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RESEARCH ARTICLE

Effect of enriched compost on palak (*Beta vulgaris* var. *bengalensis*) productivity, profitability and soil health in India's northern plains

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Abstract

The present study explores the synergistic effect of enriched compost on palak (*Beta vulgaris* var. *bengalensis*) productivity, profitability and soil health. By investigating the potential of these composts' combinations, the study contributes to enhancing agricultural sustainability through more efficient use of organic resources, reducing the reliance on synthetic fertilizers and improving economic outcomes for farmers. The investigation was carried out over two consecutive cropping seasons of 2022 and 2023 at the Vegetable Farm, School of Agriculture, Lovely Professional University, Phagwara, Punjab to improve ordinary composts for higher productivity and profitability of leafy vegetables. The variety "Harit Shobha" was used in this experiment. This research was organized using a three-replication, randomized completely block design having 10 treatment (T) combinations of organic and inorganics. The treatment combination having 50 % mineral enriched compost at 2.5 t/ha + microbial enriched compost at 2.5 t/ha (T_7) recorded the highest yield (109.12 and 102.31 q/ha), with annual net returns of ₹1.59 and ₹1.64 lacs/ha and the corresponding B:C ratio of 2.72 and 2.73 per hectare, respectively. The treatment combination T_7 (50 % MEC_1 at 2.5 t/ha + 50 % MEC_2 at 2.5 t/ha) also improved soil health as envisaged through post-harvest availability of N, P and K through 6.69, 36.59 and 3.06 % increase, over the initial content. Therefore, it can be concluded that treatment T_7 resulted in saving 100 % of fertilizers, improving growth, yield, net returns and enhanced soil health thus, can be a cost-effective combination for getting higher yield with better quality on a sustainable basis.

Keywords: B:C ratio; microorganism; nutrient-rich compost; soil fertility and yield; spinach beet

Introduction

Spinach beet, officially known as *Beta vulgaris* var. *bengalensis*, has a chromosomal count of 2n=2x=18. It is also referred to as "Palak" in Hindi and "Indian spinach" in English (1). It originated in the Indo-Chinese region and is classified as *Beta vulgaris* in the Chenopodiaceae family (2). The word 'bengalensis' is presumably derived from its early use in Bengal. Other names for it include "Beet leaf" and "Desi palak",' and has close botanical links to beetroot and chard. Notably, palak's predecessor is sea beet (*Beta vulgaris var. maritima*). Although its delicate, succulent leaves are the main reason spinach beet is grown, it also offers substantial nutritional and culinary advantages (3).

Providing the necessary vitamins and minerals, vegetables play a significant role in a person's diet. One of the most popular vegetable varieties in our nation is the leafy kind. Considered to have a high preventative food value, they are rich in nutrients (4). In addition to being used as a garnish for raw salads and cooked vegetables, leafy vegetables are rich in vitamins and minerals (5). Many diseases, including diabetes, cancer and other conditions, can be prevented with a diet rich in leafy vegetables. Hence, a sizeable amount of our diet that is well-balanced consists of green vegetables (6).

Consumers around the world are increasingly concerned with food quality and safety. While our country has effectively adopted green revolution technology, resulting in food grain self-sufficiency, the intensive farming techniques linked with them have created serious issues (7). These behaviors not only harm soil and water quality, but also endanger human health. Ensuring the protection and sustainable management of our environment and human health, therefore, is an ongoing imperative (8).

Organic farming practices prioritize using organic materials as inputs and the recycling of agricultural waste to provide nutrients, while crop rotation and soil biological processes are used to combat pests (9). They strictly prohibit the utilization of synthesized insecticides and fertilizers, which are known to have negative consequences connected with traditional farming practices (10). Conventional farming frequently leads to increased concentrations of genetically modified organisms, heavy metals, hormones, antibiotic residue, nitrate, pesticide residue and hormones in food, which have serious health consequences (11). Organic farming encourages agricultural diversification and the long-term production of healthful food. Furthermore, it can boost household income while addressing significant environmental issues (12).

