

## Effect of Different Biofertilizers and Organic Manures on Growth and Yield of Strawberry (*Fragaria* × *Ananassa* Duch.) cv Chandler

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**Abstract** The experiment was laid out in a randomized block design having 12 treatments and three replications of bio-fertilizers and organic manure at different levels. The result revealed that treatment T<sub>12</sub> (Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + FYM 6 ton ha<sup>-1</sup> + Vermicompost 3 ton ha<sup>-1</sup> + Poultry manure 3 ton ha<sup>-1</sup>) was found to be best in terms of maximum plant height (19.67 cm), plant spread (26.43 cm), number of leaves (18.13), petiole length (4.96 cm), day to first flowering (67.33), number of flowers per plant (16.80), fruit yield per plant (75.94 g), fruit yield per plot (683.46 g), fruit yield per hectare (6.83 t). Similarly the maximum gross return (Rs 1079,250), net return (Rs 696,022.95) and benefit cost ratio (2.77 : 1) for cultivation of strawberry under Allahabad agro-climatic condition respectively.

**Keywords** *Azotobacter*, Phosphobacter, FYM, Vermicompost, Poultry manure.

### Introduction

Strawberry (*Fragaria* x sp.) is native of temperate regions, but varieties are available which can be cul-

tivated in subtropical climate, Strawberry is a delicious fruit taken fresh in several ways. It is a soft and a highly perishable fruit, often shipped in frozen condition in Western countries. Strawberry thrives best in temperate climate. It is a short day plant ; the varieties grown in milder subtropical climate do not require chilling and continue to make some growth during winter. Strawberry requires a well-drained medium loam soil, rich in organic matter. The soil should be slightly acidic with pH from 5.7 to 6.5 at higher pH root formation is poor. In light soils and in those rich in organic matter, runner formation is better. Strawberry should not be cultivated in the same land for a number of years. It is preferable to plant it in green manure field. Thus, there is a tremendous pressure on non-renewable energy resource to meet the ever-increasing demand of quality fruits. Hence, it has become imperative to turn to more econ-friendly method of nutrition management in horticultural crops of which biofertilizers stands with prime importance. The beneficial effects of *Azotobacter* are not only due to its ability to fix nitrogen but also due to its ability to synthesize auxin vitamins, growth substance and its capacity to produce anti-fungal antibiotics which improve plant stands in inoculated fields by inhibiting root pathogens. *Azotobacter* is heterotrophic aerobic bacterium, the free living bacteria fixes nitrogen in the rhizosphere and provides it to the plant. Their inoculation is useful for horticultural crop with an increase in plant yield. The increase in yield is because in addition to adding nitrogen, these bacteria produce vitamins like biotin, folic acid also produces antifungal antibiotics which results an early devel-

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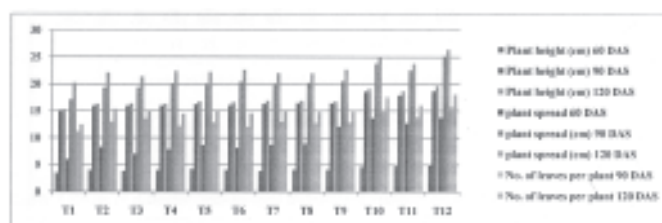


Fig. 1. Effect of different biofertilizers and organic manures on growth parameters of strawberry.

opment of roots and better starts of crop plant initially *Azotobacter* is free living nitrogen fixing bacteria fixing nitrogen equivalent to 25 to 30 kg nitrogen ha.

### Materials and Methods

The present experiment was conducted at pomology section, Department of Horticulture, SHIATS, Allahabad, during 2015-2016, in a randomized block design replicated with thrice, the experimental site is situated at a latitude of 20° and 15° North and longitude of 60° 3° East and at an altitude of 98 meters above mean sea level (MSL). Minimum temperature ranged from 4°–5°C (during Oct–Feb) and maximum temperature ranged from 45°–48°C (during March–June). One cultivar with uniform sized strawberry runners were planted during November 2015, maintaining a spacing of 30×30 cm. The biofertilizer and organic manures were prepared as per the requirement and applied to each treatments and replication at before planting and observations recorded. The recommended package of practices was followed for raising the successful crop, data on plant growth fruit yield and quality of strawberry characters were recorded when the plants were fully grown. A treatment consists:

