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IMPACT OF BIO-FERTILIZER AND ORGANIC MULCH ON THE ECONOMICS OF CULTIVATION OFSTRAWBERRY CV. KATRAIN SWEET

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ABSTRACT

To investigate the impact of bio-fertilizers and organic mulch on the economics of strawberry cv. Katrain Sweet, an experiment was carried out in Horticulture Garden, Department of Fruit Science, C.S. Azad University of Agriculture and Technology, Kanpur, during two subsequent years *i.e.,* 2022-2023 and 2023-2024 in randomized block design using 13 treatments, each replicated three times. The result showed that the use of *Azotobacter*, *Trichoderma harzianum* and PSB in combination with organic mulch, particularly in treatment T_{12}-*Azotobacter* (8g/plant) + *PSB* (8g/plant) + *Trichoderma harzianum* (6g/plant) + dried leaves, shown maximum B: C ratio (3.42) and net returns (Rs. 24,24,367/ha). The total fixed cost of cultivation was estimated at Rs. 4, 89, 944/ ha and the maximum yield recorded in T_{12} at 52.22 t/ha. The result emphasized the potential for the application of biofertilizers and organic mulches to increase strawberry production and provide producers with significant returns.

***Key words*:** Organic, Producers, B:C ratio, Mulches, Bio-fertilizer, Strawberry

Introduction

Strawberry cultivation is an appealing alternative for producers seeking to diversify their agricultural practices as it provides substantial advantages over regular crops. Strawberries can be harvested within a few months of sowing, resulting in rapid returns on investment due to their relatively brief growing season (Claire *et al.*, 2018).

The crop is suitable for small-scale and large-scale operations due to its ability to flourish in well-drained soil and its moderate requirement for fertilizers and pesticides. Strawberries are in high demand in domestic and international markets due to their versatility and popularity, which results in premium pricing for fresh and high-quality produce. This heightened demand motivates farmers to implement sustainable practices that improve soil health and decreases their dependence on chemicals. In addition, strawberries can be cultivated in a variety of systems such as traditional open fields, high tunnels and container horticulture which enable producers for their space and resources (Morris *et al.*, 2017).

Strawberry cultivation in the plains of Uttar Pradesh faces many obstacles such as climate and soil condition of the region. Strawberry plants frequently experience heat stress during the growing season which leads to inadequate fruit development and diminished yields. Powdery mildew, aphids and insects are prevalent problems in the area due to the humid climate. The cost of production is frequently increased by the necessity for farmers to invest significantly in pesticides. Furthermore, the perishable nature of strawberries restricts market access resulting in a decrease in profitability for producers in the region Rattanpal *et al.*, (2011) and Prakash and Sarkar (2017). The use of bio-fertilizers and organic mulch in the cultivation of Strawberry in Central UP can significantly influence production cost and profitability. Bio-fertilizers reduces the need for chemical inputs and organic mulches help in conservation of soil moisture. Together, these practices can enhance soil health and reduce long-term expenses, potentially increasing net returns for strawberry farmers. However, initial setup cost and availability of organic inputs may pose challenges to widespread adoption (Tripathi *et al.*, 2016).

Bio-fertilizers like *Azotobacter*, PSB and

Table 1. A comprehensive overview of the treatments and corresponding symbols used in the experiment.

S. no.	Treatment details	Symbols
1.	*Azotobacter* (5g/plant) + *Trichoderma harzianum* (5g/plant) + Paddy straw	T_1
2.	*Azotobacter* (8g/plant) + *Trichoderma harzianum* (6g/plant) + Paddy straw	T_2
3.	*Azotobacter* (5g/plant) + *Trichoderma harzianum* (5g/plant) + Dried leaves	T_3
4.	*Azotobacter* (8g/plant) + *Trichoderma harzianum* (6g/plant) + Dried leaves	T_4
5.	*Azotobacter* (5g/plant) + PSB (5g/plant) + Paddy straw	T_5
6.	*Azotobacter* (8g/plant) + PSB (8g/plant) + Paddy straw	T_6
7.	*Azotobacter* (5g/plant) + PSB (5g/plant) + Dried leaves	T_7
8.	*Azotobacter* (8g/plant) + PSB (8g/plant) + Dried leaves	T_8
9.	*Azotobacter* (5g/plant) + PSB (5g/plant) + *Trichoderma harzianum* (5g/plant) + Paddy straw	T_9
10.	*Azotobacter* (8g/plant) + PSB (8g/plant) + *Trichoderma harzianum* (6g/plant) + Paddy straw	T_{10}
11.	*Azotobacter* (5g/plant) + PSB (5g/plant) + *Trichoderma harzianum* (5g/plant) + Dried leaves	T_{11}
12.	*Azotobacter* (8g/plant) + PSB (8g/plant) + *Trichoderma harzianum* (6g/plant) + Dried leaves	T_{12}
13.	Control (5 kg FYM per bed)	T_{13}

