Effect of organic manures and biocapsules on growth, yield and quality of strawberry (*Fragaria annanasa–Winter dawn*)

ABSTRACT:-

The experiment was carried out at Research Field of Horticulture Research Farm, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) India, during October 2022-2023 to investigate the "**Effect of organic manures and bio capsules on growth, yield and quality of strawberry *(Fragaria annanasa–Winter dawn)***" thirteen treatments with their combinations, replicated thrice in a Randomized Block Design. In strawberry use the application of bio-capsules and organic manures hasten early flowering along with the expanded duration of blossoming, harvesting by increasing the growth, yield and quality of strawberry. The integrated nutrient management maximized plant height (cm), number of leaves per plant, plant spread (cm), number of flowers per plant, number of fruit per plant, fruit weight (g), fruit length (cm), fruit diameter (cm), fruit yield/ha, total soluble solids, ascorbic acid (mg/100g). The result obtained in the present investigation, thus, indicates the possibility of successful use of application of organic sources of like FYM, Vermicompost, poultry manures, goat manures along with bio capsules and it might prove to be a better option for enhancing growth, yield and quality of strawberry. It is concluded that the treatment T11 (Poultry manure (20 t/ha.) + Bio capsule (150% of optimum) was found best in terms of vegetative growth and yield characters of strawberry. The economics of the treatment T11 was found best in terms of B:C ratio 3.50 of strawberry. So application of this organic manures and bio capsules combination can be recommended to growers after few more conjunctive trials.

Keywords – Bio capsules, Organic manure's, vermicompost, Strawberry

1.INTRODUCTION:-

The modern cultivation strawberry *(Fragaria x ananassa Duch)* is a hybrid between two largely dioecious octaploid species, Fragaria chiloensis and Fragaria verginiana. Fragaria species belongs to the family Rosaceae, with basic chromosome number of x=7. However the cultivated

strawberry , (Fragaria x ananassa ,is an octaploid having chromosome number of 2n=56. In addition to Fragaria x ananassa the genus fragaria includes at least 17 other species including diploids, tetraploids, octaploids and a hexaploids. Initially strawberry was growing in temperate zone of the country. However, it can also be cultivated under subtropical climate, even at higher altitudes of tropical climate and it is propagated through one year old runners. Therefore, it is imperative that chemical fertilizers in combination with organic manures are utilized properly and not only for the source of nutrient but also for increasing nutrient use efficiency without adversely distributing the soil health.

Globalization of agriculture is increasingly calling for improved efficiency andcompetitiveness of the existing production systems. It is a universal truth that no diet isnutritious or balanced without the fruits and vegetables. Fruits and vegetables form themostnutritiousmenuofhumanandtoneuphisenergyandvigour.Theyareappreciated for their tempting succulence, pleasing flavor and high nutritive values.Beingrichsourceofvariousessentialsubstancessuchasvitamins,minerals,proteinand carbohydrates; fruits and vegetables are necessary for human health. Due to whichthey are classified as protective food that supplements the human diet in various ways.ThisfactismoreimportantforacountrylikeIndia,wherethemajorityofthepopulation is vegetarian. For all these reasons, the use of fruits and vegetables in thedaily diet is essential **(Kunte and Yawalkar, 1980)**. Fruits are not only good source offood;they arealsoservingasmedicineandtreatailments.Withdiversesoilandclimate, India comprising various agro-ecological regions provides ample possibility togrow avarietyof fruit crops.

Strawberry (*Fragaria ananassa*Duch.) is a widely grown hybrid species ofthe genus *Fragaria* belonging to the family Rosaceae. Strawberry occupies a uniqueplace amongest cultivated berry fruits. It is one of the most popular soft fruit and iscultivated in plains as well as in the hills up to an elevation of 3000m MSL. Among thefruits,strawberrygivesthequickestreturnsintheshortestpossibletime.Thestrawberryisalow-growing,herbaceousplantwithprostrategrowthhabit,whichbehaves as an annual in sub-tropical region and perennial in temperate region havingfibrousrootsystemandacrownfromwhicharisebasalleaves.Theleavesarecompound with three leaflets, saw tooth-edged and hairy. The flowers- generally white,rarely reddish, are borne

in small clusters on slender stalks arising from the axils of theleaves. Leaves and flowers are spring from almost the ground both with the similarlength. Flowering stems with no leaves holding flower have five petals, five sepals andnumerous stamens. At the end of each hairy leaf stalk, the leaves divided in threetoothedovalleaflets.Asaplantages,therootsystembecomeswoody,andthe“mother”crownsend soutrunnersthattouchthegroundandroot,thusenlargingthe plant.