In such cases, it becomes vital to seek alternative organic additions to limit the dependency on chemical fertilizers while ensuring long-term soil fertility and crop output. After completing investigations at both the local and national levels, it was shown that the poor nutrient content, bulkiness, handling challenges and labour-intensive application of traditional organic manures prevent growers from fully utilizing them (13). As a result, growers have difficulties in converting to organic farming. Seeking all these things, there is an urgent need to improve traditional organic manures and compost to reduce reliance on chemical fertilizers and reduce the amount of compost used (14). The present manuscript examines the effect of enriched compost combinations on palak productivity, profitability and soil health in India's northern plains over two consecutive cropping seasons. The use of nutrition-rich composts enhances both economic outcomes and sustainability by improving nutrient availability and nourishing soil structure.

Materials and Methods

Experiment location

The investigation was carried out at the vegetable farm of Lovely Professional University, Phagwara, Punjab. During the spring season (Feb to April) in 2022 and 2023. The farm in the Lovely Professional University, Phagwara, Punjab, the investigation was carried out in the vegetable farm, Domain of horticulture, School of Agriculture for two consecutive cropping seasons of 2022 and 2023 is located at 31 ºN (latitude) and 75 °E (longitude) at the altitude of 234 m above sea level. Phagwara (Jalandhar) had a humid subtropical climate with hot summers and winds from April-July followed by a hot humid rainy season and cold winters associated from December-January. The Meteorological Observatory of LPU, Phagwara provided the temperature, precipitation and relative humidity data, which were then carefully documented during spring-summer experimental periods of February 2022 to April 2022 and February 2023 to April 2023 (Fig. 1). The mean temperature ranged between 19.13 °C (min.) to 28.51 (max.) during the first season, while in the second season, conversely, the mean temperature varied between 14.88 °C and 28.54 °C. During the cropping period of the first and second seasons, relative humidity varies between 42.6 to 53.15 % and 44.17 to 73.80 %, respectively.

Experimental details

The study was organized using randomized block design, replicated three times containing following ten treatment combinations: T_1- recommended dose of fertilizers (RDF) + Farm yard manure (FYM) (85:30:0 N: P: K kg/ha+ 20 t/ha); T_2- recommended dose of fertilizers (RDF) + Farm yard manure (FYM) (50 % + 10 t/ha); T_3- Farm yard manure (FYM) (20 t/ha); T_4- mineral enriched compost (Rock phosphate) (MEC_1) (5 t/ha); T_5- microbial enriched compost (MEC_2) (5 t/ha); T_6- vermicompost (VC) (5 t/ha); T_7- MEC_1+ MEC_2 (50 %+50 %); T_8- MEC_1+ MEC_2 (75 % +25 %); T_9- MEC_1+ MEC_2 (25 %+75 %); T_{10}- absolute control (no application) for two consecutive years. The chemical fertilizers (NPK) were given according to the standard protocol, which contained urea (46 % nitrogen) and single super phosphate (16 % phosphorus). As a baseline dosage, the full doses of P, as well as half the amount of N, were administered prior to seed sowing. After 30 days of sowing, the left over half dose of N was used as a top dressing. During the soil preparation step, all enriched compost and manures were physically added to the different plots based on their treatment allocation in the field.

Soil sampling

Before the commencement of the investigation, random soil samples were taken and collected from various locations within the experimental area, ranging in depth from 0 to 15 cm. After combining these samples to create a composite sample, different physicochemical properties of the soil *viz.* pH, EC, organic carbon, N, P and K content were investigated (Table 1). Different methods were employed for various physicochemical characteristics of the soil.

Soil analysis

The procedures used to assess the various physicochemical parameters are described in the appropriate sections.

pH and EC (dSm^{-1})

The pH of the soil was measured with an electrical digital pH meter on a 1:25 soil water suspension. A conductivity meter was used to measure electrical conductivity through the supernatant extract from the suspension mixture (15, 16).

