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Effect of Bio-Fertilizers, Vermicompost and *Trichoderma* on Yield and Economics of Strawberry (*Fragaria* x *annanasa* Duch.) cv. Sweet Charlie

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A B S T R A C T

The present investigation was undertaken at SHUATS, Allahabad during 2013-14 and 2014-15 to study the effect of bio-fertilizers, vermicompost and *Trichoderma* in field strawberry (*Fragaria* x *annanasa* Duch.) cv. Sweet Charlie. The experiment was laid out in randomized block design with twelve treatments and three replications. Bio-fertilizers help in better utilization of added inorganic fertilizers thus reduce its level of application as well as reduce the deleterious effect of harsh chemical residues that the inorganic fertilizers leave in the soil. Vermicompost when applied to soil improve the soil physical properties, soil pH, water holding capacity and add micro and macro nutrients to the soil thus increase the nutrient availability and its ultimate absorption by plant. *Trichoderma spp*. is very effective in controlling the soil born diseases in fruit crops. The highest yield per plantwas recorded in the combination of T11 (5 kg ha^{-1} *Trichoderma* + 2.5 ton ha^{-1} Vermicompost + 7 kg ha^{-1} *Azotobacter* + 6 kg ha^{-1} PSB + 10 kg ha^{-1} VAM). The maximum cost benefit ratio (1:3.97) was found in T11(5 kg ha^{-1} *Trichoderma* + 2.5 ton ha^{-1} Vermicompost + 7 kg ha^{-1} *Azotobacter* + 6 kg ha^{-1} PSB + 10 kg ha^{-1} VAM).

Introduction

Strawberry (*Fragaria* × *ananassa* Duch.) belongs to the family Rosaceae. The cultivated strawberry is octaploid with basic chromosome number seven (Sharma, 2002). The cultivated strawberry (*Fragaria* × *ananassa* Duchesne) has resulted from cross between two wild strawberry *Fragaria verginiana* and *Fragaria chiloensis.* Strawberry is propagated through one year old runners. The use of bio-fertilizers like Arbuscular Mycorrhizal Fungi (Sabarad *et al.*, 2004), Phosphorous Solubilizing Bacteria (Mia *et al.*, 2005), *Trichoderma harzianum* (Balakrishna *et al.*, 2005) in combination with organic manures like Vermicompost (Sabarad *et al.*, 2004) results in encouraging yield, particularly in reclaimed soils through overcoming drought, salt and some pathogens stresses as well as decreasing the applied fertilizers and increasing the availability of most macro and microelements. Organic farming improves soil quality in terms of various parameters, viz. physical, chemical, biological properties, indicating an enhanced soil health and sustainability of crop production (Ramesh *et al.*, 2010). Nitrogen fixing bacteria and phosphorus solubulizers are main bio-fertilizers for horticultural crops. These micro-organisms are either free living in soil or symbiotic with plants and contribute directly or indirectly towards nitrogen and phosphorus nutrition of plants. They also produce hormones, vitamins and other growth factors required for the growth and development of plants. Atmospheric nitrogen is fixed by both micro-organisms which are symbiotic and non-symbiotic in nature.

Materials and Methods

The present investigation entitled "Response of bio-fertilizers, vermicompost and *Trichoderma* on growth, flowering, yield, quality and runners production of strawberry (*Fragaria* × *annanasa* Duch.) *cv.* Sweet charlie" was carried out under Allahabad agro-climatic conditions at the experimental field of Department of Horticulture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad U.P during 2013-14 and 2014-15. The experiment was laid out in randomized block design with twelve treatments replicated thrice. Number of plants per plot was 9. The 12 treatment were as follows

Results and Discussion

The data on fruits yield plant^{-1} of strawberry cv. Sweet Charlie as influenced by INM is given in the table 1 and graphically presented in fig 1.It is evidently clear from the table that there are significant differences among the treatments in first year, second year and their pooled data. Maximum fruit yield plant^{-1} (111.08 g) was recorded in T_{11}5 kg ha^{-1} *Trichoderma* + 2.5 t ha^{-1} Vermicompost + 7 kg ha^{-1}*Azotobacter* + 6 kg ha^{-1}PSB + 10 kg ha^{-1} VAM followed by (104.62 g) T_{10} (5 kg ha^{-1} *Trichoderma* + 2.5 t ha^{-1} Vermicompost + 6 kg ha^{-1}PSB + 10 kg ha^{-1}VAM), respectively. The minimum fruit yield plant^{-1} (53.00 g) was observed in T_0 (RDF through chemical fertilizers).

Increase in fruit yield might be contributed towards increase in the number of leaves causing enhanced photosynthetic efficiency resulting in production of higher carbohydrates in plants.