T<sub>1</sub> : Control, T<sub>2</sub> : Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> T<sub>3</sub> : Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + FYM 25 t ha<sup>-1</sup>, T<sub>4</sub> : Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + Poultry manure 12 t ha<sup>-1</sup>, T<sub>5</sub> : Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + Vermicompost 12 t ha<sup>-1</sup>, T<sub>6</sub> : Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + FYM 13 t ha<sup>-1</sup>, T<sub>7</sub> :

Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + Poultry manure 6 t ha<sup>-1</sup>, T<sub>8</sub> : Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + Vermicompost 6 t ha<sup>-1</sup>, T<sub>9</sub> : Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + FYM 13 t ha<sup>-1</sup> + Poultry manure 6 t ha<sup>-1</sup>, T<sub>10</sub> : Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + FYM 13 t ha<sup>-1</sup> + Vermicompost 6 t ha<sup>-1</sup>, T<sub>11</sub> : Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + Vermicompost 6 t ha<sup>-1</sup> + Poultry manure 6 t ha<sup>-1</sup>, T<sub>12</sub> : Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + FYM 6 t ha<sup>-1</sup> + vermicompost 3 t ha<sup>-1</sup> + Poultry manure 3 t ha<sup>-1</sup>.

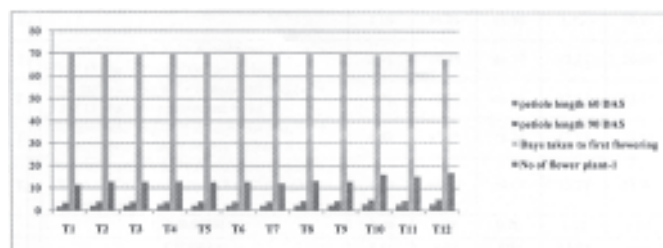
### Results and Discussion

#### Growth parameters

The mean performance of the treatments for growth parameters like plant height, plant spread, numbers of leaves per plant, petiole length, days taken to first flowering and number of flower per plant have been presented in table and figure showing significant differences for growth parameters.

#### Plant height (cm)

Maximum plant height (4.93 cm), (18.73 cm) and (19.67 cm) was recorded in treatment T<sub>12</sub> at 45, 60 and 120 DAS where as minimum plant height was recorded in treatment T<sub>1</sub> respectively (Table 1) and (Fig. 1). The application of biofertilizers and organic manures increased the chlorophyll formation which enhances the photosynthesis resulting and increase in plant growth attributes and increases the metabolism of



**Fig. 2.** Effect of different biofertilizers and organic manures on growth parameters of strawberry.

growing plants which favorable response on plant height.

Plant spread (cm)

Maximum plant spread (13.77 cm), (25.20 cm) and (26.43 cm) was recorded in treatment T<sub>12</sub> at 45, 60 and

120 DAS as minimum plant spread was recorded in treatment T<sub>1</sub> respectively (Table 1) and (Fig. 1). The application of biofertilizers and organic manures result an increase in plant growth attributes and increases the metabolism of growing plants which favorable response on plant spread. Similar results were also recorded by Singh and Singh et al. [1].

