduce beneficial microbes. All the ingredients were thoroughly mixed and the pot was covered with a white cotton cloth to allow aeration. The mixture was stirred daily for 15 days to facilitate fermentation. After the fermentation period, the EM solution was ready for use in composting.

In order to enhance the composting speed, EM was applied at 5 L/T and urea at 2 kg/T as per the treatment schedule. Turning was carried out every 15 days in the bed method of composting and watering was done on alternate days to maintain sufficient moisture levels. Pits of 5 × 5 × 5 feet were used for the pit method of composting. Chopped residues were filled up to the surface level. Moisture is maintained by sprinkling water on the pit surface. In both composting, weeds alone were used as a control to compare the efficiency of different composting methods (4). The treatment schedule adopted in this experiment was: T_1: Weeds + Urea, T_2: Weeds + EM, T_3: Weeds + Urea + EM and T_4: Weeds alone (Control).

The compost temperature was monitored continuously using dial-type thermometer. Compost samples were collected at 15-day intervals for up to 75 days and characterized for organic carbon, nitrogen, phosphorus and potassium. Based on the carbon and nitrogen content, the C:N ratio of the compost was calculated.

Results and Discussion

pH

The pH of compost varied across treatments and methods during the 75 days (Table 1). In the pit method, urea-added treatments (T_1 and T_3) showed an initial increase in pH due to urea hydrolysis and ammonification, followed by a gradual decline, while EM treatments (T_2 and T_3) maintained a more stable pH. The bed method generally recorded slightly higher and more stable pH values, likely due to better aeration (5). T_3 (Weeds + Urea + EM) consistently showed favourable pH trends in both methods, indicating enhanced microbial activity and balanced decomposition. The control (T_4) in both methods showed minimal variation, reflecting slower natural composting with minimal chemical transformations. Overall, EM helped stabilize pH and the bed method was slightly more effective in maintaining optimal composting conditions (6).

Electrical conductivity

The Electrical Conductivity (EC) of compost showed slight variations across treatments and composting methods over the 75 days. In the pit method, EC increased gradually in all treatments, with the highest values recorded in T_3 (Weeds + Urea + EM), indicating enhanced mineralization and nutrient release due to combined microbial and urea activity. The EM-only treatment (T_2) showed a steady rise in EC, while the control (T_4) maintained relatively constant and lower EC values. A similar trend was observed in the bed method, where EC was generally higher than the pit method, especially in T_3, suggesting better decomposition and nutrient accumulation under improved aeration (7). T_1 (Weeds + Urea) also showed moderate EC increases, while T_2 and T_4 remained relatively stable. Overall, the combined use of urea and EM (T_3) led to increased EC in both methods and the bed method facilitated slightly higher nutrient release compared to the pit method (Table 2).

Phosphorous content

Phosphorus concentration of the compost increased gradually throughout the composting period in all treatments, with a pronounced rise in treatments involving Urea and EM (Table 3). The highest phosphorus content was recorded in T_3 (Weeds + Urea + EM), increasing from 0.45 % to 0.73 % in the pit method and from 0.46 % to 0.75 % in the bed method. This enhancement can be attributed to the combined action of urea (which promotes microbial biomass and activity) and EM (which includes phosphate-solubilising microbes) that help in converting bulky organic biomass into nutrient-rich compost by emitting CO_2 and other gases during the decomposition process, resulting in P enrichment (8). In contrast, the control (T_4- Weeds alone) showed

Table 1. Periodical changes of pH in chemical composition during the decomposition of weeds under pit and bed method of composting

Treatments	pH					
	Initial	15th day	30th day	45th day	60th day	75th day
Pit method of composting						
T_1 - Weeds + Urea	7.3	7.6	7.6	7.2	7.1	6.9
T_2 – Weeds + EM	7.1	7.0	7.2	7.2	7.1	7.1
T_3 - Weeds + Urea+ EM	7.3	7.5	7.5	7.4	7.2	7.0
T_4 – Weeds	7.2	7.1	7.2	7.3	7.1	7.0
Bed method of composting						
T_1 - Weeds + Urea	7.5	7.8	7.6	7.5	7.4	7.3
T_2 - Weeds + EM	7.4	7.3	7.2	7.5	7.4	7.4
T_3 - Weeds + Urea+ EM	7.5	7.8	7.8	7.5	7.4	7.3
T_4 - Weeds	7.2	7.4	7.2	7.4	7.4	7.4

