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Effect of Tricho capsules and different micronutrients on growth, yield and quality of Strawberry (*Fragaria* x *ananassa* Duch.) cv. Chandler

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Abstract
An Experiment was carried out during rabi 2023-2024 at Horticulture Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P) India. To study the Effect of Tricho capsules and different micronutrients on growth, yield and quality of Strawberry (*Fragaria* x *ananassa* Duch.) cv. Chandler. The experiment was laid out in Randomized Block Design, replicated 3 times with 10 treatments with different combinations. The characters of growth, yield and quality characters are noted. Based on above characters it is concluded that treatment combination T_9 (Tricho capsules + FeSO4 (0.6%)) showed best results of plant height (25.77 cm), plant spread (22.53 cm), number of leaves per plant (11.34), number of flowers per plant (28.00), Fruit length (3.66 cm), Fruit diameter (2.60 cm), fruit weight (8.86gm), total fruit yield per plant (220.68 g), TSS ^{0}brix (8.30 ^{0}brix), Acidity (0.74%) and Ascorbic Acid (60.87 mg) of strawberry. Importance of conducting this experiment is defined that Tricho capsules and micronutrients improves the fruit size, fruit weight and firmness. So, the quality and shelf-life of a fruit also increases. It will help to export the fruits to other countries.

Keywords: Strawberry, tricho capsule, micronutrients, growth, yield etc.

Introduction
Strawberries, scientifically named Fragaria × ananassa (Duch), are a popular type of fruit that's cultivated all over the world. They're part of the Fragaria genus and are known for their tasty fruit. People love them because they smell great, look vibrant red, and have a juicy and sweet taste. In the 1750s, people made a new kind of strawberry by crossing two types: Fragaria virginiana from eastern North America and Fragaria Chiloensis, which came from Chile. This new hybrid was named Fragaria × ananassa. Since then, this hybrid strawberry has become the main type grown commercially, replacing the smaller woodland strawberry (*Fragaria vesca*). A single strawberry typically has around 200 seeds on its outer surface. While strawberries may differ in their leaf appearance and the development of their reproductive organs, most have flowers that look hermaphroditic (having both male and female parts) but function as either male or female. In commercial farming, strawberries are usually grown from runners and then sold either as bare root plants or plugs. Regardless of these variations, strawberries are still strawberries. Trichoderma has been recognized since at least the 1920s for its capacity to serve as a biocontrol agent against plant pathogens. Traditionally, it was believed that the main methods of control involved actions directly targeting the pathogens. These methods include mycoparasitism (where Trichoderma attacks and feeds on other fungi), antibiosis (production of compounds that inhibit the growth of pathogens), and competition for resources and space with the pathogens. These mechanisms help Trichoderma in its role as a beneficial organism in protecting plants from harmful pathogens. Each Trichocapsule contains a high concentration of Trichoderma, with one capsule being equivalent to 1 kilogram or liter of the microorganism. These capsules are used to apply Trichoderma to crops, serving dual purposes: controlling diseases and promoting growth. This technology harnesses the power of beneficial microorganisms to support healthier and more resilient crop systems, contributing to sustainable agriculture practices. Micronutrients are like vitamins for plants, essential for their growth.

When plants don't get enough, it can limit how much fruit they produce. Adding things like zinc sulfate and ferrous sulfate can help boost fruit yield, make fruits taste better, and even make them last longer on the shelf. But too much ferrous sulfate can actually harm plants, causing them to grow slower and produce lower-quality fruit. So, while adding these nutrients can be good, it's important to use them carefully to avoid problems.

Materials and Methods

A Field experiment was carried out at the Horticulture Research Farm, Department of Horticulture, SHUATS, Prayagraj, U.P. in the months of November 2023 to February**,** 2024. The experiment was conducted on strawberry cv. Chandler in Randomized Block Design with three replications using 10 treatment combinations. Treatments are applied at 30 Days After Transplanting, 45 Days After Transplanting. Treatment combinations are:- T_0 Control, T_1 Tricho capsules + ZnSO4 (0.2%), T_2 Tricho capsules + Borax (0.2%), T_3 Tricho capsules + FeSO4 (0.2%), T_4 Tricho capsules + ZnSO4 (0.4%), T_5 Tricho capsules + Borax (0.4%), T_6 Tricho capsules + FeSO4 (0.4%), T_7 Tricho capsules + ZnSO4 (0.6%), T_8 Tricho capsules + Borax (0.6%), T_9 Tricho capsules + FeSO4 (0.6%).