**Table 1.** Effect of different biofertilizers and organic manures on growth parameters of strawberry.

Treatments	Plant height	Plant height	Plant height	Plant spread	Plant spread	Plant spread	No. of leaves	No. of leaves
	(cm) 60 DAS	(cm) 90 DAS	(cm) 120 DAS	(cm) 60 DAS	(cm) 90 DAS	(cm) 120 DAS	plant <sup>-1</sup> 90 DAS	plant <sup>-1</sup> 120 DAS
T <sub>1</sub> Control (RDF)	3.48	14.99	15.27	6.00	17.13	20.27	11.20	12.47
T <sub>2</sub> Phosphobacter 5 kg/ha <sup>-1</sup> + Azotobacter 5 kg ha <sup>-1</sup>	4.01	15.95	16.29	8.27	19.30	22.10	13.00	15.33
T <sub>3</sub> Phosphobacter 5 kg/ha <sup>-1</sup> + Azotobacter 5 kg ha <sup>-1</sup> + FYM 25 t ha <sup>-1</sup>	3.87	15.95	16.35	7.00	19.37	21.33	13.53	15.13
T <sub>4</sub> Phosphobacter 5 kg/ha <sup>-1</sup> + Azotobacter 5 kg ha <sup>-1</sup> + Poultry manure 12 t ha <sup>-1</sup>	3.97	15.98	16.29	7.87	20.07	22.37	12.13	14.47
T <sub>5</sub> Phosphobacter 5 kg/ha <sup>-1</sup> + Azotobacter 5 kg ha <sup>-1</sup> + Vermicompost 12 t ha <sup>-1</sup>	4.20	16.22	16.77	8.67	19.90	22.23	12.80	14.93
T <sub>6</sub> Phosphobacter 5 kg/ha <sup>-1</sup> + Azotobacter 5 kg ha <sup>-1</sup> + FYM 13 t ha <sup>-1</sup>	4.05	16.08	16.61	8.17	20.43	22.63	12.07	14.53
T <sub>7</sub> Phosphobacter 5 kg/ha <sup>-1</sup> + Azotobacter 5 kg ha <sup>-1</sup> + Poultry manure 6 t ha <sup>-1</sup>	3.85	16.35	16.91	8.70	20.13	22.07	13.00	15.20
T <sub>8</sub> Phosphobacter 5 kg/ha <sup>-1</sup> + Azotobacter 5 kg ha <sup>-1</sup> + Vermicompost 6 t ha <sup>-1</sup>	4.10	16.49	16.90	8.93	20.27	22.00	12.73	14.80
T <sub>9</sub> Phosphobacter 5 kg/ha <sup>-1</sup> + Azotobacter 5 kg ha <sup>-1</sup> + FYM 13 t ha <sup>-1</sup> +Poultry manure 6 t ha <sup>-1</sup>	4.11	16.45	16.79	12.13	20.57	22.73	12.80	14.87

Table 1. Continued.

Treatments	Plant height (cm)	Plant height (cm)	Plant height (cm)	Plant spread (cm)	Plant spread (cm)	Plant spread (cm)	No. of leaves plant <sup>-1</sup>	No. of leaves plant <sup>-1</sup>
	60 DAS	90 DAS	120 DAS	60 DAS	90 DAS	120 DAS	90 DAS	120 DAS
T <sub>10</sub> Phosphobacter 5 kg ha <sup>-1</sup> + Azotobacter 5 kg ha <sup>-1</sup> + FYM 13 t ha <sup>-1</sup> +Vermicom- post 6 t ha <sup>-1</sup>	4.71	18.63	19.14	13.67	23.77	25.00	14.87	17.60
T <sub>11</sub> Phosphobacter 5 kg/ha <sup>-1</sup> + Azotobacter 5 kg ha <sup>-1</sup> + Vermicompost 6 t ha <sup>-1</sup> + Poultry manure 6 t ha <sup>-1</sup>	4.82	17.91	18.74	12.73	22.57	23.80	13.80	16.07
T <sub>12</sub> Phosphobacter 5 kg/ha <sup>-1</sup> + Azotobacter 5 kg ha <sup>-1</sup> + FYM 6 t ha <sup>-1</sup> +Vermicom- post 3 t ha <sup>-1</sup> +Poultry manure 3 t ha <sup>-1</sup>	4.93	18.73	19.67	13.77	25.20	26.43	15.80	18.13
CD (0.05%)	0.49	0.77	0.76	1.69	1.84	1.27	0.89	0.83
CV (%)	8.81	3.47	3.32	13.03	6.64	3.31	5.08	4.06
SEd (±)	0.24	0.38	0.37	0.83	0.90	0.61	0.44	0.41
F-test	S	S	S	S	S	S	S	S

#### Number of leaves per plant

Maximum number of leaves per plant (7.73), (15.80) and (18.13) were recorded in treatment T<sub>12</sub> at 45, 60 and 120 DAS as minimum number of leaves per plant was recorded in treatment T<sub>1</sub> respectively (Table 1) and (Fig. 1). The application of biofertilizers and organic manures resulting an increase number of leaves and increases the metabolism of growing plants which favorable response on number of leaves per plant.

#### Petiole length (cm)

Maximum petiole length (2.96 cm), and (4.96 cm) was

recorded in treatment T<sub>12</sub> at 60 and 120 DAS as minimum petiole length was recorded in treatment T<sub>1</sub> respectively (Table 2) and (Fig. 2). The application of biofertilizers and organic manures resulting an increase in petiole length and increases the metabolism of growing plants which favorable response on petiole length was also recorded Karlidag et al. [2].