The strawberry (*Fragaria* × *ananassa*Duch.), an aggregate fruit, hasattained the status of being one of the most important soft fruit of the world (**Umar *etal.*, 2008**). The Romans were believed to cultivate strawberries before the Christian era.However, the cultivated strawberry (*Fragaria x ananassa*) is an octaploid hybrid oftwo native American species; *F. chiloensis*and *F.virginiana*was first developed inFrance in the 17th century. The wild species *F. vesca*was found throughout the northernhemisphere long before the development of cultivated strawberry. Most of the countriesin Europe had been growing strawberry commercially since the 18th century, and todaynearly 50% of the world’s strawberry production is in Europe. *Fragaria* species has abasic chromosomal number x = 7. The name strawberry has been derived from thepractice of straw as mulch for effective cultivation of crop since many years ago.

Nutritionally strawberry is a low calorie carbohydrate fruit but a rich source of vitamin A (60IU/100g of edible portion), vitamin C (30-120mg/100g of edible portion) and fiber and also has high pectin (0.55%), available in the form of calcium pectate. Water is a major constituent (90%) of strawberry fruit. The strawberry fruit contains 5 percent of total sugar and 0.90 to 1.85% acids the prominent being malic acid, citric acid and succinic acid, with traces of quinic, glyceric, glycolic and oxalo acetic acid **.** Ripe strawberries attain attractive red colour on sudden rise in temperature after commencement of Fruiting in February. The fruits are delicious and attractive , having pleasant aroma and a delicate flavour.

The quality and yield of fruit depends on different attributes which are closely associated with nutrient uptake by the plant. The supply of nutrients to the plants should be balanced, ensuring not to over or underfertilize. In addition to NPK , micronutrients have a great bearing in influencing the yield attributes and fruit production. Micronutrients are essentially as important as macronutrients to have better growth, yield and quality in plants. In the past, there was no need of micronutrients because these trace elements were naturally supplied by the soil.

In India the total area of strawberry is 1000ha with production of 5000 MT. In india, Maharashtra is the leading state in production of strawberry fruits. The nutrition status of strawberry plant plays a vital role in determining the yield and yield attributing parameters since, it is a very sensitive plant to nutritional balance.

Manures are organic substances made from leftover animal, human, and plant faces that have complex organic structures containing plant nutrients. Farmyard manure (FYM) refers to the decomposed mixture of dung and urine of farm animals along with litter and left over material from roughages or fodder fed to the cattle. On an average well decomposed farmyard manure contains 0.5 per cent Nitrogen (N), 0.2 per cent Phosphate (P2O5) and .0.5 per cent Potassium (K2O).

Vermicompost is organic manure which is created by earthworms as they transform organic materials into humus-like substance. Vermicompost is rich in NPK (nitrogen 2-3%, phosphorus 1.55-2.25% and potassium 1.85-2.25%), micronutrients, and beneficial soil microbes and contain plant growth hormones & enzymes.

Trichoderma have been known since at least the 1920s for their ability to act as biocontrol agents against plant pathogens. Until recently, the principal mechanisms for control have been assumed to be those primarily acting upon the pathogens and included mycoparasitism, antibiosis, and competition for resources and space. These fungi colonize the root epidermis and outer cortical layers and release bioactive molecules that cause walling off of the Trichoderma thallus. At the same time, the transcriptome and the proteome of plants are substantially altered. Consequently, in addition to induction of pathways for resistance in plants, increased plant growth and nutrient uptake occur. The world first bio capsule technology, where one capsule is equal to 1kg /litre of Trichoderma. In sustainable crop production, beneficial microorganisms are applied to control diseases and for growth promotion. Trichoderma harzianum a biocontrol agent encapsulated in trichocap promotes growth, triggers defence, and imparts direct action on the pathogen.