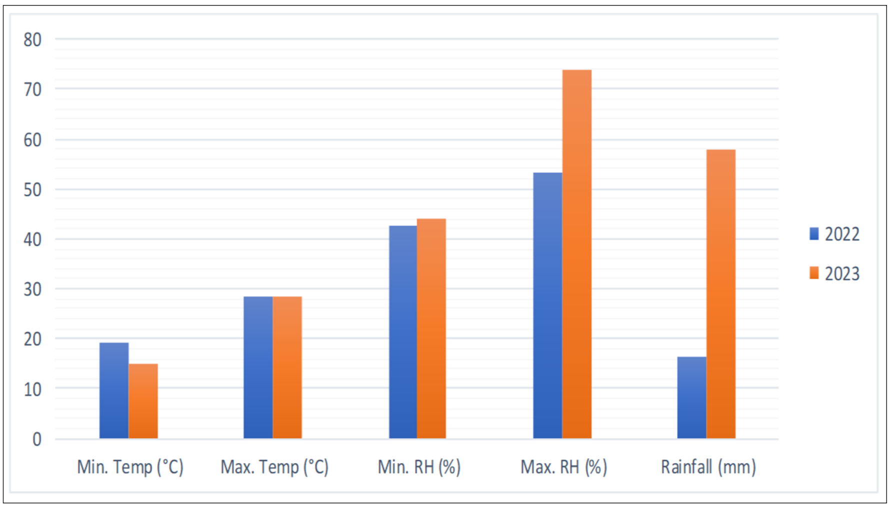

Fig. 1. Meteorological data during the period of experiment 2022-2023.

Table 1. The initial soil properties of experimental site

Specifics	Values attained		The methods adopted	Soil status
	Physical properties %			
Sand	58.97 %		Piper's method, 2019	Sandy clay loam
Silt	17.10 %			
clay	23.93 %			
	Chemical properties			
	1st year	2nd year		
Soil pH	8.5	7.9	pH digital meter	Alkaline
Soil EC (dSm^{-1})	0.65	0.58	The digital conductivity meter	Normal
Organic Carbon %	0.35	0.39	Walkley and Black's, 1934	Low
Available N(kg/ha)	138.25	138.54	Subbiah and Asija (1956) method	Low
Available P(kg/ha)	48.12	49.32	Olsen (1954), Olsen method	High
Available K(kg/ha)	219.23	221.15	The standard method Merwin and Peech, (1951)	Moderate

Organic carbon content (%)

The organic carbon content was measured using Walkley and Black's ferrous ammonium sulphate titration and dichromate oxidation technique (17).

Available nitrogen (kg/ha)

The soil's accessible nitrogen was assessed using Subbiah and Asija's alkaline potassium permanganate technique (18).

Available phosphorus and potassium (kg/ha)

The accessible phosphorus was taken out utilizing 0.5 N $NaHCO_3$ at 8.5 pH and measured utilizing spectrophotometry. The accessible potassium was extracted using typical neutral ammonium acetate and measured using a flame photometer (19, 20).

Economics of the treatments

The cultivation cost was calculated using the current input costs at the time of use. The cultivation cost was determined for each treatment. Calculating net return per hectare was done by deducting the cost of cultivation from total revenue.

Total cost of cultivation: Total variable cost + Total fixed cost.

Gross return: Total yield (kg) × Market price of the produce (₹/kg).

Net return: Gross return - total cost of cultivation.

Benefit-cost ratio: Net return/total cost of cultivation.

Statistical analysis

The recorded data were analyzed as per standard statistical procedure at a level of 5 % significance for both the cropping season of 2022 and 2023 via the software OPSTAT. The Three replications for field experimental using RBD (randomized block design) were laid out to verify the influence of different variables.

Results and Discussion

Crop productivity

In palak, the maximum leaf yield q ha^{-1}(108.70 q) was found maximum in treatment T_1 RDF 100 % (85:30:0 N: P: K kg/ha) + FYM (20 t/ha) which was at par with T_7 (50 % mineral enriched compost + 50 % microbial enriched compost) and followed by T_2 RDF 50 % + FYM (10 t/ha) in the terms of leaf yield q ha^{-1}. The lowest leaf yield q ha^{-1} (50.84 q) was reported in absolute control (T_{10}) in pooled data analysis. The increase in yield comparison to RDF treatment caused by the addition of enriched compost could be attributed to an overall improvement in soil physico-chemical properties, such as a decrease in pH, improved electrical conductivity (EC) and an increase in all nutrients. These advantageous results promoted improved availability of plant nutrients and their consistent delivery throughout growth for optimal development. Similar results related to overall yield had been seen in french bean, green gram, melons, finger millet-cowpea and palak crops respectively (10, 21-24).