#### Days taken to first flowering

Minimum days taken to first flowering (67.33), was recorded in treatment T<sub>12</sub> where as maximum days taken to first flowering was recorded in treatment T<sub>1</sub> (70.47) respectively (Table 2) and (Fig. 2). The appli-

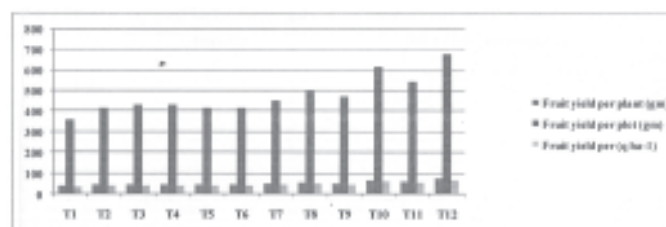


Fig. 3. Effect of different biofertilizers and organic manures on yield and attributes of strawberry.

**Table 2.** Effect of different biofertilizers and organic manures on growth parameters of strawberry.

Treatments	Petiole length (cm) 60 DAS	Petiole length (cm) 90 DAS	Days taken to first flowering	No. of flower plant <sup>-1</sup>
	T <sub>1</sub> Control (RDF)	1.69	3.41	70.47
T <sub>2</sub> Phosphobacter 5 kg/ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup>	2.11	3.84	70.27	12.73
T <sub>3</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + FYM 25 t ha <sup>-1</sup>	2.25	3.77	69.33	12.60
T <sub>4</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + Poultry manure 12 t ha <sup>-1</sup>	2.41	3.80	69.53	12.80
T <sub>5</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + Vermicompost 12 t ha <sup>-1</sup>	2.20	3.93	69.60	12.53
T <sub>6</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + FYM 13 t ha <sup>-1</sup>	2.17	3.87	69.87	12.67
T <sub>7</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + Poultry manure 6 t ha <sup>-1</sup>	2.25	3.85	69.27	12.00
T <sub>8</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + Vermicompost 6 t ha <sup>-1</sup>	2.35	4.11	69.47	13.20
T <sub>9</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + FYM 13 t ha <sup>-1</sup> + Poultry manure 6 t ha <sup>-1</sup>	2.47	4.11	69.80	12.80
T <sub>10</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + FYM 13 t ha <sup>-1</sup> +Vermicompost 6 t ha <sup>-1</sup>	2.89	4.77	69.20	16.07
T <sub>11</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + Vermicompost 6 t ha <sup>-1</sup> + Poultry manure 6 t ha <sup>-1</sup>	2.80	4.32	69.80	15.20
T <sub>12</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + FYM 6 t ha <sup>-1</sup> + Vermicompost 3 t ha <sup>-1</sup> + Poultry manure 3 t ha <sup>-1</sup>	2.96	4.96	67.33	16.80
CD (0.05%)	0.18	0.20	3.61	0.68
CV (%)	5.57	3.67	3.88	3.81
SEd (±)	0.09	0.10	1.76	0.33
F-test	S	S	S	S

cation of biofertilizers and organic manures resulting days taken to first flowering due to established as a component of several enzymes concerned with carbohydrate, nitrogen and phosphorus metabolism in addition to its involvement directly or indirectly in regulating the various physiological processes of plants and increases the metabolism of growing plants which favorable response on days taken to first flowering.

#### Number of flower per plant

Maximum number of flower per plant (16.80) was recorded in treatment T<sub>12</sub> and minimum number of flower per plant was recorded in treatment T<sub>1</sub> (11.33) respectively (Table 2) and (Fig. 2). The application of biofertilizers and organic manures resulting an increase number of flower per plant and increases the

metabolism of growing plants which favorable response on number of flower per plant was also recorded Yusuf et al. [3].