2. MATERIALSANDMETHODS:-

2.1Geographical location of the experimental site

The experimental site is located at a latitude of 25.41º North and longitude of 81.84

ºEast,with an altitudeof98meters abovethemean sealevel(MSL).

2.2 Climatic conditions of the experimental area

The area of Prayagraj comes under humid sub-tropical climate, which experiences warm humid monsoon, hot dry summer and cold dry winter. The annual mean temperature is 26.1ºC while monthly mean temperatures are 18-29ºC. The daily average maximum temperature is about 22ºC and the minimum temperature is 9ºC. The average annual rainfall received is 1042.2 mm. At this location, the temperature reaches upto 46ºC-48ºC and the minimum temperature recorded is 4ºC-5ºC. The relative humidity ranges in this location ranges between 20-94%.

2.3 Experimental details

Table 1 Treatment combination

S. No.	Notations	Treatments
1	T_0	Control (N:P:K – 100:60:40 kg/ha)
2	T_1	Vermicompost (10 t/ha)+ Bio capsule (optimum)
3	T_2	FYM (20 t/ha.) + Bio capsule (optimum)
4	T_3	Poultry manure (20 t/ha.) + Bio capsule (optimum)
5	T_4	Goat manure (20 t/ha) + Bio capsule (optimum)
6	T_5	Vermicompost (10 t/ha) + Bio capsule (50% of optimum)
7	T_6	FYM (20 t/ha.) + Bio capsule (50% of optimum)
8	T_7	Poultry manure (20 t/ha.) + Bio capsule (50% of optimum)
9	T_8	Goat manure (20 t/ha) + Bio capsule (50% of optimum)
10	T_9	Vermicompost (10 t/ha) + Bio capsule (150% of optimum)
11	T_{10}	FYM (20 t/ha.) + Bio capsule (150% of optimum)
12	T_{11}	Poultry manure (20 t/ha.) + Bio capsule (150% of optimum)
13	T_{12}	Goat mannure (20 t/ha) + Bio capsule (150% of optimum)

3. RESULTSANDDISCUSSION

3.1 Effect of organic manures and bio capsuleson plant height (cm) and number of leaves of Strawberry cv. Winter Dawn

Strawberry plants in treatment T_{11} recorded the maximum plant height (14.43 cm) and number of leaves per plant (19.04). On the other hand, the minimum plant height (11.00 cm) and number of leaves per plant (13.00) were observed in plants grown with treatment control.The increased plant height of strawberry may be due to the increased nitrogen fixation, organic nitrogen utilization, development of root system **(Beer *et al.*, 2017).** Similar results were also reported by **Tripathi *et al.* (2010)** in strawberry.Higher number of leaves & leaf area might be due to higher cell division caused by cytokinins& also due to higher supply of assimilate mediated by biocapsulesapplication. Increased number of leaves might have increased the photosynthetic activity resulting in higher accumulation of carbohydrates.. The findings are in close agreement with the findings of **Dwivedi *et al.* (1999)** in strawberry.

Table 2. Effect of organic manures and bio capsules on plant height (cm) number of leaves of Strawberry cv. Winter Dawn

Treatment	Plant height (cm)			Number of leaves per plant		
	60 Days	90 Days	120 Days	60 Days	90 Days	120 Days
T0	7.12	9.56	11	5.93	10.4	13
T1	8.13	10.53	12.66	6.66	11.2	15.2
T2	8	10.53	12.6	6.6	10.66	14.38
T3	8.75	11.3	13.4	7.86	12.6	16.64
T4	8.6	10.96	13	7.6	12.1	16.55
T5	8.31	10.66	12.76	7.06	11.6	15.96
T6	8.26	10.54	12.66	6.86	11.4	15.6
T7	9.41	11.51	13.86	8.02	12.66	17.73
T8	9.23	11.5	13.76	7.91	12.6	16.66
T9	8.48	10.93	12.86	7.33	11.8	16.53
T10	8.36	10.8	12.76	7.17	11.73	16.33
T11	10.2	12.26	14.43	9.26	13.4	19.04
T12	9.5	12.1	13.9	8.13	12.86	18.26
Ftest	S	S	S	S	S	S
SE(m)±	0.6	0.75	0.63	0.55	0.57	0.86
CD 5%	1.37	2.18	1.83	1.62	1.68	2.5
CV	12.05	11.93	8.4	12.93	8.43	9.1

