Effect of Trichocapsules and different organic manures on yield and quality of Strawberry (*Fragaria* × *ananassa* Duch.) cv. Winter dawn

ABSTRACT

Aim and Study: The garden strawberry is a widely grown hybrid species of the genus *Fragaria*, collectively known as the strawberries, which are cultivated worldwide for their fruit. The fruit is widely appreciated for its characteristic aroma, bright red colour, juicy texture, and sweetness. It is consumed in large quantities, either fresh or in such prepared foods as jam, juice, pies, ice cream, milkshakes, and chocolates. The present investigation was done to understand the plant growth, fruit yield and quality of strawberry using different combinations of treatment using organic, inorganics and bio-fertilizers.

Methodology: The experiment was carried out at Horticultural Research Farm (HRF), Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences (SHUATS), Prayagraj during the *Winter* season of 2022 with a view to identify the effects of different combinations of organics, inorganics and biofertilizers nutrition and its role in growth, yield and quality of fruit of strawberry Cultivar Winter drawn. The experiment was laid in Randomized block design with 10 treatments and 3 replications with different combination in Trichocapsules (Trichodex) and application of organic nutrition.

Results and Conclusion: The study showed positive responses of strawberry Cv. Winter Dawn to application of Trichocapsules in enhancing the vegetative growth, yield, quality of fruits and showed a better resistance to disease incidence. Based on growth, yield, quality parameters Treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) was found best in this research experiment.

Keywords: *Farmyard Manure, Vermicompost, Trichocapsules, Strawberry.*

INTRODUCTION

Strawberry botanically known as *Fragaria* × *ananassa* (Duch) is a widely grown hybrid species of the genus *Fragaria* (Manganaris *et al.*, 2014), collectively known as the strawberries, which are cultivated worldwide for their fruit. The fruit is widely appreciated for its characteristic aroma, bright red colour, juicy texture, and sweetness. It is consumed in large quantities, either fresh or in such prepared foods as jam, juice, pies, ice cream, milkshakes, and chocolates. Artificial strawberry flavourings and aromas are also widely used in products such as candy, soap, lip gloss, perfume, and many others. The garden strawberry was first bred in Brittany, France, in the 1750s via a cross of Fragaria virginiana from eastern North America and *Fragaria chiloensis*, which was brought from Chile (Anonymous, 2010). Cultivars of *Fragaria* × *ananassa* have replaced, in commercial production, the woodland strawberry (*Fragaria vesca*), which was the first strawberry species cultivated in the early 17th century (Martin, 2008). Greenhouses produce a small number of strawberries during the off season. The strawberry, regardless of its appearance, is classified as a dry, not a fleshy fruit. Botanically, it is not a berry; it is an aggregate-accessory fruit, the latter term meaning the fleshy part is derived not from the plant's ovaries but from the receptacle that holds the ovaries (Esau, 1977). Numerous dry achenes are attached to the outside of the fruit-flesh; they appear to be seeds but each is an ovary of a flower, with a seed