Trichoderma harzianum together with organic mulches like paddy straw and dried leaves can boost strawberry output by improving soil health and plant development. They boost nutrient availability and root health which results in stronger plants, greater fruit quality and more yield. These natural ingredients promote sustainable strawberry production by reducing artificial fertilizers and pesticide usage Rashmi *et al*., (2022) and Simpson (2018).

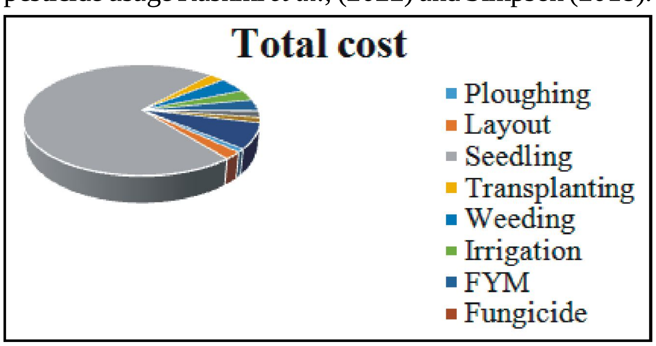

Fig. 1: Effect of bio-fertilizers and organic mulch on total cost of cultivation (Rs./ha).

Table 2: Cost of bio-fertilizers and organic mulch.

Particulars	Rate
Azotobacter	Rs. 100/kg
Trichoderma harzianum	Rs. 127/kg
PSB	Rs. 100/kg
Paddy straw	Rs. 10,000/ha
Dried leaves	Rs. 10,000/ha

This study investigates the impact of bio-fertilizers and organic mulch on the economics of cultivating Strawberry cv. Katrain Sweet aims to provide a comprehensive understanding of the effects of these organic inputs on profitability and sustainability in strawberry production in Central Uttar Pradesh.

Materials and Methods

The present investigation of field experiment was conducted in both years *i.e*. 2022-2023 and 2023-2024 at Horticulture Garden, Department of Fruit Science, College of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh. Geographically, the Kanpur district lies in a subtropical zone between 25.26° and 26.58° North latitude; and 79.31° and 80.34° East longitude, at 135 meters above sea level. For the experimentation, a randomized block design was employed, incorporating thirteen treatments as different bio-fertilizers and organic mulches were used for strawberry yield characters as well as the economics.

The assignment of treatments to experimental units followed a random process using the Fisher and Yates random table method (Panse and Sukhatme, 1985) and was replicated thrice for statistical robustness.

Observations Recorded

Fruit yield (kg/plant)

The number of fruits set per strawberry plant is calculated by counting the total number of fruits formed on each plant and multiplying by its weight. This count is averaged across multiple plants to determine the typical yield of fruits in each treatment.

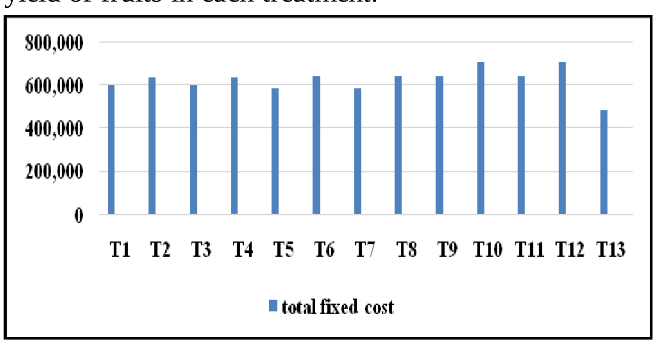

Fig. 2: Effect of bio-fertilizers and organic mulch on total fixed cost of treatments (Rs./ha).

Table 3: Effect of bio-fertilizer sand organic mulch on total cost of cultivation (Rs./ha).