Table. 2. Periodical changes of EC in chemical composition during the decomposition of weeds under Pit and bed method of composting

Treatments	EC (dS m^{-1})					
	Initial	15th day	30th day	45th day	60th day	75th day
			Pit method of composting			
T_1 - Weeds + Urea	1.39	1.40	1.43	1.41	1.40	1.41
T_2 – Weeds + EM	1.29	1.30	1.32	1.32	1.34	1.35
T_3 - Weeds + Urea+ EM	1.30	1.44	1.45	1.45	1.43	1.44
T_4 - Weeds	1.26	1.26	1.27	1.25	1.28	1.26
			Bed method of composting			
T_1 - Weeds + Urea	1.41	1.42	1.45	1.43	1.41	1.43
T_2 – Weeds + EM	1.31	1.32	1.31	1.32	1.33	1.34
T_3 - Weeds + Urea+ EM	1.32	1.46	1.45	1.46	1.45	1.46
T_4 - Weeds	1.28	1.27	1.28	1.26	1.29	1.27

Table. 3. Periodical changes of total phosphorus in chemical composition during the decomposition of weeds under pit and bed method of composting

Treatments	Total phosphorus (%)					
	Initial	15th day	30th day	45th day	60th day	75th day
			Pit method of composting			
T_1 -Weeds + Urea	0.46	0.5	0.56	0.61	0.65	0.67
T_2 – Weeds + EM	0.46	0.49	0.53	0.58	0.62	0.65
T_3 - Weeds + Urea + EM	0.45	0.49	0.55	0.63	0.68	0.73
T_4 – Weeds	0.45	0.47	0.5	0.55	0.59	0.61
			Bed method of composting			
T_1 - Weeds + Urea	0.47	0.52	0.59	0.64	0.67	0.69
T_2 - Weeds + EM	0.45	0.49	0.53	0.58	0.62	0.66
T_3 - Weeds + Urea + EM	0.46	0.51	0.57	0.65	0.7	0.75
T_4 - Weeds	0.45	0.49	0.52	0.57	0.61	0.63

the lowest increase, ranging from 0.45 % to 0.61 % in the pit method and 0.45 % to 0.63 % in the bed method, due to slower decomposition and limited microbial activity (9). The bed method showed slightly higher phosphorus content across all treatments compared to the pit method, likely because of better aeration, moisture regulation and microbial efficiency in surface-level composting systems. These findings underline that the synergistic application of urea and EM, especially in the bed method, enhances phosphorus mineralization and availability in compost.

Potassium content

The potassium content in compost increased steadily across all treatments, with higher values observed in the bed method compared to the pit method (Table 4). Among the treatments, T_3 (Weeds + Urea + EM) consistently recorded the highest potassium content, reaching 1.02 % in the pit method and 1.11 % in the bed method by the 75th day (10). This indicates that the combined application of urea and EM enhanced potassium mineralization, likely due to increased microbial activity and improved decomposition. In both methods, T_1(Weeds + Urea) and T_2 (Weeds + EM) also showed moderate increases, while T_4 (Weeds only) had the lowest potassium content throughout (11). The bed method outperformed the pit method overall, suggesting that better aeration in the bed system facilitated faster organic matter breakdown and nutrient release. Thus, combining urea and EM under bed composting conditions appears to be the most effective strategy for enriching compost with potassium (12).

