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Influence of macro and micro nutrients on growth and yield parameters of tomato (*Solanum lycopersicum* L.) under open field conditions

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Abstract
The field experiment was carried out at Campus for Research and Advanced Studies, Dhablan, PG Department of Agriculture, GSSDGS Khalsa College, Patiala during *Rabi* season in 2021-2022. The experiment was laid out in Randomized block design (RBD) comprising of eleven treatments and three replications. In case of different treatments maximum plant height (124.42 cm), number of branches plant^{-1} (18.91), number of leaves plant^{-1} (159.27) and in yield attributes maximum results are recorded such as diameter of fruit (4.89 cm),weight of single fruit (87.23 g), fruit yield kg plot^{-1} (44.85), fruit yield q ha^{-1} (461.38) was observed in the treatmentT_7 – 75% RDF + $ZnSO_4$ (12.5%) + B (12.5%) and this treatment was significantly superior over the other treatments. The minimum growth and yield were obtained from the treatment T_1 (control).

Keywords: Tomato, macronutrients, micronutrients, growth and yield

Introduction
Tomato (*Solanum lycopersicum* L.) popularly known as wolf apple, love of apple or Vilayati bangan and the most prominent vegetable crop, belongs to family Solanaceae having chromosome number 2n = 2x = 24. It is self-pollinated crop and it originates in central and South America, more likely western coasts of South America. (Dink and Lee. 1984) [8].
Tomato is classified as an annual plant cultivated in warm season with the average optimum growing temperature range of 25 °C to 29 °C. Tomato contains β-carotene and Lycopene pigments. Tomatoes also keep the blood vessels in healthy condition and prevent scurvy. Tomato plays an important role based on nutritional point of view as it contains calcium (48 mg), ascorbic acid (27 mg), phosphorus (20 mg), carbohydrates (3.6 g), proteins (0.9 g), fiber (0.8 g), iron (0.4 mg), fat (0.2 g) and calories (20 K) of energy per 100g (Ejaz *et al.* 2011) [10].
All vegetables respond constructively to the application of small quantities of micro as well as macro-nutrients (Naz *et al.* 2011) [14]. By maintaining adequate level of nutrients in soil or foliar application, quality and yield of tomato can be enhanced. Both macro and micro nutrients play an important role in quality tomato production. It is now well-established point that chemical fertilizers increase the growth of plants directly (Mehdizadeh *et al.* 2013) [13].
Macronutrients are the nutrients required by the plants in large amounts. These include nitrogen, phosphorus, potassium, sulphur, calcium, carbon, hydrogen and oxygen. Carbon, hydrogen and oxygen are obtained from air and water while the others are obtained from the soil. Effect of nitrogen on vegetative and fruit yield is more distinct than other nutrients, as it promotes the setting of flowers and fruits and it is important for protein production (Sainju *et al*. 2003) [15]. Phosphorus has strong effect on tomato plant. The availability of phosphorous throughout the root zone is essential for root development and good utilization of water and other nutrients by the plant. And, potassium has been found to improve the quality of tomato fruits, regulation of water and nutrient movement and it is essential in nearly all processes needed to sustain plant growth and reproduction (Davis *et al*. 2003) [7].
Micronutrients plays an important role in plant activities and foliar application can improve the vegetative growth, fruit set and yield of tomato (Adams, 2004) [1] by increasing photosynthesis of green plants (Mallick and Muthukrishnan, 1980) [12]. Zn and B are important micronutrient for plant nutrition. Tomato requires both macro and micronutrients, for its proper plant growth. Zinc plays significant role on growth and development as well in carbohydrates, protein metabolism and sexual fertilization of plant (Imtiaz *et al*. 2003, Vasconcelos *et al*. 2011) [11, 18] while the B deficiency decreased tomato yield and quality.

A Balanced fertilization with macro and micro nutrients can increase production (Swan *et al.* 2001[, Ali *et al.* 2008) [17, 3] but foliar application of micronutrients is not only efficient but is a secured way. Thus, micronutrients as their requirement is low but they are essential as the larger amount of primary and secondary nutrients for plant growth and development (Aghtape *et al.* 2011) [2].