3.2 Plant Spread(cm) and Flower Parameter

The maximum spread of plant(24.02 cm) was recorded in plants in the treatment T_{11}- Poultry manure (20 t/ha.) + Bio capsule (150% of optimum), whereas, minimum plant spread (19.63 cm) were observed in treatment T0 control. **Beer et al., 2017,** reported increase in plant spread might be due

toincreased growth of plant in the form of height, which accumulated morephotosynthesis & thereby increases leaf area per plant. These findings arecorroborates with the finding of **Umar et al. (2009).**

Minimumdays takenfirst floweringand fruitingwasrecordedwithT_{11}(Poultry manure (20 t/ha.) + Bio capsule (150% of optimum)),(101.00).CloselyfollowedbyT_{12}(101.13).Maximum days taken for first floweringand fruiting was recorded in T_0(111.00).These outcomes have got the support of the findings of Kumar et al., (2015) who also recorded earliest flowering and fruiting with the application of cent per cent biocapsules and organic fertilizers, **Shukla *et al.*, (2009),** who recorded earliest flowering.**Tripathi *et al.* (2015)** also recorded advancement in flowering.Number of days required minimum to produce first flower might be due to balanced supply of vermi-compost & bio-fertilizers, which provides all the necessary elements to plant to become early flowering and fruiting.

Maximumnumber of flowers per plant was recorded with T_{11}(Poultry manure (20 t/ha.) + Bio capsule (150% of optimum))27.45. Closely followed by T_{12}(26.26).Minimum number of flowers per plant was recorded in T_0control (21.00).This might due to the effect of organic manures and biocapsles obtained from the cell elongation and division. Soluble bio capsules increases photosynthetic activities of leaves, which leading to development of primary flowers, production of viable flowers. Similar results were also obtained by **Tripathi *et al.* (2015) and Singh *etal.* (2015)** in strawberry.

Maximumthe number of days to taken first fruit set per plant was recorded with T_{11}(Poultry manure (20 t/ha.) + Bio capsule (150% of optimum))5.90. Closely followed by T_{12}(5.80).Minimum the number of days to taken first fruit set per plant was recorded in T_0control (4.15).The data presented in the revealed the number of days to fruit maturitywassignificantlyinfluencedbydifferent treatments. Maximumthe number of days to fruit maturity was recorded with T_{11}(Poultry manure (20 t/ha.) + Bio capsule (150% of optimum))31.58. Closely followed by T_{12}(31.33).Minimum the number of days to taken fruit maturity was recorded in T_0control (25.97).

Table 3Effect of organic manures and bio capsules on plant spread (cm) and Flower parameter of Strawberry fruits cv. Winter Dawn

Treatment	Plant spread (cm)			No. of days to first flowering	No. of flowers per plant	No. of days Taken to first fruit set	Days to fruit Maturity
	60 Days	90 Days	120 Days				
T0	13.76	16.5	18.83	111	21	4.15	25.97
T1	14.6	17.7	20	109.46	23.73	4.26	26.97
T2	14.13	16.96	19.1	109.73	23.32	4.23	26.73
T3	17.2	20	22.09	103.04	25.36	5.6	28.46
T4	16.73	19.33	21.76	103.4	25.02	4.73	28.15
T5	16.46	18.62	21.18	106.53	24.06	4.36	27.2
T6	16.46	18.33	21.02	109.11	23.8	4.3	27.15
T7	17.93	20.76	22.3	102.33	26.06	5.79	30
T8	17.4	20.26	22.27	102.75	25.4	5.68	28.61
T9	16.73	19.2	21.51	105.72	24.48	4.56	27.63
T10	16.73	18.83	21.36	105.81	24.36	4.53	27.52
T11	18.6	21.62	24.2	101	27.45	5.9	31.58
T12	18.02	20.86	23.17	101.13	26.26	5.8	31.33
Ftest	S	S	S	S	S	S	S
SE(m)±	0.89	1.01	0.09	1.96	0.8	0.17	0.5
CD 5%	2.6	2.94	2.77	3.22	2.32	0.52	1.45
CV	9.26	9.14	7.66	5.73	5.65	6.36	3.46