Carbon content

Among the pit method of composting, concerning total carbon content (%), the treatment Weeds + Urea + EM (T_3) recorded a reduction in carbon content from 42.1 % to 31.9 %, followed by Weeds + EM (T_2) which decreased from 41.8 % to 32.5 %, compared to Weeds alone (T_4) which reduced from 42.0 % to 37.6 % over the 75thday composting period (13). In the bed method of composting, the treatment Weeds + Urea + EM (T_3) showed a notable reduction in carbon content from 42.0 % to 32.3 %, followed by Weeds + EM (T_2) from 41.9 % to 31.9 %, whereas Weeds alone (T_4) showed a reduction from 42.1 % to 38.1 % (14). The initial carbon contents across all treatments ranged between 41.8 % and 42.2 %, which gradually decreased by the 75th day to 33.5 % (T_1), 31.9 % (T_2), 32.3 % (T_3) and 38.1 % (T_4) in the bed method and to 33.2 % (T_1), 32.5 % (T_2), 31.9 % (T_3) and 37.6 % (T_4) in the pit method, indicating significant organic matter decomposition during the composting process (15). The reduction in total carbon content is primarily attributed to microbial degradation of organic matter, wherein carbon is lost

Table. 4. Periodical changes of total potassium (%) in chemical composition during the decomposition of weeds under pit and bed method of composting

Treatments	Total potassium (%)					
	Initial	15th day	30th day	45th day	60th day	75th day
			Pit method of composting			
T_1 - Weeds + Urea	0.67	0.64	0.72	0.79	0.87	0.91
T_2 – Weeds + EM	0.69	0.64	0.7	0.77	0.82	0.86
T_3 - Weeds + Urea+ EM	0.68	0.66	0.75	0.88	0.95	1.02
T_4 - Weeds	0.69	0.64	0.69	0.74	0.78	0.82
			Bed method of composting			
T_1 - Weeds + Urea	0.69	0.74	0.82	0.89	0.97	1.01
T_2 - Weeds + EM	0.7	0.73	0.79	0.86	0.91	0.95
T_3 -Weeds + Urea+ EM	0.69	0.75	0.84	0.97	1.04	1.11
T_4 - Weeds	0.68	0.71	0.76	0.81	0.85	0.89

as carbon dioxide (CO_2) due to microbial respiration, as shown in Table 5 (16). The addition of urea and EM accelerates microbial activity, thereby enhancing the rate of organic matter breakdown and resulting in greater carbon loss from the composting mass (17).

Nitrogen content

Among the pit method of composting, the treatment Weeds + Urea + EM (T_3) recorded the highest increase in total nitrogen content from 0.94 % to 1.33 %, followed by Weeds + Urea (T_1), which increased from 0.94 % to 1.27 % (Table 6). The treatment Weeds + EM (T_2) showed an increase from 0.83 % to 1.21 %, while the Weeds alone (T_4) treatment recorded a lower rise from 0.84 % to 1.16 % by the 75th day of composting (18). In the bed method of composting, the treatment Weeds + Urea + EM (T_3) exhibited the highest nitrogen content, increasing from 0.94 % to 1.36 %, followed by Weeds + Urea (T_1) from 0.95 % to 1.33 % and Weeds + EM (T_2) from 0.82 % to 1.25 %. The Weeds alone (T_4) treatment showed a moderate increase from 0.83 % to 1.18 % during the composting period (19). The observed increase in total nitrogen content is attributed to the mineralization of organic nitrogen compounds during decomposition, enhanced microbial activity and concentration of nutrients as the compost mass reduces (20, 21). Though the residues contain varying nutrient content (22), the addition of urea contributes directly to nitrogen enrichment, while EM promote microbial biomass buildup and stabilization of nitrogen, thereby minimizing nitrogen loss and improving nitrogen retention in the final compost product (23).