Materials and Methods

The field experiment was carried out at Campus for Research and Advanced Studies, Dhablan, PG Department of Agriculture, GSSDGS Khalsa College, Patiala during *Rabi* season in 2021-2022. The experiment was laid out in Randomized block design (RBD) comprising of eleven treatments and three replications. The soil of the experimental field was clayey in texture and having pH 7.8, organic carbon 0.51%, available nitrogen 251.13 kg ha^{-1}, phosphorous 17.23 kg ha^{-1} and available potassium 101.21 kg ha^{-1}.

The nursery raising was done on 2nd November 2021 and the healthy, disease-free seedlings were transplanted at the spacing of 60× 45 cm.

The layout of the field was prepared on 6th December, 2021. The 33 plots were prepared as 10 cm raised ridges along with the addition of the basal doses of manures and fertilizers. Six ridges were made in each plot in row to row and plant-to-plant maintaining a spacing of 60 cm × 45 cm respectively.

Healthy and uniform sized 35 days old seedlings were uprooted separately from the seedbeds. The seed beds were watered before uprooting the seedlings so as to reduce the root injury. The seedlings were transplanted on the ridges of the experimental plots in the morning of 8th December, 2021 maintaining a spacing of 60 cm and 45 cm between the rows and plants respectively and irrigation was given immediately after transplanting. The data was taken from each plot from randomly selected 5 plants after every 30 days of interval i.e 30, 60, 90, 120 DAT and at harvest.

Details of layout

Experimental design	**Randomized Block Design**
No. of replication	3
No. of treatment	11
Total number of plots	33
Spacing	65× 45 cm
Net plot size	3.6 × 2.7 m
Variety	Punjab Upma

Treatment Details

T_1	Control
T_2	100% RDF
T_3	75% RDF
T_4	50% RDF
T_5	75% RDF + $ZnSo_4$ (12.5%) + Mo (12.5%)
T_6	50% RDF + $ZnSo_4$ (25%) + B (25%)
T_7	75% RDF + $ZnSO_4$ (12.5%) + B (12.5%)
T_8	50% RDF + $ZnSo_4$ (25%) + Mo (25%)
T_9	75% RDF + B (12.5%) + Mo (12.5%)
T_{10}	50% RDF + B (25%) + Mo (25%)
T_{11}	25% RDF + $ZnSo_4$ (25%) + B (25%) + Mo (25%)

Results and Discussion

Influence of macro and micro nutrients on growth parameters of tomato (*Solanum lycopersicum* L.): The effect of macro and micro nutrients on the growth attributing characters of tomato are presented in Table 1. At harvest maximum plant height (124.42 cm) was recorded with treatment T_7 with the application of 75% RDF + $ZnSO_4$ (12.5%) + B (12.5%). This treatment was at par with T_5 treatment i.e. 75% RDF + $ZnSo_4$ (12.5%) + Mo (12.5%). The minimum plant height (75.45 cm) was found in treatment T_1 (Control). (Basavarrajeswari *et al.* 2008) [9]

Treatment T_7 with an application of 75% RDF + $ZnSO_4$ (12.5%) + B (12.5%) showed the highest number of branches $plant^{-1}$ (18.91). This treatment was at par with the T_5 treatment i.e. 75% RDF + $ZnSo_4$ (12.5%) + Mo (12.5%) (18.76) and T_2 treatment 100% RDF (18.24). The lowest number of branches $plant^{-1}$ was found from treatment T_1 (Control) (9.44). (Mehdizadeh *et al.* 2013) [13]

Among all the treatments the highest number of leaves $plant^{-1}$ was given by the treatment T_7: 75% RDF + $ZnSO_4$ (12.5%) + B (12.5%) (159.27) and at par with treatment i.e. T_5: 75% RDF + $ZnSo_4$ (12.5%) + Mo (12.5%) (157.72). The lowest number of leaves $plant^{-1}$ was recorded from the treatment T_1 (Control) (125.37). (Singh and Maurya, 2009) [16]

The application of macro and micronutrients provides the nutrients for the proper growth and development of plant. Application of NPK in combined doses with micronutrients helps in the cell elongation, enlargement and cell division. The availability of nitrogenous compounds increases the vegetative growth of the plant that increases the rate of photosynthesis and chlorophyll occurs. It increases the supply of water and food material to the various parts of the plant which makes it more vigorous.

Table 1: Influence of macro and micro nutrients on growth parameters of tomato (*Solanum lycopersicum* L.)

