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IMPACT OF MICRONUTRIENTS ON GROWTH, FLOWERING AND YIELD OF STRAWBERRY (*FRAGARIA* × *ANANASSA* DUCH.) CV. CHANDLER IN WESTERN UTTAR PRADESH INDIA

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ABSTRACT

The present investigation was conducted during the winter season of 2021-22 at the Horticulture Research Block of Janta Vedic College, Baraut, Baghpat, to assess the effects of exogenous application of micronutrients viz., boron, zinc, copper and iron, individually and in combination, on the growth, yield and quality of strawberry plants under open field conditions. The experiment was laid out in a Randomized Block Design with three replications and fourteen treatments along with one control. Results indicated significant improvements in growth parameters such as plant height, number of leaves and petiole length, particularly with the treatment T_{14} (Boric acid + Zinc Sulphate + Copper Sulphate +Ferrous Sulphate @ 0.4 %). The maximum plant height at 30, 60, and 90 days was observed in treatment T_{14} (9.58 cm, 16.41 cm, and 22.1 cm, respectively), along with the maximum number of leaves (12.99, 22.11, and 29.11, respectively) and petiole length (9.22 cm, 13.31 cm, and 17.37 cm, respectively). This treatment also resulted in the earliest flowering (42.44 days), the shortest time to fruit set from flowering (4.11 days) and the quickest fruit maturity (19.22 days). Furthermore, T_{14} produced the highest number of flowers per plant (24.22) and fruits per plant (24.44), with the best fruit set percentage (83.93%). Yield attributes, including the fruit weight (16.29 g) and fruit yield per plant (331.17 g), were maximized with this treatment, indicating the considerable benefits of micro-nutrient application in strawberry cultivation.

***Keywords*:** Micronutrients, Growth, Flowering, Yield, Strawberry (*Fragaria* × *ananassa* Duch.)

Introduction

Strawberry (*Fragaria* × *ananassa* Duch.) is one of the most attractive and delicious fruits in the world, belonging to the Rosaceae family. This aggregate fruit consists of numerous achenes, with its edible part being the fleshy thalamus**.** Strawberries are in high demand both in fresh markets and processing industries due to their delightful flavor and nutritional benefits. As heavy feeders, strawberries require a balanced supply of macro and micronutrients to ensure high yield and quality. Micronutrients like zinc and copper are vital for the plant's growth and development, preventing deficiencies that cause chlorosis (due to zinc deficiency) and stunted growth (due to copper deficiency) (Zewail *et al.*, 2020). Furthermore, micronutrient foliar feeding has shown to significantly improve plant growth, yield, and fruit quality by minimizing nutrient losses and enhancing nutrient use efficiency (Sangeeta *et al.*, 2019). The application of micronutrients like zinc and iron has been noted to improve production and quality in several fruit crops (Shanker *et al.*, 2019). Environmental factors also play a crucial role in the growth and development of strawberries (Patil and Chetan, 2018). The marketing and profitability of strawberries cultivated in Western Uttar Pradesh are adversely affected by the lack of desired quality and size of the fruit. Micronutrients, which are involved in virtually all metabolic and cellular functions within the plant, play a crucial role in improving the quality and sustaining the production of strawberries (Hansch *et al.*, 2009). Deficiencies in these micronutrients often limit crop productivity and quality. Given the significance of micronutrients in strawberry cultivation, the present study aims to evaluate the effects of exogenous application of boron, zinc, copper and iron, both individually and in combination, on the growth, yield and quality of strawberry plants under open field conditions.