C:N ratio

The C:N ratio gradually declined in both pit and bed methods of composting across all treatments, reflecting progressive decomposition (24). In the pit method, the lowest C:N ratio was observed in T_3 (Weeds + Urea + EM), reaching 23.98 by the 75th day, followed by T_1 (Weeds + Urea) at 26.14 and T_2 (Weeds + EM) at 26.86, whileT_4 (Weeds alone) retained a relatively high ratio of 32.41, indicating slower decomposition (25). Similarly, in the bed method, T_3 again recorded the lowest C:N ratio (23.75), followed by T_1 (25.19), T_2 (25.52) and T_4 (32.29). When comparing the two methods, the bed method of composting showed a slightly faster reduction in C:N ratio, particularly in the T_3 treatment, suggesting better aeration and microbial activity (26) (Table 7). The enhanced reduction in C:N ratio with the combined application of Urea and EM (T_3) is attributed to the synergistic effect of increased nitrogen availability from urea and accelerated microbial breakdown of organic matter by EM. In contrast, weeds alone (T_4) decomposed more slowly due to limited nitrogen and microbial action, thereby maintaining a higher C:N ratio. Overall, the bed method with T_3 treatment proved most effective for rapid compost maturation (27).

Table 5. Periodical changes in total carbon content (%) during the decomposition of weeds under pit and bed method of composting

Treatments	Total carbon content (%)					
	Initial	15th day	30th day	45th day	60th day	75th day
Pit method of composting						
T_1 - Weeds + Urea	42.0	40.6	38.4	36.1	34.5	33.2
T_2 - Weeds + EM	41.8	40.3	38.3	36.0	34.4	32.5
T_3 - Weeds + Urea+ EM	42.1	40.3	37.9	35.6	33.7	31.9
T_4 - Weeds	42.0	41.1	40.5	39.7	39.0	37.6
Bed method of composting						
T_1 - Weeds + Urea	42.2	40.8	38.6	36.4	34.8	33.5
T_2 - Weeds + EM	41.9	40.1	38.1	36.2	34.1	31.9
T_3 - Weeds + Urea+ EM	42.0	40.2	37.9	35.7	33.9	32.3
T_4- Weeds	42.1	41.6	40.9	40.1	39.3	38.1

Table 6. Periodical changes in total N content (%) during the decomposition of weeds under pit and bed method of composting

Treatments	Total nitrogen content (%)					
	Initial	15th day	30th day	45th day	60th day	75th day
Pit method of composting						
T_1 -Weeds + Urea	0.94	0.99	1.08	1.14	1.21	1.27
T_2 – Weeds + EM	0.83	0.87	0.95	1.01	1.09	1.21
T_3 - Weeds + Urea + EM	0.94	1.01	1.10	1.19	1.28	1.33
T_4 - Weeds	0.84	0.87	0.94	0.99	1.07	1.16
Bed method of composting						
T_1 - Weeds + Urea	0.95	1.02	1.11	1.18	1.26	1.33
T_2 – Weeds + EM	0.82	0.88	0.97	1.04	1.12	1.25
T_3-Weeds + Urea + EM	0.94	1.01	1.10	1.21	1.29	1.36
T_4- Weeds	0.83	0.88	0.93	1.01	1.09	1.18

Table 7. Periodical changes in C:N ratio during the decomposition of weeds under pit and bed method of composting

Treatments	Carbon nitrogen ratio					
	Initial	15th day	30th day	45th day	60th day	75th day
Pit method of composting						
T_1- Weeds + Urea	44.68	41.01	35.56	31.67	28.51	26.14
T_2 - Weeds + EM	50.36	46.32	40.32	35.64	31.56	26.86
T_3 - Weeds + Urea + EM	44.79	39.90	34.45	29.92	26.33	23.98
T_4 - Weeds	50.00	47.24	43.09	40.10	36.45	32.41
Bed method of composting						
T_1 - Weeds + Urea	44.42	40.00	34.77	30.85	27.62	25.19
T_2 - Weeds + EM	51.10	45.58	39.28	34.81	30.45	25.52
T_3 - Weeds + Urea + EM	44.68	39.80	34.45	29.50	26.28	23.75
T_4 - Weeds	50.72	47.27	43.98	39.72	36.06	32.29