Treatment Details

T_0	Control
T_1	5 kg ha^{-1}*Trichoderma* + 2.5 t ha^{-1} Vermicompost
T_2	5 kg ha^{-1}*Trichoderma* + 7 kg ha^{-1}*Azotobacter*
T_3	5 kg ha^{-1}*Trichoderma* + 6 kg ha^{-1}PSB
T_4	5 kg ha^{-1}*Trichoderma* + 10 kg ha^{-1} VAM
T_5	5 kg ha^{-1}*Trichoderma* + 2.5 t ha^{-1} Vermicompost + 7 kg ha^{-1}*Azotobacter*
T_6	5 kg ha^{-1}*Trichoderma* + 2.5 t ha^{-1} Vermicompost + 6 kg ha^{-1}PSB
T_7	5 kg ha^{-1}*Trichoderma* + 2.5 t ha^{-1} Vermicompost + 10 kg ha^{-1}VAM
T_8	5 kg ha^{-1}*Trichoderma* + 2.5 t ha^{-1} Vermicompost + 7 kg ha^{-1}*Azotobacter* + 6 kg ha^{-1}PSB
T_9	5 kg ha^{-1}*Trichoderma* + 2.5 t ha^{-1} Vermicompost + 7 kg ha^{-1}*Azotobacter* + 10 kg ha^{-1}VAM
T_{10}	5 kg ha^{-1}*Trichoderma* + 2.5 t ha^{-1} Vermicompost + 6 kg ha^{-1}PSB + 10 kg ha^{-1}VAM
T_{11}	5 kg ha^{-1}*Trichoderma* + 2.5 t ha^{-1} Vermicompost + 7 kg ha^{-1}*Azotobacter* + 6 kg ha^{-1}PSB + 10 kg ha^{-1}VAM

The data on yield were subjected to Fisher's method of analysis of variance (ANOVA) as outlined by Panse and Sukhatme (1985).

Table.1 Effect of bio-fertilizers, vermicompost and *Trichoderma* on yield of Strawberry cv. Sweet Charlie

Treatment	2013-14	2014-15	Pooled
T_0	51.50	54.50	53.00
T_1	64.11	68.25	66.18
T_2	67.71	75.17	71.44
T_3	69.43	80.19	74.81
T_4	72.15	70.85	71.50
T_5	89.13	90.44	89.79
T_6	93.47	94.97	94.22
T_7	101.60	105.82	103.71
T_8	100.78	102.12	101.45
T_9	101.96	104.67	103.32
T_{10}	102.84	106.40	104.62
T_{11}	109.54	112.62	111.08
SE.m ($\pm$)	**2.77**	**2.58**	**2.68**
CD t 0.5%	**8.11**	**7.58**	**7.62**

Table.2 Benefit: Cost ratio of different treatments in strawberry

Treatments	Cost of cultivation (Rs. ha^{-1})	Yield (q ha^{-1})	Sale rate (Rs. q^{-1})	Gross Return (Rs. ha^{-1})	Net Return (Rs. ha^{-1})	Benefit : Cost ratio
T_0	300,629	47.70	15000	712500	411871	1.37
T_1	307,401	59.56	15000	893400	585999	1.91
T_2	303,401	64.29	15000	964350	660949	2.17
T_3	353,401	67.32	15000	1009800	656399	1.86
T_4	313,401	64.35	15000	965250	651849	2.08
T_5	328,401	80.81	15000	1212150	883749	2.69
T_6	305,401	84.79	15000	1271850	966449	3.16
T_7	318,401	93.34	15000	1400100	1081699	3.39
T_8	308,401	91.30	15000	1369500	1061099	3.44
T_9	330,401	92.98	15000	1394700	1064299	3.22
T_{10}	310,401	94.62	15000	1419300	1108899	3.57
T_{11}	307,801	99.97	15000	1499550	1191749	3.87

Also due to increase in number of flowers, which resulted in higher fruit yield because of capability of bio-fertilizers and vermicompost in producing plant growth hormones, enzymes, antifungal as well as antibacterial compounds, which enhanced the fruit yield over rest of the treatments. Similar findings also reported by Singh *et al.,* (2015), Yadav *et al.,* (2010) and Tripathi *et al.,* (2010) and Singh and Singh (2009) in strawberry.

The economics of different treatment viz. cost of cultivation of strawberry (Rs ha^{-1}), net return (Rs ha^{-1}) and benefit cost ration has been worked out and presented in table 2. The maximum cost benefit ratio was found 3.87 in T_{11} (5 kg ha^{-1}*Trichoderma* + 2.5 t ha^{-1} Vermicompost + 7 kg ha^{-1}*Azotobacter* + 6 kg ha^{-1}PSB + 10 kg ha^{-1}VAM), followed by 3.57 with T_{10} (5 kg ha^{-1}*Trichoderma* + 2.5 t ha^{-1} Vermicompost + 6 kg ha^{-1}PSB + 10 kg ha^{-1}VAM) while minimum was recorded 1.32 with T_0 (Recommended dose of nutrients through chemical fertilizers). Various workers also presented the higher cost benefit ratio with the application of vermicompost and bio-fertilizers and *Trichoderma* viz. Niyati *et al.*, (2017), Yadav *et al.,* (2010) and Verma and Rao, (2012) in strawberry.

On the basis of present investigation 2013-14 and 2014-15, it is concluded that the treatment T_{11} (5 kg ha^{-1}*Trichoderma* + 2.5 t ha^{-1} Vermicompost + 7 kg ha^{-1}*Azotobacter* + 6 kg ha^{-1}PSB + 10 kg ha^{-1}VAM) was found best in terms of yield (112.63 g plant-1) Also, maximum benefit: cost ratio (1: 3.87) was recorded with T_{11} (5 kg ha^{-1}*Trichoderma* + 2.5 t ha^{-1} Vermicompost + 7 kg ha^{-1} *Azotobacter* + 6 kg ha^{-1}PSB + 10 kg ha^{-1} VAM).

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