Soil pH

During both years, the highest pH values were recorded in treatment T_{10}(Control) with the value of 8.47 and 8.51 and were followed by T_1RDF 100 % (85:30:0 N: P: K kg/ha) + FYM (20 t/ha) and $T_2$with the values of 8.43, 8.40 and 8.41, 8.46, respectively. The soil pH for treatment T_7 (50 % Mineral enriched compost + 50 % microbial-enriched compost) was found to be 7.63 and 7.68, which was the lowest among all treatment combinations. Also, in pooled data analysis, the highest soil pH was recorded in treatment T_1 RDF 100 % (85:30:0 N: P: K kg/ha) + FYM (20 t/ha) with a value of 8.46 which was followed by T_{10}(Control) with values of 8.46, respectively. The activity of bacteria that aids in the breakdown of organic matter, converting previously unavailable mineral nutrients into forms that are suitable for crop growth and development, enhancing the soil's organic carbon content and maintaining a balance pH (21, 22, 25).

Soil electrical conductivity (dSm^{-1})

During both years, the EC value was recorded highest in treatment combination T_1 i.e. RDF 100 % (85:30:0 N: P: K kg/ha) + FYM (20 t/ha) with the values of 0.58 dSm^{-1} and 0.63 Ds m^{-1} and was followed by treatments T_2, T_3 and T_{10}, respectively. The soil EC for treatment T_7(50 % Mineral-enriched compost + 50 % microbial enriched compost) was found to be 0.37 and 0.38 dS m^{-1}, which was the lowest among all treatment combination. Also, in pooled data analysis, the highest soil EC was recorded in treatment T_1 RDF 100 % (85:30:0 N: P: K kg/ha) + FYM (20 t/ha) with a value of 0.61 dSm^{-1} which was followed by T_2 and T_3. The soil EC for treatment T_7(50 % Mineral-enriched compost + 50 % microbial enriched compost) was found to be 0.37 dSm^{-1}, which was the lowest among all treatment combinations in the pooled analysis. The findings in Table 2 reveal a significant decrease in EC of soil treated with organic matter (Enriched compost) and it might be due to the addition of humic compounds by the organic matter. This may be the consequence of chelating, which detoxifies the harmful ions, particularly Na^+ and Cl^- leads to improvement in soil aggregation and the generation of organic acids during the breakdown of organic materials (22, 23, 26, 27).

Organic carbon content (%)

During both years, the value of organic carbon 0.61 and 0.72 percent in soil was observed highest under treatment T_7 (50 %

Table 2. Effect of various treatments on pH, Electrical conductivity (EC dSm^{-1}) and organic carbon content (%) in soil under palak crop experiment

Treatments	pH			EC (dSm^{-1})			Organic carbon content (%)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T_1	8.43	8.40	8.42	0.58	0.63	0.61	0.47	0.48	0.48
T_2	8.41	8.46	8.46	0.55	0.61	0.58	0.42	0.42	0.42
T_3	8.20	8.23	8.22	0.57	0.60	0.58	0.53	0.53	0.53
T_4	7.90	7.93	7.92	0.36	0.39	0.38	0.57	0.59	0.58
T_5	7.87	7.82	7.85	0.42	0.40	0.41	0.60	0.61	0.61
T_6	7.67	7.72	7.70	0.38	0.58	0.48	0.47	0.50	0.48
T_7	7.63	7.68	7.66	0.37	0.38	0.37	0.61	0.72	0.66
T_8	8.00	8.00	8.00	0.40	0.41	0.41	0.51	0.53	0.52
T_9	7.97	7.89	7.93	0.39	0.58	0.48	0.55	0.57	0.56
T_{10}	8.47	8.51	8.46	0.49	0.52	0.51	0.44	0.46	0.45
Mean	8.05	8.07	8.06	0.45	0.51	0.48	0.52	0.54	0.53
CD($p \le 0.05$)	0.26	0.16	0.28	0.12	0.07	0.12	0.01	0.02	0.05
CV %	1.88	1.17	1.15	15.69	8.77	11.40	2.14	2.94	0.18

Note *T_1= RDF 100 % (85:30:0 N: P: K kg/ha) + FYM (20 t/ha); *T_2**=** RDF 50 % + FYM (10 t/ha); *T_3= FYM (20 t/ha)

*T_4= Mineral (Rock phosphate) enriched compost (5 t/ha); *T_5= Microbial (N-fixing, PSB, KSB, & *Trichoderma*, *Pseudomonas*) enriched compost t/ha); *T_6= Vermicompost (5 t/ha); *T_7= 50 % Mineral enriched compost + 50 % Microbial enriched compost; *T_8= 75 % Mineral enriched compost + 25 % Microbial enriched compost; *T_9= 25 % Mineral enriched compost + 75 % Microbial enriched compost; *T_{10}= Control