inside Strawberry is an octoploid self-pollinated plant species with chromosome number 2n=8x=56 (Folta and Barbey, 2019). It is grown in temperate countries and biennial plant. The strawberry and its juice are freely consumed for its great taste, nutritional benefit, and flavor content. At present its productivity is 8.9 t/ha fruit per year in world (Anonymous, 2021). As per National Institute of Nutrition (NIN, 2008), nutritional composition of beetroot constituted Moisture (91 %), Protein (1.7 g), Crude fibre (2.9 g), Carbohydrates (7.68 g), Calories (33 Kcal), Calcium (16 mg/100g), Phosphorus (24 mg/100g) and Iron (0.41 mg), Vitamin B_3 (0.386 mg/100g), Vitamin C (58.8 mg/100g) and Magnesium (13 mg/100g). Strawberries contain a modest amount of essential unsaturated fatty acids in the achene (seed) oil. Pelargonidin-3-glucoside is the major anthocyanin in strawberries and cyanidin-3-glucoside is found in smaller proportions. Although glucose seems to be the most common substituting sugar in strawberry anthocyanins, rutinose, arabinose, and rhamnose conjugates have been found in some strawberry cultivars (Giampieri *et al.,* 2012). The area under production of strawberry in India is estimated to be around 1.68 thousand hectares and production is 13.53 million metric tons. Haryana ranks first in strawberry production followed Maharashtra and Jammu Kashmir. (*Source: NHB*, Ministry of Agriculture & Farmers Welfare, Government of India, 2020-21). Rahman *et al*. (2020) investigated the effects of different types of organic manure on the growth and yield of strawberry plants. They found that the application of cow manure, vermicompost, and poultry manure led to increased plant height, leaf area, and yield compared to control treatments. Similarly, another study by Islam *et al*. (2019) found that the application of vermicompost led to increased plant height, leaf area, and yield of strawberry plants. Strawberries are a heart-healthy fruit that can reduce inflammation, improve digestive health, and lower blood pressure. Unfortunately, their availability in local markets is limited due to low production. Organic agriculture can help mitigate global warming by sequestering carbon in soil. Trichocapsules, an encapsulated form of Trichoderma harzianum MTCC 5179, is a preferable alternative to chemical fertilizers as it contains organic materials that do not harm soil fertility or release harmful gases into the atmosphere. Trichocapsules can improve growth, root production, and nutrient mobilization while protecting crops against soil-borne pathogens. Additionally, Trichocapsules are easy to handle, transport, and store, making them an ecologically safe and sustainable choice.

MATERIALAND METHODS

Area of study: The present experiment was done to understand the effect of Trichocapsules (Trichodex) and different organic manures on yield and quality of strawberry variety Winter dawn.

Experimental Site and Design: The experiment was carried out at Horticultural Research Farm (HRF), Department of Horticulture, Naini Agricultural Institute SHUATS, Prayagraj, U.P., during the *Rabi* season of 2022. The experiment was laid out in Randomised Block Design with three replications. The different combination doses of organic manures and Trichocapsules (Trichodex) mentioned in table 1 and replicated thrice.

Observations were recorded at different stages of growth periods for characters like plant height, number of leaves per plant, plant spread, fruit length, fruit weight etc. The data were statistically analysed by the method suggested by Fisher and Yates, 1963**.**

Table 1 Details of different doses of Trichocapsules and organic manure.

Notation	Treatment Details
T_1	Control
T_2	RDF [Recommended dose of fertilizer i.e., 80:60:60 NPK]
T_3	RDF + Trichocapsules@400ppm
T_4	RDF + Trichocapsules@200ppm
T_5	Vermicompost (2.8t/ha)
T_6	Vermicompost + Trichocapsules@400ppm
T_7	Vermicompost + Trichocapsules@200ppm
T_8	FYM (15t/ha)
T_9	FYM + Trichocapsules@400ppm
T_{10}	FYM + Trichocapsules@200ppm

RESULTS AND DISCUSSION

Data from the table 2 and 3 depicts the growth parameters observed for strawberry.

Total Number of leaves per plant

Maximum No of Leaves [8.92 (30DAP), 16.17 (60 DAP), 19.50 (90 DAP), 26.33 (120 DAP)] was recorded in treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and Minimum was recorded in Treatment T_1 (Control) [2.83 (30 DAP), 4.50 (60 DAP), 8.92 (90 DAP), 10.08 (120 DAP)]. Organic manures provide a slow, steady release of nutrients to plants, improving soil structure, increasing water-holding capacity, nutrient retention, and aeration. This enhances the development of roots, leading to more leaves in the strawberry plant. Organic manures also contain beneficial microorganisms that break down organic matter in the soil, releasing nutrients that can be easily absorbed by plants, improving soil health, plant immunity, and promoting more vigorous growth. Similar results have also been reported by Singh *et al.,* (2008); Uddin *et al.,* (2014); Pokhrel *et al.,* (2018); Soni *et al.,* (2018); Sahana *et al*., (2020); Singh and Sadawarti (2021); Yashasvi *et al.,* (2021) and Singh *et al.,* (2022) in Strawberry.