Particulars	Unit and frequency	Rate	Total cost
Ploughing	Soil turning plough (one)	2,400	2,400.00
	Cultivator with planking (one)	2,400	2,400.00
Layout	Labour (35)	300/labour	10,500.00
Seedling	Plants (88,889)	4/Plant	3,55,556.00
Transplanting	Labour (40)	300/labour	12,000.00
Weeding	Labour (three times with twenty five labours each time)	300/labour	22,500.00
Irrigation	Charges (8 times)	1,000/irrigation	8,000.00
	Labour (24)	300/labour	7,200.00
FYM	Kg (4000)	4/kg	16,000.00
Fungicide	Neem oil (4 liters)	250/liter	1000.00
Harvesting	Labour (six times with five labours each time)	300/labour	9,000.00
Packaging	Labour six times with four labours each time)	300/labour	7,200.00
TOTAL			4,53,756.00
Total working cost	Interest on working capital @5% Depreciation on fixed cost Rental value of land Miscellaneous		22,687.00
			500.00
			8,000.00
			5,000.00
TOTAL			4,89,944.00

Estimated fruit yield (tons/ha)

Yield per hectare was computed by multiplying the yield per plant by the number of plants accommodated in one hectare and expressed in tons/ hectare.

Cost of cultivation (Rs./ha)

The cost of cultivation of strawberry (treatment-wise) was calculated separately by adding the value of each input *i.e.* labour charges, cost of plants, cost of organic inputs and bio-fertilizers, etc. in each treatment during the experimental period and expressed as Rupees/hectare (Rs./ha).

The total cost involved field ploughing, layout, seedling, transplanting, weeding, irrigation, FYM, fungicide, harvesting, packaging and total working cost was calculated. Then each treatment cost was estimated at the following values.

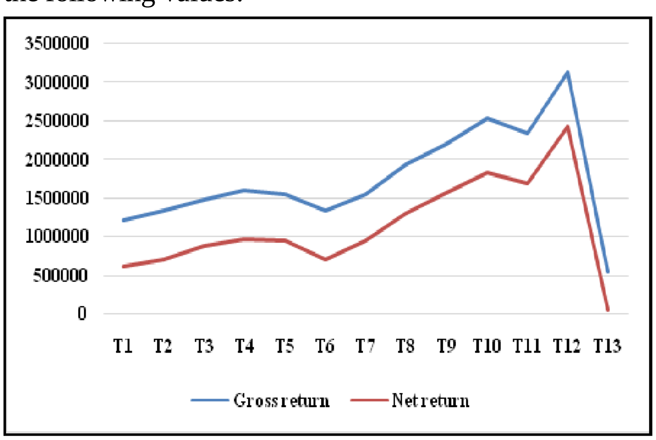

Fig. 3: Effect of bio-fertilizers and organic mulch on gross return and net return (Rs./ha)

Gross return (Rs./ha)

The yield of strawberry (treatment-wise) was converted into gross income based on the prevailing market price.

Gross return (Rs./ha) = Selling price × Total yield

Net return (Rs./ha)

The net income per hectare was calculated for each treatment by deducting the cost of production from the gross income obtained in each treatment.

Net return (Rs./ha) = Gross return-Total fixed cost

Benefit-cost ratio

The Benefit-cost ratio of different treatments was calculated by dividing the gross income by the respective cost of cultivation of different treatments using the following formula.

$$\text{B:C ratio} = \frac{\text{Net return}}{\text{Total fixed cost}}$$

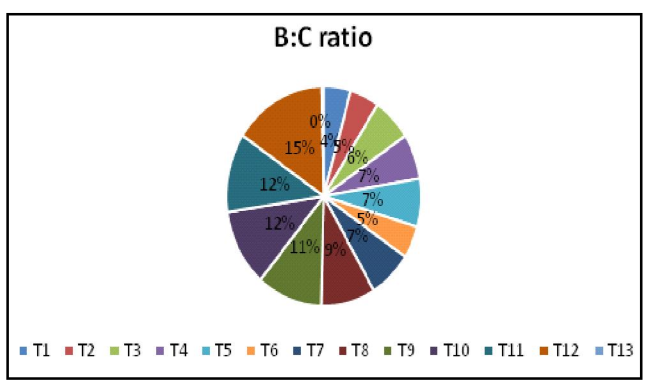

Fig. 4: Effect of bio-fertilizers and organic mulch on B:C ratio.

Table 4. Effect of bio-fertilizers and organic mulch on the cost of treatments (Rs. /ha).