3.3 Fruit Parameter

The data presented in the revealed the number of fruits per plantwassignificantlyinfluencedbydifferent treatments. Maximumnumber of fruits per plant and was recorded with T_{11}(Poultry manure (20 t/ha.) + Biocapsule (150% of optimum)) with 19.66. Closely followed by T_{12}(17.67).Minimum number of fruits per plant was recorded in T_0control (12.33).

Maximumfruit weight (g)was recorded with T_{11} (Poultry manure (20 t/ha.) + Bio capsule (150% of optimum))38.04 g closely followed by T_{12}(37.26 g).Minimum fruit weight (g)was recorded in T_0control (32.00 g).Maximumfruit length (cm)was recorded with T_{11} (Poultry manure (20 t/ha.) + Bio capsule (150% of optimum))3.89 cm closely followed by T_{12}(3.66 cm).Minimum fruit length (cm)was recorded in T_0control (2.17 cm).Maximumfruit diameter of fruitwas recorded with T_{11} (Poultry manure (20 t/ha.) + Bio capsule (150% of optimum))3.84 cm closely followed by T_{12}(3.58 cm).Minimum fruit diameter of fruitwas recorded in T_0control (2.71 cm).The results are consistent withthose of**Singh *et al.* (2006)** in strawberry, and they are similar tothose of **Al-Madhagi*et al.* (2012). Nor *et al.* (2014)** also reported increased fruit volume with the application of organic fertilizer and biocapsules in strawberry.

Table 4Fruit Parameter of plants

Treatment	No. of fruit per plant	Fruit Weight (g)	Fruit length (cm)	Fruit Diameter (cm)
T0	12.33	32	2.17	2.71
T1	13.66	34.2	2.84	2.73
T2	12.33	33.38	2.63	2.98
T3	16.66	35.64	3.5	3.38
T4	16.33	35.55	3.47	3.03
T5	14.66	34.96	3.31	3.24
T6	14.33	34.6	3.14	3.59
T7	17.33	36.73	3.65	3.81
T8	17	35.66	3.61	3.58
T9	16	35.53	3.41	3.62
T10	15	35.33	3.32	3.72
T11	19.66	38.04	3.89	3.84
T12	17.66	37.26	3.66	3.58
Ftest	S	S	S	S
SE(m)±	1.06	0.38	0.14	**0.38**
CD 5%	3.08	0.24	0.42	**0.19**
CV	12.06	3.84	7.58	0.42

3.4 Yield parameter and quality parameter

The maximum yield per plant (747.78 g) was recorded in plants in the treatment T_{11}- Poultry manure (20 t/ha.) + Bio capsule (150% of optimum). The minimum number of fruits per plant (394.56 g) was recorded in treatment T0- control. The maximum yield per plot (6.00 kg) was recorded in plants in the treatment T_{11}- Poultry manure (20 t/ha.) + Bio capsule (150% of optimum). The minimum number of fruits per plant (2.90 kg) was recorded in treatment T0- control. The maximum number of fruits per plant (51.66 q) was recorded in plants in the treatment T_{11}- Poultry manure (20 t/ha.) + Bio capsule (150% of optimum). The minimum number of fruits per plant (30.67 q) was recorded in treatment T0- control. The strawberry plants in treatment T_{11}- Poultry manure (20 t/ha.) + Bio capsule (150% of optimum) had fruits with the maximum TSS (11.40 °B) while the minimum (7.64 °B) was recorded in treatment T0- Control. The maximum titratable acidity (0.52 per cent) was observed in fruits in treatment T_{11} while the minimum(0.33 per cent) was found in fruits in treatment T0. The maximum vitamin C (58.94 mg100g-1) was recorded in treatment T_{11}-, while minimum (47.21 mg100g-1) was recorded in treatment T0. The results are in line with**Nowsheen*et al.*, 2006** and **Umar *et al.*, 2009** in the