Materials and Methods

The present investigation was carried out during the winter season of 2021-22 at the Horticulture Research Block, Janta Vedic College, Baraut, Baghpat, Uttar Pradesh (29.1058°N, 77.2661°E). The study aimed to evaluate the impact of micronutrients on the growth, flowering and yield attributes of strawberry (*Fragaria X ananassa*) cv. Chandler under open field conditions. Raised beds, each one meter wide, were prepared for planting the runners. Uniformly sized and disease-free planting material of the cultivar Chandler was selected. Prior to planting, the plants were treated with a solution 0.1% solution of Bavistin. Planting of the runners took place during the first week of November. 300-gauge thickness black polythene mulch was applied at the time of planting. Fourteen distinct treatments, along with one control (T_0, untreated), were implemented in a Randomized Block Design (RBD) with three replications for the experiment. The treatments included: T_1 (Boric acid @ 0.4%), T_2 (Zinc Sulphate @ 0.4%), T_3 (Copper Sulphate @ 0.4%), T_4 (Ferrous Sulphate @ 0.4%), T_5 (Boric acid + Zinc Sulphate @ 0.4%), T_6 (Boric acid + Copper Sulphate @ 0.4%), T_7 (Boric acid + Ferrous Sulphate @ 0.4%), T_8 (Zinc Sulphate + Copper Sulphate @ 0.4%), T_9 (Zinc Sulphate + Ferrous Sulphate @ 0.4%), T_{10} (Copper Sulphate + Ferrous Sulphate @ 0.4%), T_{11} (Boric acid + Zinc Sulphate + Copper Sulphate @ 0.4%), T_{12} (Boric acid + Zinc Sulphate + Ferrous Sulphate @ 0.4%), T_{13} (Zinc Sulphate + Copper Sulphate + Ferrous Sulphate @ 0.4%) and T_{14} (Boric acid + Zinc Sulphate + Copper Sulphate + Ferrous Sulphate @ 0.4%). The study adhered to recommended doses of NPK (nitrogen, phosphorus, and potassium) and maintained uniform cultural practices throughout. Well decomposed farmyard manure at a rate of 5 tonnes per hectare and vermicompost at 5 tonnes per hectare were uniformly incorporated into the soil 20 days prior to planting. Essential agronomic measures such as regular irrigation and effective pest and disease management were implemented as per requirement during the entire duration of the investigation. Statistical analysis of the data was performed using analysis of variance (ANOVA) for the Randomized Block Design (RBD), following the methods outlined by Gomez and Gomez (1984).

Results and Discussion

Growth parameters

In the study, treatment effects on the growth parameters of strawberry cv. Chandler were evaluated across various intervals. Treatment T_{14} consistently showed superior performance, with the tallest plants observed at 30, 60 and 90 days, reaching heights of 9.58 cm, 16.41 cm, and 22.1 cm, respectively (Figure 1). Similarly, T_{14} exhibited the highest number of leaves at these intervals, with counts of 12.99, 22.11, and 29.11 leaves, statistically at par with T_{12} counts of 12.78, 21.49, and 28.55 leaves (Figure 2). Furthermore, T14 also produced the maximum number of runners per plant, with 5.66 runners, statistically similar to T_{12}, T_{13}, and T_{11}, which recorded 5.22, 5.11, and 4.89 runners, respectively (Table 1). The findings are consistent with the notion that zinc facilitates the synthesis of tryptophan, a precursor of auxin, which regulates plant growth and development (Skoog, 1940). Moreover, iron is known to play a critical role in electron transport chains, thereby enhancing energy metabolism and supporting various physiological processes in plants (Singh *et al.*, 2015). The current results align closely with the previous discoveries made by Saha *et al.* (2019).