Treat-ments	Fixed cost	Variable cost				Total fixed cost (Rs.)
		Azotobacter	*Trichoderma harzianum*	PSB	Dried leaves/ paddy straw	
T_1	489944.00	44,444.00	55556.00	0	10,000.00	5,99,944.00
T_2	489944.00	71,111.00	66667.00	0	10,000.00	6,37,722.00
T_3	489944.00	44,444.00	55556.00	0	10,000.00	5,99,944.00
T_4	489944.00	71,111.00	66667.00	0	10,000.00	6,37,722.00
T_5	489944.00	44,444.00	0	44,444.00	10,000.00	5,88,832.00
T_6	489944.00	71,111.00	0	71,111.00	10,000.00	6,42,166.00
T_7	489944.00	44,444.00	0	44,444.00	10,000.00	5,88,832.00
T_8	489944.00	71,111.00	0	71,111.00	10,000.00	6,42,166.00
T_9	489944.00	44,444.00	55556.00	44,444.00	10,000.00	6,44,388.00
T_{10}	489944.00	71,111.00	66667.00	71,111.00	10,000.00	7,08,833.00
T_{11}	489944.00	44,444.00	55556.00	44,444.00	10,000.00	6,44,388.00
T_{12}	489944.00	71,111.00	66667.00	71,111.00	10,000.00	7,08,833.00
T_{13}	489944.00	0	0	0	0	4,89,944.00

Results and Discussion

While working on strawberry cultivation for the subsequent years *i.e.*, 2022-2023 and 2023-2024. The yield of strawberry was recorded with 13 treatments and data was arranged in tabular form as presented in Table 4.

Fruit yield (t/h)

The highest fruit yield was recorded in T_{12}-*Azotobacter* (8g/plant) + PSB (8g/plant) + *Trichoderma harzianum*(6g/plant) + dried leaves at 52.22 t/ha, followed by in T_{10}-*Azotobacter* (8g/plant) + PSB (8g/plant) + *Trichoderma harzianum* (6g/plant) + paddy straw at 42.22 t/ha. The lowest yield was recorded at 8.88 t/ha in T_{13}-control (Table 4). The increased fruit yield in strawberry with the use of *Azotobacter, Trichoderma harzianum* and Phosphate-Solubilizing Bacteria (PSB) is due to their synergistic effects on plant growth and development. *Azotobacter* enhances nitrogen fixation, providing essential nutrients, while *Trichoderma harzianum* acts as a bio-control agent, suppressing pathogens and promoting root growth. PSB helps in solubilizing phosphorus, making it more accessible to plants. Together, they improve nutrient availability, stimulate root development, enhance plant immunity and promote overall plant vigour, leading to higher fruit yields. This integrated approach also boosts soil health, resulting in sustainable and improved productivity in strawberry cultivation Kumar *et al.*, (2020). A similar finding was reported by Nayyer *et al.*, (2014) and Bhadauria and Tripathi (2023) in strawberry.

Cost of cultivation

The highest cost of cultivation was found in T_{12}-*Azotobacter* (8g/plant) + PSB (8g/plant) + *Trichoderma harzianum* (6g/plant) + dried leaves at Rs. 7,08,833.00/ha which was similar to T_{10}-*Azotobacter* (8g/plant) + PSB (8g/plant) + *Trichoderma harzianum*(6g/plant) + paddy straw at Rs. 7,08,833.00/ha. The lowest value in cost of cultivation was found in control (T_{13}) at Rs. 4,89,944.00/ha. The cost of strawberry cultivation increases with the use of *Azotobacter, Trichoderma harzianum* and Phosphate-Solubilizing Bacteria (PSB) due to additional expenses associated with procuring and applying these bio-inoculants. While these bio-inoculants improve yield and soil health, the up front investment in purchasing quality inoculants, along with costs for labour and application equipment, contributes to an overall increase in the cost of cultivation (Conti *et al.*, 2014).

Table 5: Effect of bio-fertilizers and organic mulch on B:C ratio.

Treatment	Total Fixed Cost	Yield (t/ha)	Selling price (Rs./ha)	Gross return (Rs./ha)	Net return return (Rs./ha)	B:C
T_1	5,99,944.00	20	60,000.00	1200000.00	6,00,056.00	1.00
T_2	6,37,722.00	22.2	60,000.00	1332000.00	6,94,278.00	1.08
T_3	5,99,944.00	24.44	60,000.00	1466400.00	8,66,456.00	1.44
T_4	6,37,722.00	26.66	60,000.00	1599600.00	9,61,878.00	1.50
T_5	5,88,832.00	25.55	60,000.00	1533000.00	9,44,168.00	1.60
T_6	6,42,166.00	22.22	60,000.00	1333200.00	6,91,034.00	1.07
T_7	5,88,832.00	25.55	60,000.00	1533000.00	9,44,168.00	1.60
T_8	6,42,166.00	32.22	60,000.00	1933200.00	12,91,034.00	2.01
T_9	6,44,388.00	36.66	60,000.00	2199600.00	15,55,212.00	2.41
T_{10}	7,08,833.00	42.22	60,000.00	2533200.00	18,24,367.00	2.57
T_{11}	6,44,388.00	38.88	60,000.00	2332800.00	16,88,412.00	2.62
T_{12}	7,08,833.00	52.22	60,000.00	3133200.00	24,24,367.00	3.42
T_{13}	4,89,944.00	8.88	60,000.00	532800.00	42,856	0.08