Plant height and Plant spread (cm)

Maximum plant Height [8.53 (30 DAP), 11.30 (60 DAP), 13.93 (90 DAP), 18.13 (120 DAP)] was recorded in treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and Minimum was recorded in Treatment T_1 (Control) [4.58 (30 DAP), 5.38 (60 DAP), 5.50(90 DAP), 6.93 (120 DAP)].

Maximum Plant Spread [E-W= 26.23 cm] [N-S=26.28 cm] (120 DAP)] was recorded in treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and Minimum was recorded in Treatment T1 (Control) E-W= 18.45 cm] [N-S= 18.39 cm] (120 DAP)]. Effect of treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) recorded the maximum plant spread [E-W= 12.73] [N-S=13.38] (30DAP), [E-W= 17.17 cm] [N-S=17.39 cm] (60 DAP) [E-W= 25.53 cm] [N-S=22.19 cm] (90 DAP), [E-W= 26.23 cm] [N-S=26.28 cm] (120 DAP)] over all other treatments where-as Treatment T_1 (Control) [E-W= 6.42] [N-S= 6.28](30 DAP), [E-W= 9.05 cm] [N-S= 8.98 cm] (60 DAP), [E-W= 14.10 cm] [N-S= 14.02 cm](90 DAP), E-W= 18.55 cm] [N-S= 18.39 cm] (120 DAP)] was found having significantly minimum plant spread. Organic manures provide a slow, steady release of nutrients to plants, improving soil structure, increasing water-holding capacity, nutrient retention, and aeration. This enhances the development of roots, leading to enhancement in plant height and spread in the strawberry plant. Organic manures also contain beneficial microorganisms that break down organic matter in the soil, releasing nutrients that can be easily absorbed by plants, improving soil health, plant immunity, and promoting more vigorous growth. Similar results have also been reported by Singh *et al.,* (2008); Uddin *et al.,* (2014); Pokhrel *et al.,* (2018); Soni *et al.,* (2018); Sahana *et al.,* (2020); Singh and Sadawarti (2021); Yashasvi *et al.,* (2021) and Singh *et al.,* (2022) in Strawberry.

Data from the table 4 depicts the phenological characters observed for strawberry.

Days to flower bud initiation, Days to first flowering, Days to first fruiting and Days from Flowering to harvest duration

Minimum number of days for flower bud initiation to flowering [16.50 days] was recorded in treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and Maximum was recorded in Treatment T_1 (Control) [22.17 days]. Minimum number of days for first flower appearance [48.0 days] was recorded in Treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and longest days was recorded in Treatment T_1 (Control) [62.17 days].

Minimum number of days for first fruit appearance [68.08 days] was recorded in Treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and longest days was recorded in Treatment T_1 (Control) [83.67 days]. Minimum number of days for first flowering to harvest duration [29.25 days] was recorded in Treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and longest days was recorded in Treatment T_1 (Control) [35.50 days]. Earliness is essential requirement for crop maturity. Organic manures and bio capsules can promote early flowering in plants by providing essential nutrients, natural plant growth hormones, beneficial microorganisms, and stress mitigation. Nutrient availability of essential nutrients such as nitrogen, phosphorus, and potassium stimulate early flowering. Hormones like auxins and cytokinin in organic manures and bio capsules promote the production of flower buds. Beneficial microorganisms enhance nutrient uptake and hormone synthesis in plants, leading to early flowering. Finally, stress mitigation helps to cope with unfavourable environmental conditions, promoting early flowering. Similar findings were reported by Singh *et al.,* (2008); Uddin *et al.,* (2014); Beer *et al.,* (2017); Pradeep and Sarvanan (2018); Soni *et al.*, (2018); Sahana *et al*., (2020); Singh and Sadawarti (2021); Yashasvi *et al.,* (2021) and Singh *et al.,* (2022) in Strawberry.