Conclusion

Research on composting using weeds has gained significant attention due to its potential to improve soil health and mitigate the environmental impact of agricultural waste. Weeds, often viewed as a nuisance, actually provide valuable organic matter and essential nutrients that can be effectively utilized in composting. The current study on composting weed biomass using urea and EM under the pit and bed methods highlights distinct differences influenced by the composting treatments. Compost temperature increased notably, especially in treatments involving urea, which stimulated microbial activity. The pit method generally exhibited higher compost temperatures compared to the bed method, likely due to limited aeration in the pit. The chemical composition, including pH, EC, phosphorus, potassium and carbon content, varied depending on the composting method and treatment. The bed method maintained a more stable pH and exhibited higher EC, phosphorus and potassium levels, likely due to better aeration and microbial efficiency. The application of urea and EM, especially in the bed method, significantly enhanced nutrient mineralization and availability, leading to higher concentrations of nitrogen, phosphorus and potassium. In conclusion, the combined use of urea and EM, particularly in the bed method, proved to be the most effective approach for promoting decomposition, nutrient enrichment and overall compost quality.

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Authors' contributions

BT and KM conceived the idea and prepared the manuscript outline. AV and AK participated in the sequence alignment and drafted the manuscript. RM and MV critically revised the manuscript and provided valuable comments. SV collected information on habitat and ecology. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: The authors declare that they have no conflicts of interest.

Ethical issues: None

References

1. Bunt AC. Modern potting composts. State College (PA): The Pennsylvania State University Press; 1976.
2. Subhash Babu, Rathore SS, Singh R, Kumar S, Singh VK, Yadav SK et al. Exploring agricultural waste biomass for energy, food and feed production and pollution mitigation: A review. Bioresour Technol. 2022;360:127566. https://doi.org/10.1016/j.biortech.2022.127566
3. Inbar Y, Boehm MJ, Hoitink HA. Hydrolysis of fluorescein diacetate in sphagnum peat container media for predicting suppressiveness to damping-off caused by *Pythium ultimum*. Soil Biol Biochem. 1991;23(5):479–83. https://doi.org/10.1016/0038-0717(91)90013-A
4. Prasanthrajan M, Doraisamy P, Pandiyan M, Sivakumar KP. Influence of poultry composts on growth and yield attributes of sunflower. Int J Forestry and Crop Improve. 2014;5(2):37–41. https://doi.org/10.15740/HAS/IJFCI/5.2/37-41
5. Prasanthrajan M, Shalini S, Balaji T, Veeramani P. Evaluation of biochemical changes during the storage of poultry composts for effective land application. Int J Forestry and Crop Improve. 2015;6(1):87–90. https://doi.org/10.15740/HAS/IJFCI/6.1/87-90
6. Aryal UK, Xu HL, Fujita M. Rhizobia and AM fungal inoculation improve growth and nutrient uptake of bean plants under organic fertilization. J Sustain Agric. 2003;21(4):11–20. https://doi.org/10.1300/J064v21n03_04
7. Bhatti AA, Haq S, Bhat RA. Actinomycetes benefaction role in soil and plant health. Microb Pathog. 2017;111:458–67. https://doi.org/10.1016/j.micpath.2017.09.036
8. Bustamante M, Paredes C, Marhuenda-Egea F, Pérez-Espinosa A, Bernal M, Moral R. Co-composting of distillery wastes with animal manures: carbon and nitrogen transformations in the evaluation of compost stability. Chemosphere. 2008;72:551–7. https://doi.org/10.1016/j.chemosphere.2008.03.030
9. Cai M, Yao J, Yang H, Wang R, Masakorala K. Aerobic biodegradation process of petroleum and pathway of main compounds in water flooding well of Dagang oil field. Bioresour Technol. 2013;144:100–6. https://doi.org/10.1016/j.biortech.2013.06.082
10. Canet R, Pomares F, Cabot B, Chaves C, Ferrer E, Ribo M et al. Composting olive mill pomace and other residues from rural southeastern Spain. Waste Manag. 2008;28:2585–92. https://doi.org/10.1016/j.wasman.2007.11.015
11. Condor AF, Gonzalez P, Lakre C. Effective microorganisms: Myth or reality? Peru J Biol. 2007;14:315–9. https://doi.org/10.15381/rpb.v14i2.1837
12. Cortez J, Billes G, Bouche MB. Effect of climate, soil type and earthworm activity on nitrogen transfer from a nitrogen-15-labelled decomposing material under field conditions. Biol Fertil Soils. 2000;30(4):318–27. https://doi.org/10.1007/s003740050010
13. Daniel O, Anderson JM. Microbial biomass and activity in contrasting soil materials after passage through the gut of the earthworm *Lumbricus rubellus* Hoffmeister. Soil Biol Biochem. 1992;24(5):465–70. https://doi.org/10.1016/0038-0717(92)90209-G
14. Hu C, Qi C. Long-term effective microorganisms application promote growth and increase yields and nutrition of wheat in China. Eur J Agron. 2013;46:63–7. https://doi.org/10.1016/j.eja.2012.12.003
15. Hussain T, Javaid T, Parr JF, Jilani G, Haq MA. Rice and wheat production in Pakistan with effective microorganisms. Am J Altern Agric. 1999;14:30–6. https://doi.org/10.1017/S0889189300007980
16. Iriti M, Scarafoni A, Pierce S, Castorina G, Vitalini S. Soil application of effective microorganisms (EM) maintains leaf photosynthetic efficiency, increases seed yield and quality traits of bean (*Phaseolus vulgaris* L.) plants grown on different substrates. Int J Mol Sci. 2019;20:2327. https://doi.org/10.3390/ijms20092327
17. Javaid A, Bajwa R. Field evaluation of effective microorganisms (EM) application for growth, nodulation and nutrition of mung bean. Turk J Agric For. 2011;35:443–52. https://doi.org/10.3906/tar-1001-599
18. Johan S, Jesper M. Antifungal lactic acid bacteria as bio preservatives. Trends Food Sci Technol. 2005;1:70–8. https://doi.org/10.1016/j.tifs.2004.02.014
19. Joshi H, Somdutt, Choudhary P, Mundra SL. Role of Effective Microorganisms (EM) in Sustainable Agriculture. Int J Curr Microbiol App Sci. 2019;8(3):172–81. https://doi.org/10.20546/ijcmas.2019.803.024
20. Jusoh ML, Manaf LA, Latiff PA. Composting of rice straw with effective microorganisms (EM) and its influence on compost quality.