Flowering and Fruiting Attributes

The minimum days to first flowering were observed in treatment T_{14} (42.44), which was statistically superior to all other treatments. Similarly, the minimum days to fruit set from days to flowering were recorded in treatment T_{14} (4.11), closely followed by treatments T_{12} (4.22), T_{13} (4.44), and T_{11} (4.22), all of which were statistically at par. Treatment T_{14} also exhibited the minimum days to fruit maturity from fruit set (19.22), which was statistically significant compared to other treatments. Treatment T_{14} showed the highest number of flowers per plant (24.22), statistically superior to all other treatments (Table 1). Additionally, treatment T_{14} produced the highest number of fruits per plant (24.44), significantly outperforming other treatments in the experiment. In terms of fruit set percentage, treatment T14 (83.93%) showed statistically superior results compared to treatment T_{12} (82.33%) and all other treatments. Regarding yield attributes, treatments T_{14} and T_{12} exhibited the maximum length to diameter ratio (1.64 and 1.62, respectively), both significantly different from other treatments (Table 1). Treatment T_{14} also produced the maximum fruit weight (16.29 g) and fruit yield per plant (331.17 g). Abdollahi *et al.* (2012) demonstrated that the application of ZnSO4 led to increased inflorescence and fruit size in strawberry cv. Selva. This effect is attributed to zinc's crucial role in enhancing pollination and fruit set. Additionally, zinc is known to accelerate photosynthetic activity and the translocation of photosynthates, thereby contributing to the enlargement of fruit size (Graham *et al.*, 2000). Boron enhances flower formation and pollen germination, crucial for robust flowering in plants like strawberries. Copper supports enzymatic processes and nutrient uptake, vital for plant vigor and fruit development, thereby enhancing overall yield. The results of presented investigation are also in conformity with findings by Saha *et al.* (2019) who noticed the application of both $ZnSO_4$ and $FeSO_4$ at 0.4% significantly enhanced vegetative growth, flowering, fruiting and fruit quality parameters compared to the control, yielding similar estimated benefit-to-cost ratios of 2.69 and 2.68, respectively. Specifically, ZnSO4 at 0.4% led to the highest fruit weight recorded at 21.50 g and improved productivity to 2.58 t ha^{-1}.

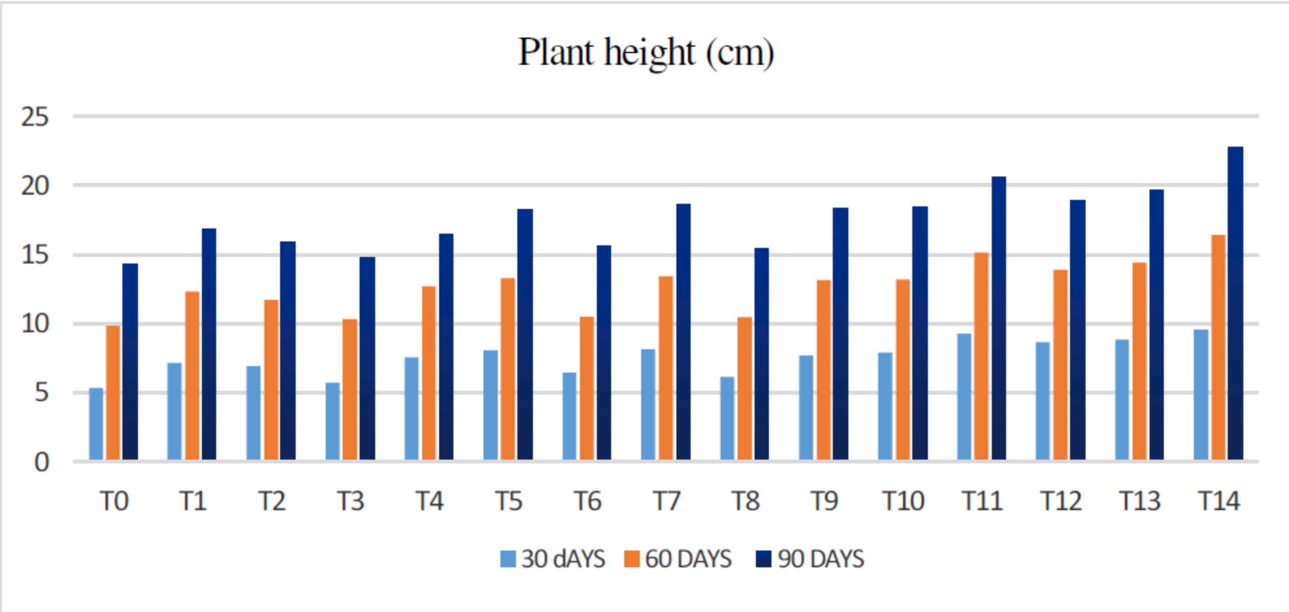

Fig. 1: Effect of micro-nutrients on plant height after 30, 60 and 90 days of planting.