Mineral enriched compost + 50 % microbial Enriched Compost) which was followed by treatment T_5 (microbial enriched compost 5 t ha^{-1}) with the value of 0.60 and 0.61 percent, respectively. Also, in pooled data analysis, the highest organic carbon was recorded in treatment T_7(50 % Mineral enriched compost + 50 % microbial enriched compost) with a value of 0.66 % which was followed by T_5 (Microbial enriched compost 5 t/ha) with a value of 0.61 % (Table 2). The organic carbon for T_2 treatment was found to be 0.42 %, which was the lowest among all treatment combinations. It could be because organic manure has a larger carbon content than other organic and inorganic treatments. The minimal distribution of the soil, which promotes greater storage, may be the cause of the rise in organic carbon. Comparable outcomes were published by (22, 28, 29). They noticed a noteworthy enrichment in the proportion of organic carbon in the mineral + microbial-enriched compost.

Available nitrogen (kg/ha)

The maximum amount of accessible nitrogen 146.24 and 148.77 kg/ha in soil was obtained under treatment T_7(50 % Mineral enriched compost + 50 % microbial enriched compost) which was superior over T_1 (RDF 100 % (85:30:0 N: P: K kg/ha + FYM 10 t/ha) treatment as well as control (T_{10}) during both the years (Table 3). The lowest value of soil available nitrogen 95.47 and 106.71 kg/ha, was recorded under control (T_{10}) for both years. During pooled data analysis, the maximum accessible nitrogen was recorded in treatment T_7(50 % Mineral enriched compost + 50 % microbial enriched compost) with a value of 147.50 kg/ha which was followed by T_1 with a value of 143.12 kg/ha, respectively. The available nitrogen for control i.e. treatment (T_{10}) was found to be 101.11 kg/ha, which was the minimum among all treatment combinations. As a result of the mineralization of both native and applied nutrients via organics, the total and accessible nutrient status of the soil increased and the affiliation fixing atmospheric N into the rhizosphere during the cropping season by combining *Rhizobium* with *Azotobacter* and *Azospirillum* may be the cause of the increase of accessible N significantly after the addition of mineral + microbial enriched compost into soil (22, 28, 30, 31).

Available phosphorus (kg/ha)

Value for maximum available phosphorus 62.50 and 68.96 kg/ha were recorded under treatment T_7(50 % Mineral enriched compost + 50 % microbial enriched compost) followed by T_6 (vermicompost 5 t ha^{-1}) and T_5 (microbial enriched compost 5 t ha^{-1}) treatments with the value of 60.27, 65.54 and 55.57, 59.00 kg/ha, respectively during both the years (Table 3). The lowest value of available phosphorus 47.73 and 49.12 kg/ha were

Table 3. Effect of various treatments on available N, P and K in soil under palak crop experiment (kg/ha)

Treatments	Available Nitrogen (kg/ha)			Available Phosphorus (kg/ha)			Available Potassium (kg/ha)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
T_1	143.84	142.40	143.12	51.17	54.50	52.83	224.33	226.02	225.18
T_2	138.94	140.63	139.79	50.33	52.81	51.57	222.67	223.16	222.92
T_3	100.97	113.10	107.03	55.03	58.21	56.62	224.67	225.83	225.25
T_4	135.52	138.02	136.77	54.87	58.94	56.90	223.00	223.94	223.47
T_5	137.25	138.31	137.78	55.57	59.00	57.28	224.33	224.54	224.44
T_6	134.21	143.77	138.99	60.27	65.54	62.91	222.33	223.57	222.95
T_7	146.24	148.77	147.50	62.50	68.96	65.73	224.67	227.23	225.95
T_8	132.97	133.05	133.01	53.83	55.68	54.76	222.67	223.75	223.21
T_9	131.49	132.31	131.90	53.23	55.23	54.23	222.33	224.72	223.53
T_{10}	95.47	106.75	101.11	47.73	49.12	48.43	221.67	223.04	222.35
Mean	129.69	133.71	131.70	54.45	57.80	56.13	223.27	224.58	223.92
CD($p \le 0.05$)	3.61	4.46	5.25	2.23	2.60	3.13	4.06	2.26	4.25
CV %	1.62	1.94	1.79	2.38	2.63	2.52	1.06	0.58	0.85