Iran J Environ Health Sci Eng. 2013;10(1):17. https://doi.org/10.1186/1735-2746-10-17

21. Khaliq A, Abbasi MK, Hussain T. Effect of integrated use of organic and inorganic nutrient sources with effective microorganisms (EM) on seed cotton yield in Pakistan. Bioresour Technol. 2006;97:967–72. https://doi.org/10.1016/j.biortech.2005.05.002
22. Kumar BL, Gopal DVR. Effective role of indigenous microorganisms for sustainable environment. 3 Biotech. 2015;5:867–76. https://doi.org/10.1007/s13205-015-0293-6
23. Lévai L, Veres SZ, Makleit P, Marozsán M, Szabó B. New trends in plant nutrition. In: Proceedings of 41st Croatian and 1st International Symposium on Agriculture; 2006. p. 435–6.
24. Manikandan K, Sharma R, Ahlawat OP. Nitrogen calculator: A decision support tool for compost production of white button mushroom. Int J Chem Stud. 2021;9(2):649–52. https://doi.org/10.22271/chemi.2021.v9.i2j.11888
25. Gorski R, Kleiber T. Effect of effective microorganisms (EM) on nutrient contents in substrate and development and yielding of Rose (*Rosa × hybrida*) and Gerber (*Gerbera jamesonii*). Ecol Chem Eng. 2010;17(4):505–13.
26. Chrispaul M, David M, Joseph A, Ogur S, Okello SV. Effective microorganisms and their influence on growth and yield of pigweed (*Amaranthus dubians*). ARPN J Agric Biol Sci. 2010;5(1):17–22.
27. Chantal K, Shao X, Wang W, Basil T. Effects of effective microorganisms on yield and quality of vegetable cabbage comparatively to nitrogen and phosphorus fertilizers. Pak J Nutr. 2010;9(11):1039–42. https://doi.org/10.3923/pjn.2010.1039.1042

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