#### Yield and yield attributes

Application of Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + FYM 6 t ha<sup>-1</sup> + Vermicompost 3 t ha<sup>-1</sup> + Poultry manure 3 t ha<sup>-1</sup> has significant influence on Fruit yield per plant (g), Fruit yield per plot (g), Fruit yield (q/ha<sup>-1</sup>) and Cost Benefit Ratio of strawberry over control. Maximum number of Fruit yield per plant (75.94 g), Fruit yield per plot (683.46 g), Fruit yield per q ha<sup>-1</sup> (68.34 q) and Cost Benefit Ratio (2.27:1) were recorded in treatment T<sub>12</sub>, while minimum number of Fruit yield per plant (39.95 g), Fruit yield per plot (359.55 g), Fruit yield per q ha<sup>-1</sup> (35.95 q) and Cost Benefit Ratio (1.39 : 1) were recorded in treat-

**Table 3.** Effect of different biofertilizers and organic manures on yield and attributes of strawberry.

Treatments	Fruit yield per plant (g)	Fruit yield per plot (g)	Fruit yield per (q ha <sup>-1</sup> )	Cost benefit ratio
T <sub>1</sub> Control (RDF)	39.95	359.55	35.95	1.39:1
T <sub>2</sub> Phosphobacter 5 kg/ha + <i>Azotobacter</i> 5 kg ha <sup>-1</sup>	46.68	420.09	42.01	1.45:1
T <sub>3</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + FYM 25 t ha <sup>-1</sup>	44.64	431.76	43.17	1.79:1
T <sub>4</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + Poultry manure 12 t ha <sup>-1</sup>	48.14	433.29	43.32	2.13:1
T <sub>5</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + Vermicompost 12 t ha <sup>-1</sup>	46.37	417.36	41.73	2.05:1
T <sub>6</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + FYM 13 t ha <sup>-1</sup>	46.31	416.76	41.67	1.10:1
T <sub>7</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + Poultry manure 6 t ha <sup>-1</sup>	50.65	455.88	45.58	1.69:1
T <sub>8</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + Vermicompost 6 t ha <sup>-1</sup>	55.86	502.74	50.27	1.72:1
T <sub>9</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + FYM 13 t ha <sup>-1</sup> + Poultry manure 6 t ha <sup>-1</sup>	52.51	472.56	47.25	1.98:1
T <sub>10</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + FYM 13 t ha <sup>-1</sup> +Vermicompost 6 t ha <sup>-1</sup>	68.70	618.30	61.83	1.49:1
T <sub>11</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + Vermicompost 6 t ha <sup>-1</sup> + Poultry manure 6 t ha <sup>-1</sup>	60.60	545.37	54.53	1.67:1
T <sub>12</sub> Phosphobacter 5 kg ha <sup>-1</sup> + <i>Azotobacter</i> 5 kg ha <sup>-1</sup> + FYM 6 t ha <sup>-1</sup> + Vermicompost 3 t ha <sup>-1</sup> + Poultry manure 3 t ha <sup>-1</sup>	75.95	683.46	68.34	2.27:1
CD (0.05%)	3.34	21.95	2.19	
CV (%)	4.70	3.42	3.42	
SEd (±)	1.63	10.71	1.07	
F-test	S	S	S	

ment T<sub>1</sub>. However, treatment T<sub>11</sub> and T<sub>10</sub> was found to be statistically at par to treatment T<sub>12</sub> Fruit yield per plant (g), Fruit yield per plot (g), Fruit yield (q ha<sup>-1</sup>) (Table 3 and Fig. 3) and Cost Benefit Ratio (Table 3) and (Fig. 3) respectively. The probable reason may be due to beneficial effect of biofertilizers and organic manures resulting increase Fruit yield per plant (g), Fruit yield per plot (g), Fruit yield (q ha<sup>-1</sup>) and Cost Benefit Ratio of strawberry. However the essential role of organic manure and biofertilizers has been established as a component of several enzymes concerned with carbohydrate and NPK metabolism, in addition to its involvement directly or indirectly in regulating the various physiological and reproductive processes of plants. Similar findings have been reported by Umar et al. [4] and Sahoo and Singh [5].

## Conclusion

Considering the result presented in investigation. It is concluded that treatment combination of Phosphobacter 5 kg ha<sup>-1</sup> + *Azotobacter* 5 kg ha<sup>-1</sup> + FYM 6 t ha<sup>-1</sup> + Vermicompost 3 t ha<sup>-1</sup> + Poultry manure 3 t ha<sup>-1</sup> was the best treatment for growth, yield and fruit quality of strawberry and 2.27 : 1 maximum benefit cost ratio. The experiment may be repeated to substantiate the findings which are on the basis of one year trial.

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