Number of flowers per plant and number of fruits per plant

Maximum No of flowers/plant [24.08] was recorded in Treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and Minimum was recorded in Treatment T_1 (Control) [12.58]. Maximum No of fruits / plant [22.67] was recorded in Treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and Minimum was recorded in Treatment T_1 (Control) [12.08]. Organic manures and bio capsules promote an increased number of fruits due to several reasons. Firstly, they provide a steady release of essential nutrients like nitrogen, phosphorus, and potassium that are essential for fruit development and maturation. Secondly, they contain natural plant growth hormones such as auxins and cytokinin, which can stimulate the production of flower buds and increase the number of fruits per plant. Thirdly, they can improve the health and activity of pollinators like bees and butterflies, which can increase the rate of fruit set. Finally, they help plants to cope with environmental stresses like drought or disease, which can lead to more consistent fruit production and higher yields. Results were in accordance with the findings of Iqbal *et al.,* (2009); Anil *et al.,* (2015); Beer *et al.,* (2017); Pradeep and Sarvanan (2018); Kumar *et al.,* (2020); Laugale *et al.,* (2020); Sahana *et al*., (2020); Singh and Sadawarti (2021); Yashasvi *et al.,* (2021) and Singh *et al.,* (2022) in Strawberry.

Data from the table 4 depicts the yield characters observed for strawberry.

Fruit length, Fruit diameter, Fruit weight and Total production per plant

Maximum Fruit Length [5.76 cm] was recorded in Treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and Minimum was recorded in Treatment T_1 (Control) [3.34 cm]. Maximum Fruit Diameter [3.96 cm] was recorded in Treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and Minimum was recorded in Treatment) T_1 (Control) [2.68 cm]. Maximum Fruit Weight [27.67g] was recorded in Treatment T_6 (Vermicompost+ Trichocapsules @ 400ppm) and Minimum was recorded in Treatment T_1 (Control) [11.75 g]. Maximum No of Production/plant [361.48g] was recorded in Treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and Minimum was recorded in Treatment T_1 (Control) [185.18g].

Bio capsules and manures provide essential nutrients, plant growth hormones, improve water retention and enhance microbial activity, resulting in larger and healthier fruits. They promote cell division and elongation in fruits by supplying natural plant hormones. Additionally, they improve the soil structure and enhance the ability of plants to absorb water and nutrients, leading to an increase in fruit size and thus yield. Results were in accordance with the findings of Iqbal *et al.,* (2009); Anil *et al.,* (2015); Beer *et al.,* (2017); Pradeep and Sarvanan (2018); Kumar *et al.,* (2020); Laugale *et al.,* (2020); Sahana *et al*., (2020); Singh and Sadawarti (2021); Yashasvi *et al.,* (2021) and Singh *et al.,* (2022) in Strawberry.

TSS and Acidity

Maximum TSS [12.00 ^{0}Brix] was recorded in Treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and Minimum was recorded in Treatment T_1 (Control) [8.20 ^{0}Brix]. Lowest Acidity % [0.58] was recorded in Treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) and Highest was recorded in Treatment T_1 (Control) [0.96]. Results were in accordance with the findings of Iqbal *et al.,* (2009); Anil *et al.,* (2015); Beer *et al.,* (2017); Pradeep and Sarvanan (2018); Kumar *et al.,* (2020); Laugale *et al.,* (2020); Sahana *et al*., (2020); Negi *et al.,* (2021); Singh and Sadawarti (2021); Yashasvi *et al.,* (2021) and Singh *et al.,* (2022) in Strawberry. Data from the table 4 depicts the quality characters observed for strawberry.