Note *T_1= RDF 100 % (85:30:0 N: P: K kg/ha) + FYM (20 t/ha); *T_2**=** RDF 50 % + FYM (10 t/ha); *T_3= FYM (20 t/ha)

*T_4= Mineral (Rock phosphate) enriched compost (5 t/ha); *T_5= Microbial (N-fixing, PSB, KSB, & *Trichoderma*, *Pseudomonas*) enriched compost t/ha); *T_6= Vermicompost (5 t/ha *T_7= 50 % Mineral enriched compost + 50 % Microbial enriched compost; *T_8= 75 % Mineral enriched compost + 25 % Microbial enriched compost; *T_9= 25 % Mineral enriched compost + 75 % Microbial enriched compost; *T_{10}= Control

recorded under control (T_{10}) over the years. Also, in pooled data analysis, the available phosphorus was recorded maximum in treatment T_7 (50 % Mineral enriched compost + 50 % microbial enriched compost) with a value of 65.73 kg/ha which was followed by T_6 with a value of 62.91 kg/ha. The available phosphorus for control i.e. treatment (T_{10}) was found to be 48.43 kg/ha, which was the minimum among all other treatment combinations. The higher available P in treatment may be due to the creation of different organic acids by microorganisms that solubilize phosphate and the expulsion of organic acids during the breakdown of organic materials and rock phosphate. This organic acid acts as a chelating agent and produces steady combinations with iron and aluminium, which are common in acid soil. The creation of more stable organic chelates with organic legends, which are less susceptible to precipitation, adsorption and fixation in soil, increased nutrient availability (22, 31, 32).

Available potassium (kg/ha)

The value for the maximum available potassium i.e. 224.67 and 223.27 kg/ha in soil was recorded under treatment T_7 (50 % Mineral enriched compost + 50 % microbial enriched compost) during both the years (Table 3) in soil analysis that was done after harvest. The lowest value of available potassium i.e. 221.67 and 223.04 kg/ha in soil were recorded under control (T_{10}). Also, in pooled data analysis, the maximum available potassium was recorded under treatment T_7 (50 % Mineral enriched compost + 50 % microbial enriched compost) with a value of 225.95 kg/ha which was followed by T_1 (RDF 100 % (85:30:0 N: P: K kg/ha) + FYM (20 t/ha) with a value of 225.18 kg/ha, respectively. The available potassium for control i.e. treatment (T_{10}) was found to be 222.35 kg/ha, which was the minimum among all treatment combinations. The enhanced nutrient availability may also be related to the intrinsic capability of enriched compost, which accelerates the mineralization of organically bound macronutrients found in native soil. Additionally, it might have been caused by higher K retention from organic sources, which prevented leaching loss (10, 22, 30).

Profitability

Through Tables 4 and 5 treatment-wise cultivation cost and return analysis (B:C ratio) has been shown for two consecutive years of the study. During economic analysis, the treatment combination T_7 (50 % Mineral enriched compost + 50 % microbial enriched compost) obtained the highest net returns of ₹164648 and ₹159806 per hectare with corresponding B:C ratio of 2.72 and 2.73 for first and second year respectively. This was followed by treatment combination T_1 RDF 100 % (85:30:0 N: P: K kg/ha) + FYM (20 t/ha) which earned ₹123604 with B:C ratio of 1.81 during the first and second year it was followed by treatment combination T_4 (mineral enriched compost 5 t/ha) which earned ₹120212 having B:C ratio of 2.00. Without any application of inorganic fertilizers in treatment T_7 it has reduced cultivation cost and gave more net return per hectare (23, 24, 29, 31).