Cost and return

The total fixed cost came to be Rs. 4,89,944/ ha by adding all necessary particulars needed for the cultivation of strawberry (Table 3).

The cost for each treatment is calculated in which highest value is amounted to T_{10}-*Azotobacter* (8g/plant) + PSB (8g/plant) + *Trichoderma harzianum* (6g/plant) + paddy straw and T_{12}-*Azotobacter* (8g/plant) + PSB (8g/plant) + *Trichoderma harzianum* (6g/plant) + dried leaves at Rs. 7,08,833.00/ ha each. The lowest value of cost of cultivation was recorded in T_{13}- Control using 5 kg FYM per bed at Rs. 4,89,944.00/ ha (Table 4).

Gross return

The highest gross return is founded in treatment T_{12}-*Azotobacter* (8g/plant) + PSB (8g/plant) + *Trichoderma harzianum* (6g/plant) + dried leaves at Rs. 31,33,200.00/ ha, followed by in T_{10}-*Azotobacter* (8g/plant) + PSB (8g/ plant) + *Trichoderma harzianum* (6g/plant) + paddy straw at Rs. 25,33,200.00/ha. The lowest gross return was recorded in control at Rs. 5, 32,800.00/ha (Table 5). Gross return in strawberry increases with the use of *Azotobacter, Trichoderma harzianum* and PSB due to higher fruit yield and quality. These bio-inoculants enhance nutrient availability, improve plant health and reduce disease incidence, leading to more marketable produce and increased profitability for farmers Tripathi *et al.*, (2017) and Siddiqui *et al.*, (2021).

Net return

The highest net return recorded in treatment T_{12}-*Azotobacter* (8g/plant) + PSB (8g/plant) + *Trichoderma harzianum* (6g/plant) + dried leaves at Rs. 24,24,367.00/ ha, followed by in T_{10}-*Azotobacter* (8g/plant) + PSB (8g/ plant) + *Trichoderma harzianum* (6g/plant) + paddy straw at Rs. 18,24,367.00/ha. The lowest net return was recorded in control at Rs. 42,856.00/ha (Table 5). Net return in strawberry increases with the use of *Azotobacter, Trichoderma harzianum* and PSB because the boost in yield and quality outweighs the additional costs of these bio-inoculants. Higher productivity and better-quality fruits results in greater revenue which ultimately leads in improved profitability despite there is increased cultivation expenses Tripathi *et al.*, (2010) and Pawlak *et al.*, (2022).

Cost: benefit ratio

After calculating the values, it was noted down that highest B:C ratio was recorded in treatment T_{12}-*Azotobacter* (8g/plant) + PSB (8g/plant) + *Trichoderma harzianum* (6g/plant) + dried leaves at 3.42, followed by in T_{11}-*Azotobacter* (5g/plant) + PSB (5g/plant) + *Trichoderma harzianum* (5g/plant) + dried leaves at 2.62. The control (T_{13}) treatment shows the minimum B:C ratio at 0.08 (Table 5). It can be interpreted that the addition of *Azotobacter*, PSB and *Trichoderma harzianum* together with organic mulch: paddy straw, and dried leaves provided the necessary environment for optimum strawberry production and increased over all cost-benefit ratio (Bashan *et al.*, 2014).

Conclusion

In the present experiment, revealed that the use of *Azotobacter*, *Trichoderma harzianum* and PSB in combination with organic mulch, particularly in treatment T_{12}-*Azotobacter* (8g/plant) + *PSB* (8g/plant) + *Trichoderma harzianum* (6g/plant) + dried leaves, shown significantly maximum B: C ratio (3.42) and net returns (Rs. 24,24,367.00/ha) in strawberry. The total fixed of cultivation estimated at Rs. 4, 89, 944/ ha and maximum yield recorded in T_{12} at 52.22 t/ha. These findings imply that using bio-fertilizers and organic mulches in strawberry growing might improve sustainability and efficiency in North Indian plains, benefiting producers and the environment.

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