Results and Discussion

The Maximum plant height (25.77 cm) was recorded in T_9 Tricho capsules + FeSO4 (0.6%). Whereas the minimum plant height (20.95 cm) was recorded in T_0 Control. Here, plant height is measured using a measuring scale in centimetres. In this, trail maximum plant height is seen in the T_9 treatment, this might be due to trichocapsule and Ferrous Sulphate which plays a vital role by slowly releasing nutrients that support plant growth, making plants taller. This height increase is often linked to higher chlorophyll levels in the plants. Chlorophyll is crucial for photosynthesis, the process by which plants make food. When chlorophyll levels rise, it indirectly stimulates cell division and elongation, contributing to the overall height of the plants. In simpler terms, giving plants these nutrients helps them grow taller by making them healthier and promoting the growth of their cells. Similar findings were reported by Li *et al*. (2018) [11] Zhang *et al*. (2019) [12] Xu *et al*. (2021) [13] Suda *et al*. (2018) [14] Mahnaz *et al*. (2010) [15].

The maximum plant spread (22.53 cm) was recorded in T_9 Tricho capsules + FeSO4 (0.6%) in east west direction. Whereas the minimum plant spread (14.10 cm) was found recorded in T_0 Control. In this trail treatment T_9 shows the best result with respect to plant spread, this is due to Micronutrients and Tricho capsules contain nutrients which are essential for root development by promoting plant growth, and also contribute to improving soil structure which enhances increased water holding capacity, nutrient retention also it fosters microbial activity, ultimately increases plant spread. Similar findings were reported by Li *et al*. (2018) [11] Zhang *et al*. (2019) [12] Xu *et al*. (2021) [13] Suda *et al*. (2018) [14] Mahnaz *et al*. (2010) [15].

The maximum number of leaves per plant (11.34) was found in treatment T_9 Tricho capsules + FeSO4 (0.6%) and minimum number of flowers per plant (8.00) was found in treatment T_0 Control. In this trail maximum flower per plant is seen in the T_9 this might be due to Micronutrients like zinc, boron, and iron, along with Tricho capsules, give plants a slow and steady supply of nutrients. This helps the soil become better at holding onto water and nutrients, and it also lets air get to the roots ultimately which increase the number of leaves per plant. Similar results were observed by Li *et al*. (2018) [11] Zhang *et al*. (2019) [12] Xu *et al*. (2021) [13] Suda *et al*. (2018) [14] Mahnaz *et al*. (2010) [15].

The maximum Number of flowers per plant (28.00) shown in table 1 was found in treatment T_9 Tricho capsules + FeSO4 (0.6%)). Whereas the minimum Number of fruits per plant (17.90) was found in treatment T_0 Control. In this trail maximum leaves per plant is seen in the T_9. Results were in accordance with the findings of Li *et al*. (2018) [11] Zhang *et al*. (2019) [12] Xu *et al*. (2021) [13] Suda *et al*. (2018) [14] Mahnaz *et al*. (2010) [15].

The maximum Fruit length (3.66 cm) was found in treatment T_7 Tricho capsules + $ZnSO_4$ (0.6%)). Where as the minimum Fruit length (3.10 cm) was found in treatment T_0 Control. In this trail maximum fruit length is seen in the T_7 this might be due to Bio capsules and micronutrients such as Zinc (Zn), Boron (B), and Iron (Fe) play crucial roles in promoting plant health and fruit development. By providing essential nutrients, they support various physiological processes within the plant, including water retention and microbial activity. This results in the production of larger and healthier fruits. these supplements is their ability to promote cell division and elongation in fruits which are essential for regulating growth processes. which can lead to higher fruit length. Similar results was observed by Li *et al*. (2018) [11] Zhang *et al*. (2019) [12] Xu *et al*. (2021) [13] Suda *et al*. (2018) [14] Mahnaz *et al*. (2010) [15].

The maximum Fruit diameter (2.60 cm) was found in T_7 Tricho capsules + $ZnSO_4$ (0.6%)). Whereas the minimum Fruit diameter (2.11 cm) was found in treatment T_0 Control. In this trail maximum fruit per plant is seen in the T_7 this might be due to Biocapsules and Micro nutrients like Zinc,Boron and Iron are like super food per plants. They provide the necessesary nutrients, help the soil hold on to water better and boost the activity of helpful microbes. Results were in accordance with the findings of Li *et al*. (2018) [11] Zhang *et al*. (2019) [12] Xu *et al*. (2021) [13] Suda *et al*. (2018) [14] Mahnaz *et al*. (2010) [15].