Summary and Conclusion

The present study on effect of Trichocapsules and different organic manures on yield and quality of strawberry (*Fragaria* × *ananassa* Duch.) Winter Dawn, suggested that cultivation of strawberry with application of Vermicompost + Trichocapsules @ 400ppm was found more effective to increase growth, yield and quality. The study showed positive responses of strawberry Cv. Winter Dawn to application of Trichocapsules in enhancing the vegetative growth, yield, quality of fruits and showed a better resistance to disease incidence. Based on growth, yield, quality parameters Treatment T_6 (Vermicompost + Trichocapsules @ 400ppm) was found best in this research experiment.

Table 2 Performance of different treatment combinations of Trichocapsules and organic manure on number of leaves and plant height of strawberry.

Treatment symbol	Treatment Details	No of leaves (30DAP)	No of leaves (60DAP)	No of leaves (90 DAP)	No of leaves (120DAP)	Plant height (30DAP) (cm)	Plant height (60DAP) (cm)	Plant height (90DAP) (cm)	Plant height (120DAP) (cm)
T_1	Control	2.83	4.5	8.92	10.08	4.58	5.38	5.5	6.93
T_2	RDF	6.17	10	11.42	18	5.07	7.93	11.54	14.25
T_3	RDF + Trichocapsules@400ppm	5.75	9.58	13.42	19.17	5.44	8.05	12.28	13.6
T_4	RDF + Trichocapsules@200ppm	6.58	10.25	14.42	23.33	6.58	8.48	12	15
T_5	Vermicompost (2.8t/ha)	6.33	11	12.67	20.67	5.67	7.48	11.27	13.67
T_6	Vermicompost+Trichocapsules@400ppm	8.92	16.17	19.5	26.33	8.53	11.3	13.93	18.13
T_7	Vermicompost+Trichocapsules@200ppm	7.67	14.92	16.5	24.92	7.68	10.72	12.95	17.23
T_8	FYM (15t/ha)	6.33	11.83	15.25	20.42	7.08	8.79	12.18	15.55
T_9	FYM + Trichocapsules@400ppm	7.5	12.58	13.33	23.58	6.32	9.88	11.45	16.82
T_{10}	FYM + Trichocapsules@200ppm	5.83	10.58	15.17	20	6.79	9.44	12.14	16.08
F-Test		**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S.E.(m) (±)		**0.32**	**0.64**	**1.22**	**0.68**	**0.29**	**0.25**	**0.5**	**0.59**
C.D. (5%)		**0.94**	**1.89**	**3.62**	**2.02**	**0.86**	**0.75**	**1.48**	**1.75**
C.V.		**8.73**	**10.09**	**15.37**	**5.81**	**7.83**	**5.02**	**7.51**	**6.94**

Abbreviations used: **RDF**: Recommended doses of Fertilizers, **FYM**: Farmyard Manure

Table 3 Performance of different treatment combinations of Trichocapsules and organic manure on plant spread of strawberry.