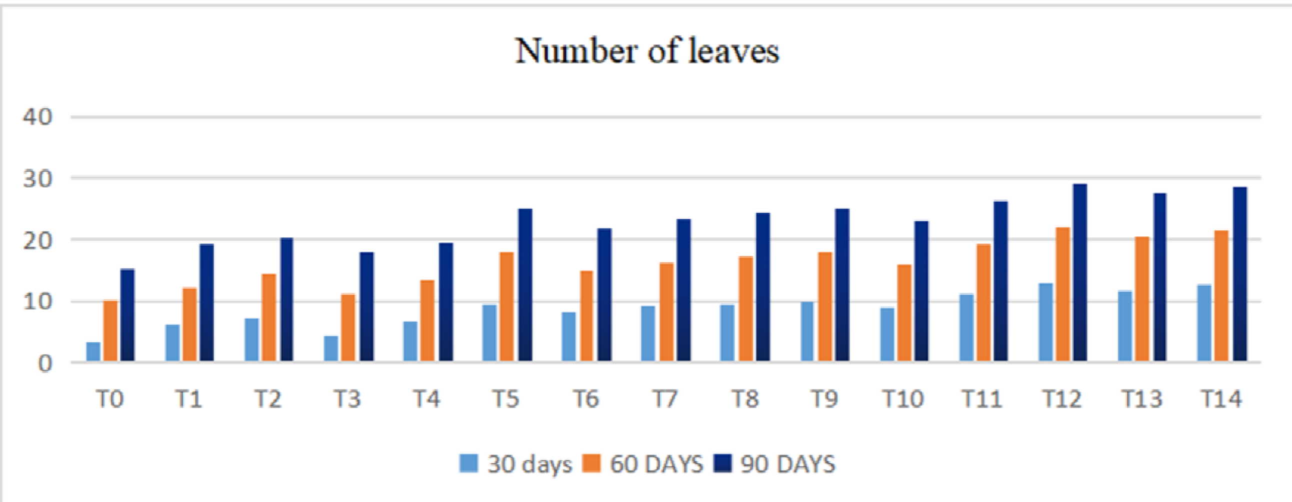

Fig. 2 : Effect of micro-nutrients on number of leaves after 30, 60 and 90 days after planting.

Table 1: Impact of Micronutrients on Growth, Flowering and Yield of Strawberry cv. Chandler

Treatment	Number of flowers per plant	Days to first flowering	Days to fruit set from flowering	Days to fruit maturity from fruit set	Number of fruits per plant	Fruit set (%)	Fruit weight (g)	Fruit yield per plant (g)	Number of runners per plant
T_0	14.22	58.11	8.55	26.55	10.11	71.1	10.26	103.72	2.33
T_1	16.22	55.33	6.67	25.22	12.11	74.66	12.92	156.46	3.22
T_2	17.22	50.55	5.55	23.55	13.22	76.78	13.42	177.41	3.66
T_3	14.55	57.22	7.44	26.22	10.89	72.53	11.28	122.72	2.11
T_4	18.22	49.11	5.22	21.11	13.89	76.23	13.83	192.09	4.44
T_5	18.55	52.44	5.88	23.77	14.33	77.27	13.89	199.04	3.77
T_6	19.22	53.22	6.55	25.55	15.22	79.20	14.15	215.36	3.11
T_7	21.22	48.22	5.67	24.22	16.33	76.95	14.47	236.29	4.11
T_8	19.33	51.33	5.55	23.22	15.33	79.30	15.51	237.76	4.55
T_9	20.11	47.22	5.44	22.33	15.66	77.87	15.11	236.62	4.67
T_{10}	18.55	54.55	5.67	22.55	14.55	77.85	14.83	215.78	3.89
T_{11}	21.45	46.56	4.55	21.55	17.44	81.33	15.59	271.89	4.89
T_{12}	23.55	43.11	4.22	20.22	19.44	82.33	16.07	312.4	5.22
T_{13}	22.33	45.66	4.44	21.00	17.99	80.58	15.84	284.96	5.11
T_{14}	24.22	42.44	4.11	19.22	20.33	83.93	16.29	331.17	5.66
CD (P=0.05)	0.42	0.44	0.94	0.67	0.49	2.32	0.14	7.87	0.89

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