strawberrywho described maximum yield in the strawberry. Increment in the number of runners perplant may be because of enhanced growth of vegetative and leaves number that gathered more photo-synthates and hence increased runners and the leaf area per plant.PGR and micronutrientsmight have an effecton runner production because of its ability to increase the nutrient availability in the soil as well asprovidebetterenvironment forbetter and healthyroot development.

Table 5 Yield parameter and quality parameter

Treatment	Yield per Plant(g)	Yield per Plot (kg)	Yield per Hectare(q)	Total titrabeacidiy %	TSS (°Brix)	Ascorbic acids (mg/100g of fruit)
T0	394.56	2.9	30.67	0.33	7.64	47.21
T1	467.17	3.35	37.28	0.36	8.33	48.66
T2	411.58	3.15	35.01	0.34	7.66	47.06
T3	593.76	4.99	40.51	0.44	10.16	56.2
T4	580.53	4.87	39.13	0.43	10.1	58.42
T5	512.51	4.05	30.06	0.38	9.05	50.86
T6	495.82	3.45	23.39	0.37	9	56.63
T7	636.53	5.31	44.09	0.45	11.4	53.7
T8	606.22	5.25	43.8	0.45	10.66	51.14
T9	568.48	4.8	38.33	0.4	10	57.36
T10	529.95	4.17	31.4	0.39	10	57.36
T11	747.87	6	51.66	0.52	11.41	58.94
T12	658.01	5.49	46.06	0.45	12.41	54.53
Ftest	S	S	S	S	S	S
SE(m)±	23.19	0.41	4.52	0.03	0.74	3.47
CD 5%	15.08	1.2	13.18	0.09	2.15	10.14
CV	16.35	16.31	16.23	13.64	6.4	8.92

3.4 Economics of cluster bean

The maximum Cost of cultivation (Rs.), gross return, net return and benefit cost ratio was recorded in the Treatment T_{11} with cost of cultivation Rs.249700, Gross return Rs. 1033200 and Net Return Rs 783500 and Benefit cost ratio Rs 3.14.

Table 6: Economics of different treatment combination of Cluster bean

Notation	Fruit yield(q)	Selling rate (Rs./q)	Gross return (Rs.)	Cost of cultivation	Net return(Rs.)	B/C ratio
T0	30.67	20000	613400	211700	401700	1.9
T1	37.28	20000	745600	214700	530900	2.47
T2	35.01	20000	700200	206700	493500	2.39
T3	40.51	20000	810200	213700	596500	2.79
T4	39.13	20000	782600	225200	557400	2.48
T5	30.06	20000	601200	207700	393500	1.89
T6	23.39	20000	467800	209700	258100	1.23
T7	44.09	20000	881800	219200	662600	3.02
T8	43.8	20000	876000	221200	654800	2.96
T9	38.33	20000	766600	225200	541400	2.4
T10	31.4	20000	628000	207700	420300	2.02
T11	51.66	20000	1033200	249700	783500	3.14
T12	46.06	20000	921200	219200	702000	3.2

Conclusion:-

The result obtained in the present investigation, thus, indicates the possibility of successful use of application of organic sources of like FYM, Vermicompost, poultry manures, goat manures along with bio capsules and it might prove to be a better option for enhancing growth, yield and quality of strawberry. It is concluded that the treatment T_{11} (Poultry manure (20 t/ha.) + Bio capsule (150% of optimum) was found best in terms of vegetative growth and yield characters of strawberry. The economics of the treatment T_{11} was found best in terms of B:C ratio 3.50 of strawberry. So application of this organic manures and bio capsules combination can be recommended to growers after few more conjunctive trials.

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