Treatment symbol	Treatment Combination	Plant spread (30 DAP) (cm)		Plant spread (60 DAP) (cm)		Plant spread (90 DAP) (cm)		Plant spread (120 DAP) (cm)	
		E-W	N-S	E-W	N-S	E-W	N-S	E-W	N-S
T_1	Control	6.42	6.28	9.05	8.98	14.1	14.02	18.45	18.39
T_2	RDF	7.63	7.48	9.78	10.38	15.38	15.7	19.68	19.76
T_3	RDF + Trichocapsules@400ppm	8.24	7.93	10.62	11.55	16.88	16.7	20.43	20.47
T_4	RDF + Trichocapsules@200ppm	10.53	10.67	12.68	12.38	18	17.78	21.83	21.6
T_5	Vermicompost (2.8t/ha)	8.85	7.99	10.82	10.34	16.74	16.58	18.88	18.65
T_6	Vermicompost+Trichocapsules@400ppm	12.73	13.83	17.17	17.39	22.53	22.19	26.23	26.28
T_7	Vermicompost+Trichocapsules@200ppm	12.55	13.07	16.75	16.53	20.96	21.33	23.3	25.18
T_8	FYM (15t/ha)	11.42	10.74	15.69	16.27	19.25	18.21	23.69	20.87
T_9	FYM + Trichocapsules@400ppm	11.68	10.62	15.58	15.52	19.02	18.85	21.85	21.74
T_{10}	FYM + Trichocapsules@200ppm	12	11.95	15.26	15.6	16.67	17.93	19.46	19.07
F-Test		**S**	**S**	**S**	**S**	**S**	**NS**	**S**	**S**
S.E.(m) (±)		**0.36**	**0.13**	**0.38**	**0.19**	**0.66**	**-**	**0.21**	**0.19**
C.D. (5%)		**1.08**	**0.38**	**1.13**	**0.58**	**1.97**	**-**	**0.61**	**0.55**
C.V.		**2.07**	**2.19**	**4.94**	**1.32**	**6.41**	**-**	**1.41**	**1.5**

Abbreviations used: **RDF**: Recommended doses of Fertilizers, **FYM**: Farmyard Manure

Table 4 Performance of different treatment combinations of Trichocapsules and organic manure on yield parameters of strawberry.

Treatment symbol	Treatment Details	Days to first flower initiation	Days to first fruiting	Days to first harvest duration	No of flowers/plant	No of fruits/plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Total fruit production/plant (g/plant)	TSS [°Brix]	Acidity (%)
T_1	Control	62.17	83.67	35.5	12.58	12.08	3.34	2.68	11.75	141.94	8.2	0.96
T_2	RDF	60.58	81.08	34	15.58	15.08	3.68	3.23	18.25	275.21	8.47	0.94
T_3	RDF + Trichocapsules@400ppm	60.17	80.75	32.58	17.08	16.67	3.76	3.5	22.29	371.57	8.67	0.91
T_4	RDF + Trichocapsules@200ppm	54.67	76	31.17	19.67	19.17	4.23	3.61	26.11	500.53	9.97	0.71
T_5	Vermicompost (2.8t/ha)	59	77.83	33.75	17.17	16.75	3.55	3.62	23.28	389.94	9.4	0.82
T_6	Vermicompost+Trichocapsules@400ppm	48	68.08	29.25	24.08	22.67	5.76	3.96	27.67	627.28	12	0.58
T_7	Vermicompost+Trichocapsules@200ppm	49.33	69.75	29.67	21.67	20	5.4	3.77	25.97	519.4	11.2	0.61
T_8	FYM (15t/ha)	53.83	74.5	30.58	19.58	18.08	4.71	3.61	27.12	490.33	10.4	0.63
T_9	FYM + Trichocapsules@400ppm	56.67	77.75	29.83	20	17.5	5.03	3.5	29.08	508.9	9.47	0.82
T_{10}	FYM + Trichocapsules@200ppm	53.33	75.5	29.67	17.08	16.5	4.54	3.44	30.23	498.8	8.7	0.73
F-Test		**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**	**S**
S.E.(m) (±)		**0.21**	**0.72**	**0.7**	**0.55**	**0.4**	**0.1**	**0.09**	**0.39**	**9.49**	**0.27**	**0.01**
C.D. (5%)		**0.64**	**2.14**	**2.07**	**1.65**	**1.19**	**0.29**	**0.26**	**1.17**	**28.19**	**0.81**	**0.02**
C.V.		**0.67**	**1.63**	**3.82**	**5.2**	**3.97**	**3.88**	**4.36**	**2.85**	**5.92**	**4.91**	**1.53**

Abbreviations used: **RDF**: Recommended doses of Fertilizers, **FYM**: Farmyard Manure

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