Treatments	**Plant height (cm)**	**Number of branches $plant^{-1}$**	**Number of leaves $plant^{-1}$**
T_1	75.45	9.44	125.37
T_2	115.83	18.24	155.93
T_3	107.58	16.93	150.37
T_4	94.54	14.96	143.32
T_5	123.65	18.76	157.72
T_6	101.99	16.13	146.21
T_7	124.42	18.91	159.27
T_8	100.28	15.39	145.93
T_9	113.83	17.38	153.11
T_{10}	97.58	15.15	145.11
T_{11}	87.83	10.88	132.37
SE (m) ±	0.90	0.51	0.81
CD 5%	1.87	1.07	1.69

Influence of macro and micro nutrients on yield parameters of tomato (*Solanum lycopersicum* L.): The data regarding yield parameters illustrated in Table 2. At harvest the maximum fruit diameter (4.89 cm) was attained from the treatment T_7 with 75% RDF + $ZnSO_4$ (12.5%) + B (12.5%) which was at par with the treatment T_5: 75% RDF + $ZnSo_4$ (12.5%) + Mo (12.5%) (4.71 cm) and T2:100% RDF (4.67 cm). The minimum fruit diameter was found from treatment T_1 (Control) (3.23). (Ali *et al.* 2013) [4]

The maximum weight of single fruit (87.23 g) was assessed from the treatment T_7: 75% RDF + $ZnSO_4$ (12.5%) + B (12.5%). This was at par with the treatment T_5: 75% RDF + $ZnSo_4$ (12.5%) + Mo (12.5%) (85.83 g). The minimum weight of single fruit (54.78 g) was obtained from the treatment T_1 (Control). (Bhatt *et al.* 2004) [6]

Out of all the treatments maximum fruit yield (44.85 kg $plot^{-1}$) was noted from the treatment T_7 with an application of 75%

RDF + $ZnSO_4$ (12.5%) + B (12.5%). This treatment was at par with the T_5: 75% RDF + $ZnSo_4$ (12.5%) + Mo (12.5%) (43.89 kg plot^{-1}). And the minimum fruit yield (14.92 kg plot^{-1}) was recorded from the treatment T_1 (Control). (Basavarajeswari *et al.* 2008) [5]

In study the maximum total yield (461.38q ha^{-1}) was evaluated from the treatment T_7 with an application of 75% RDF + $ZnSO_4$ (12.5%) + B (12.5%) which was at par with the treatment T_5: 75% RDF + $ZnSo_4$ (12.5%) + Mo (12.5%) (451.55 q ha^{-1}). The minimum yield (153.53 q ha^{-1}) was observed from the treatment T_1 (Control). (Dixit *et al.* 2018) [9]

Application of macro and micronutrients provides the favourable conditions for the development of fruit and also improves the transport of water and nutrients. Due to an increased vegetative growth, plants prepare more food. The higher vegetative as well as reproductive growth shows the regular nutrition of plants throughout the growing period. The nutrients provide a favourable condition for the proper growth of the plant that leads to the higher yield characteristics.

Table 2: Influence of macro and micro nutrients on yield parameters of tomato (*Solanum lycopersicum* L.)

Treatments	Fruit Diameter (cm)	Weight of single fruit (g)	Fruit yield (kg plot^{-1})	Fruit yield (q ha^{-1})
T_1	3.23	54.78	14.92	153.53
T_2	4.67	82.86	38.38	394.88
T_3	4.45	75.35	31.49	323.97
T_4	3.92	66.44	24.26	249.58
T_5	4.71	85.83	43.89	451.55
T_6	4.25	71.66	29.28	301.26
T_7	4.89	87.23	44.85	461.38
T_8	4.37	74.83	28.85	296.77
T_9	4.56	78.74	35.31	363.23
T_{10}	4.13	70.24	26.38	271.43
T_{11}	3.78	61.19	21.68	223.07
SE (m) ±	0.42	0.79	0.97	10.00
CD 5%	0.88	1.65	2.03	20.85

Conclusion

It was determined that application of macro and micronutrients performed better with respect to higher growth characters (plant height, number of branches plant^{-1}, number of leaves plant^{-1}), and yield attributes (fruit diameter, weight of single fruit, fruit yield kg plot^{-1}, fruit yield q ha^{-1}) of tomato crop. The maximum results are obtained from the treatment T_7: 75% RDF + $ZnSO_4$ (12.5%) + B (12.5%). Therefore, application of 75% NPK with zinc and boron may be suggested after on farm testing for commercial cultivation of tomato for getting higher yield.

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