The maximum Fruit Weight (8.86 g) was found in treatment T_7 Tricho capsules + $ZnSO_4$ (0.6%)). Where as the minimum Fruit Weight (6.84 g) was found in treatment T_0 Control. In this trail maximum fruit yield is seen in the T_7 this might be due to Biocapsules and Micronutrients such as Zinc,Boron and Iron are like special fuel for plants. They give plants the essential nutients they need, help the soil to water holding capacity and boost the activity of helpful microbes in the soil ultimately increases the fruit weight. Same results were found by Li *et al*. (2018) [11] Zhang *et al*. (2019) [12] Xu *et al*. (2021) [13] Suda *et al*. (2018) [14] Mahnaz *et al*. (2010) [15] in Strawberry.

The maximum total fruit yield/plant (220.68 g) was found in T_9 Tricho capsules + FeSO4 (0.6%). Where as the minimum Fruit yield (125.9 g) was found in T_0 control. In this Trail maximum total fruit yield/plant is seen in the T_9 this might be due to Micronutrients like zinc, boron and Iron along side with Biocapsules can significantly boost strawberry yield by gradually releasing vital nutrients which fosters robust root growth and improves the overall health of the soil. These supplements help strawberry better withstand tough condition like drought or diseases, ensuring more reliable fruit production and ultimately leading to higher

yields Results were in accordance with the finding/plants of Li *et al*. (2018) [11] Zhang *et al*. (2019) [12] Xu *et al*. (2021) [13] Suda *et al*. (2018) [14] Mahnaz *et al*. (2010) [15] in Strawberry.

The maximum TSS ^{0}Brix (8.30) found in treatment T_7 Tricho capsules + $ZnSO_4$ (0.6%)). Where as the minimum TSS ^{0}Brix (7.41) was found in treatment T_0 Control. In this trail maximum TSS is seen in the T_7 this might be due Micronutrients such as Zinc, Boron and Iron are essential for physiological process in plants. Per instance, Zinc is crucial for enzyme activation and protein synthesis, Boron plays a role in cell wall formation and carbohydrate metabolism, While Iron is essential for Chlorophyll synthesis and photosynthesis. Supplementing of the soil with these micronutrients ensures that the plant have access to all the necessary building blocks for growth and development and Biocapsules which often contain beneficial microorganisms and organic matter, can further enhances soil health and fertility these capsules can promote microbial activity in the soil, aiding in nutrient cycling and organic matter decomposition which ultimately increases Tss. Results were in accordance with the findings of Li *et al*. (2018) [11] Zhang *et al*. (2019) [12] Xu *et al*. (2021) [13] Suda *et al*. (2018) [14] Mahnaz *et al*. (2010) [15].

The maximum Ascorbic acid (60.87 mg/100g fresh weight) treatment T_7 Tricho capsules + $ZnSO_4$ (0.6%)). Where as the minimum Ascorbic acid (58.25 mg/100g fresh weight) was found in treatment T_0 Control. In this trail maximum juice content is seen in the T_7 this might be due to micronutrients in the plant can boost its overall health and metabolism. This can lead to higher production of ascorbic acid, known as vitamin C, since its synthesis is influenced by different metabolic pathways. Moreover, micronutrients like zinc, boron, and iron play roles in regulating the activity of enzymes involved in ascorbic acid synthesis. Thus, by ensuring these nutrients are available, it indirectly supports higher levels of vitamin C in strawberries. So, it's essential to apply it judiciously which indirectly contribute to maximum ascorbic acid. Same results are found by Li *et al.* (2018) [11] Zhang *et al*. (2019) [12] Xu *et al*. (2021) [13] Suda *et al.* (2018) [14] Mahnaz *et al*. (2010) [15] and Singh *et al.* (2022) [10].

The maximum Acidity (0.74%) shown in table 2 was found in treatment T_0 Control and the minimum Acidity (0.70%) was found in treatment T_7: Tricho capsules + $ZnSO_4$ (0.6%)). In this trail maximum pH is seen in the T_0 this might be due to adding micronutrients like zinc, boron, and iron, along with bio capsules, to the soil can make sure that strawberry plants get all the nutrients they need to grow well. These nutrients help the plants grow strong and healthy, produce more fruit, and make the fruit better quality. Using micronutrients and bio stimulants also makes the soil healthier and better at holding onto nutrients, so the plants can use them more effectively Similar results were found by Li *et al*. (2018) [11] Zhang *et al*. (2019) [12] Xu *et al.* (2021) [13] Suda *et al*. (2018) [14] Mahnaz *et al*. (2010) [15] and Singh *et al.* (2022) [10].