Conclusion

The findings of this research work highlight the significant benefits of enriched compost on palak (*Beta vulgaris* var. *bengalensis*) productivity, profitability and soil health. On the basis of the results analysis, we concluded that, among different organic and inorganic treatment combinations, T_7 which comprised of 50 % mineral-enriched compost at 2.5 t/ha + 50 % microbial-enriched compost at 2.5 t/ha resulted in highest yield, maximum profit and showed substantial

Table 4. Effect of various treatments on economics in palak crop experiment (First year)

Treatment	Total cost	Sale Price	Yield (q/ha) 2023	Gross income (Rs.)	Net income (Rs.)	B:C Ratio
T_1	68384	1800	110.73	199,314.00	130,930.00	1.91
T_2	66784	1800	92.95	167,310.00	100,526.00	1.51
T_3	65184	1500	66.32	99,480.00	34,296.00	0.53
T_4	60184	1800	100.22	180,396.00	120,212.00	2.00
T_5	56684	1800	79.45	143,010.00	86,326.00	1.52
T_6	143184	1800	86.26	155,268.00	12,084.00	0.08
T_7	58434	2000	109.12	218,240.00	159,806.00	2.73
T_8	59559	1900	80.55	153,045.00	93,486.00	1.57
T_9	57559	1800	80.38	144,684.00	87,125.00	1.51
T_{10}	53184	1500	47.04	70,560.00	17,376.00	0.33

Note *T_1= RDF 100 % (85:30:0 N: P: K kg/ha) + FYM (20 t/ha); *T_2**=** RDF 50 % + FYM (10 t/ha); *T_3= FYM (20 t/ha); *T_4= Mineral (Rock phosphate) enriched compost (5 t/ha); *T_5= Microbial (N-fixing, PSB, KSB, & *Trichoderma, Pseudomonas*) enriched compost t/ha); *T_6= Vermicompost (5 t/ha); *T_7= 50 % Mineral enriched compost + 50 % Microbial enriched compost; *T_8= 75 % Mineral enriched compost + 25 % Microbial enriched compost; *T_9= 25 % Mineral enriched compost + 75 % Microbial enriched compost; *T_{10}= Control

Table 5. Effect of various treatments on economics in palak crop experiment (Second year)

Treatment	Total cost	Sale Price	Yield (q/ha) 2022	Gross income (Rs.)	Net income (Rs.)	B:C Ratio
T_1	68384	1800	106.66	191,988.00	123,604.00	1.81
T_2	66784	1800	104.44	187,992.00	121,208.00	1.81
T_3	65184	1500	65.27	97,905.00	32,721.00	0.50
T_4	62184	1800	89.99	161,982.00	99,798.00	1.60
T_5	58684	1800	78.06	140,508.00	81,824.00	1.39
T_6	143184	1800	87.05	156,690.00	13,506.00	0.09
T_7	60434	2200	102.31	225,082.00	164,648.00	2.72
T_8	61309	1900	84.7	160,930.00	101,371.00	1.70
T_9	59559	1800	77.05	138,690.00	77,381.00	1.26
T_{10}	53824	1500	54.64	81,960.00	28,136.00	0.52

Note *T_1= RDF 100 % (85:30:0 N: P: K kg/ha) + FYM (20 t/ha); *T_2**=** RDF 50 % + FYM (10 t/ha); *T_3= FYM (20 t/ha); *T_4= Mineral (Rock phosphate) enriched compost (5 t/ha); *T_5= Microbial (N-fixing, PSB, KSB, & *Trichoderma*, *Pseudomonas*) enriched compost t/ha); *T_6= Vermicompost (5 t/ha); *T_7= 50 % Mineral enriched compost + 50 % Microbial enriched compost; *T_8= 75 % Mineral enriched compost + 25 % Microbial enriched compost; *T_9= 25 % Mineral enriched compost + 75 % Microbial enriched compost; *T_{10}= Control variations for soil fertility status after harvesting the palak crop. The improved soil health as envisaged through post-harvest availability of N, P and K by 6.69, 36.59 and 3.06 %, respectively after the experiment, was recorded, which resulted in the saving of 100 % of the fertilizers. The experimental findings have proved the utility of enriched compost as an important source of nutrients in the cultivation of leafy vegetables. The use of enriched compost has made it possible by reducing the quantity which will be very less as compared to ordinary farm yard manure and its easy handling. The treatment combination T_7 (50 % mineral enriched compost at 2.5 t/ha + 50 % microbial enriched compost at 2.5 t/ha application can be recommended as a cost-effective combination for reaping maximum yields coupled with best quality leafy vegetable crops based on sustainable under Northern plains of Punjab region.

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Authors' contributions

LK carried out the enriched composts studies, participated in the writing and drafted the manuscript. ST participated in the design of the study and performed the statistical analysis. SS, EG and B participated in its design, coordination and language improvement. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

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