Table 1: Effect of tricho capsule and micronutrients on plant height, plant spread, number of leaves and number of flowers/plant, fruit length, fruit diameter, and fruit weight

Symbol	Plant Height			Plant Spread			No. of leaves			No. of flowers/plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT				
T_0	6.81	8.29	20.95	6.28	8.98	14.02	6.50	6.44	8.00	17.9	3.10	2.11	6.84
T_1	7.59	10.97	23.49	7.48	10.38	15.70	7.22	9.11	10.56	19.7	3.54	2.48	7.33
T_2	7.64	11.33	23.9	7.93	11.55	16.70	7.22	9.50	10.78	23.8	3.33	2.32	7.75
T_3	7.77	9.14	22.1	10.67	12.38	17.78	7.28	7.72	8.72	19.1	3.16	2.23	7.64
T_4	7.63	9.32	22.17	7.99	10.34	16.58	7.17	7.94	9.00	22.5	3.58	2.56	8.64
T_5	7.50	10.90	23.84	11.95	15.60	17.93	7.00	9.39	10.39	22.5	3.37	2.36	7.66
T_6	8.40	8.47	21.33	10.74	16.27	18.21	7.89	7.00	8.05	19.8	3.25	2.31	8.60
T_7	8.75	11.59	24.08	13.07	16.53	21.33	8.33	9.5	11.11	26	3.66	2.60	8.86
T_8	8.05	9.93	22.62	10.62	15.52	18.85	7.61	8.05	9.44	23.7	3.43	2.50	8.06
T_9	8.83	11.75	25.77	13.83	17.39	22.19	8.39	10.28	11.34	28	3.35	2.39	7.36
F-Test	S	S	S	S	S	S	S	S	S	S	S	S	S
S.Ed(±)	0.96	1.81	0.02	0.13	0.004	0.03	0.95	1.51	1.74	2.18	0.004	0.03	0.95
C.D.(5%)	0.60	0.44	0.44	0.38	0.009	0.08	0.78	1.35	1.03	4.63	0.009	0.08	0.51
C.V.	14.92	21.80	0.05	2.19	0.16	1.93	15.65	21.8	21.89	12.02	0.16	1.93	14.89

Table 2: Effect of Tricho-capsule and micronutrients on yield/plant, TSS, acidity, ascorbic acid, total sugar, reducing sugar, non reducing sugar, b:c ratio

Symbol	Yield/plant (g/)	TSS °Brix	Acidity (%)	Ascorbic acid (mg/100g)	Total sugar (%)	Reducing sugar (%)	Non - reducing sugar (%)	B:C Ratio
T_0	125.9	7.41	0.74	58.25	5.39	3.11	2.28	1.35
T_1	148.5	7.67	0.73	59.83	6.60	4.31	2.29	1.60
T_2	182.08	7.57	0.72	60.72	6.74	4.38	2.36	2.03
T_3	142.96	7.63	0.71	60.02	6.55	4.29	2.26	2.58
T_4	192.74	7.92	0.72	60.44	6.82	4.43	2.39	1.97
T_5	171.49	7.71	0.71	60.23	6.62	4.31	2.31	2.40
T_6	172.18	7.82	0.73	59.81	6.76	4.39	2.37	1.93
T_7	218.36	8.30	0.70	60.87	6.70	4.35	2.35	2.69
T_8	191.03	7.90	0.72	59.14	6.65	4.36	2.29	2.50
T_9	220.68	8.02	0.73	59.63	6.74	4.37	2.37	2.99
F-Test	S	S	S	S	S	S	S	
S.Ed(±)	27.55	0.002	0.001	0.032	0.821	0.536	0.035	
C.D.(5%)	58.34	0.004	0.003	0.068	0.306	0.416	0.075	
C.V.	19.15	0.032	0.216	0.065	16.820	15.494	1.853	

Conclusion

From the present investigation it was concluded that the treatment T_9 Tricho capsules + FeSO4 (0.6%) was found to be best in the terms of Vegetative growth, yield and yield attributes, and quality parameters.

Future aspects

The future of using Tricho capsules in agriculture is promising, offering significant advancements in sustainable farming. Tricho capsules, containing beneficial fungi like Trichoderma, enhance soil health and plant growth by promoting nutrient uptake and suppressing soil-borne pathogens. As agriculture shifts towards eco-friendly practices, Tricho capsules will play a crucial role in reducing chemical pesticide and fertilizer use, minimizing environmental impact, and promoting biodiversity. With ongoing research and development, these biocontrol agents are expected to become more effective and specialized, targeting specific crops and pests. Additionally, integrating Tricho capsules with precision farming technologies will optimize their application, enhancing crop yields and resilience to climate change. The adoption of Tricho capsules aligns with the global push towards organic farming and sustainable agriculture, ensuring food security and environmental conservation for future generations.

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