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Studies on effect of foliar nutrition of macro and micronutrients on growth and yield of tomato (*Solanum lycopersicum* L.)

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Abstract
A field experiment was conducted at Demo field of Krishi Vigyan Kendra, Theni, Tamil Nadu from 2018 to 2019. The experiment was laid out in a randomized block design and replicated thrice with following eight treatments; T_1 - Control (RDF), T_2 - 100 % RDF+ foliar spray of WSF and IIHR vegetable special, T_3 - 90 % RDF + foliar spray of WSF and IIHR vegetable special, T_4 - 80 % RDF + foliar spray of WSF and IIHR vegetable special, T_5 - 70 % RDF + foliar spray of WSF and IIHR vegetable Special, T_6 - 60 % RDF + foliar spray of WSF and IIHR vegetable special, T_7 - 50 % RDF + foliar spray of WSF and IIHR vegetable special. T_8 - 40 % RDF + foliar spray of WSF and IIHR vegetable special. Different levels of recommended dose of fertilizer were applied at the time of field preparation as a basal dose. Water-soluble fertilizers (19:19:19) and IIHR vegetable special were applied @ 0.25 % (2.5 g L^{-1}) at different stages of growth, i.e., flowering and fruit-development stage. Among the different treatments tried application of 80 % RDF + foliar spray of WSF and IIHR vegetable Special (T4) resulted higher growth characters, viz., plant height (128 cm), number of leaves per plant (87.05), number of branches per plant (4.55), number of flowers per plant (64.01) and yield attributes viz., number of fruits per plant (44.06), fruit weight (65.04 gm), fruit diameter (4.90 mm), fruit yield per plant (3.20 kg $plant^{-1}$) and fruit yield per ha (48.06 t ha^{-1}). Based on the experimental results, it could be concluded that foliar spray of WSF and IIHR vegetable special along with 80 % of recommended dose of fertilizer could be considered as a better option for achieving higher productivity and profitability and improved quality of Tomato.

Keywords: Foliar nutrition, macro, micronutrients, growth, yield, tomato, *Solanum lycopersicum* L.

Introduction
Tomato (*Solanum lycopersicum* L.), belongs to the family solanaceae and an herbaceous plant. It is an important cash crop for small-medium scale farmers and widely cultivated vegetable crop in the world. It is an important source of vitamins and minerals. In terms of human health, tomato is a major component in the daily diet in many countries, and constitutes an important source of minerals, vitamins, and antioxidants (Grierson and Kader, 1986) [3]. Success of tomato cultivation depends on careful application of fertilizers, efficient use of water, spacing, time of planting, weed control etc., Sufficient supply of plant nutrients can increase the fruit yield and quality of tomato (Shukla and Naik, 1993) [10]. The efficiency of fertilizers applied to soil is generally low due to various losses like fixation. Foliar application, a relatively new technology of feeding plants by applying liquid fertilizers directly to their leaves, has been one of the approaches found beneficial to achieve an improvement in yield and quality of different vegetable crops including fruit crops to meet the demand. It reduces fertilizer input by avoiding losses by soil fixation and leaching. Foliar application of micro nutrients eliminates the problem of fixation and immobilization. Hence, foliar nutrition is recognized as an important method of fertilization in modern agriculture, The plant nutrients can be applied by soil and foliar application methods to supply required macro and micro nutrients. The foliar application of micro nutrients is more useful than soil application because it can be utilized by plants effectively. Thus, foliar application provides ample scope for utilization of nutrients efficiently and for correcting nutrient deficiencies rapidly. In this study, the present investigation was undertaken in tomato to study the effect of foliar feeding of water-soluble fertilizers, in combination with soil-applied fertilizers, on growth, yield and quality attributes tomato.

Materials and methods
A field experiment was conducted at Demo field of Krishi Vigyan Kendra, Theni, Tamil Nadu during 2018 - 2019. The experimental site is situated in subtropical region.

The soil in the experimental field was sandy loam in texture, with pH 7.24 (neutral), available N 235 kg ha-1 (low), available P 10.2 kg ha^{-1} (low), available K 294 kg ha^{-1} (high) and organic matter content 0.41 %. The experiment was laid out in a randomized block design and replicated thrice with following eight treatments; T_1 - Control (RDF), T_2 - 100 % RDF+ foliar spray of WSF and IIHR vegetable special, T_3 - 90 % RDF + foliar spray of WSF and IIHR vegetable special, T_4 - 80 % RDF + foliar spray of WSF and IIHR vegetable special, T_5 - 70 % RDF + foliar spray of WSF and IIHR vegetable Special, T_6 - 60 % RDF + foliar spray of WSF and IIHR vegetable special, T_7 - 50 % RDF + foliar spray of WSF and IIHR vegetable special. T_8 - 40 % RDF + foliar spray of WSF and IIHR vegetable special. The tomato variety was used in this experiment. Different levels of recommended dose of fertilizer were applied at the time of field preparation as a basal dose. Water-soluble fertilizers (19:19:19) and IIHR vegetable special were applied @ 0.25 % (2.5 g L^{-1}) at different stages of growth, i.e., flowering stage and fruit-development stage. Observations on growth and yield were recorded in randomly selected plants.

Result and Discussion

Growth attributes

Plant height (cm)

The plant height was significantly influenced by the foliar application of macro and micro nutrients along with soil application of recommended dose of fertilizers. The highest plant height of 128.06 cm (Table 1.) was recorded in the treatment that received 80 % RDF + Foliar spray of WSF and IIHR vegetable special (T_4) and was found to be on par with application of 100 % RDF + foliar spray of WSF and IIHR vegetable special (124.10 cm). The lowest plant height of 61.02 cm was recorded in Control (T_1). The increase in plant height might be due to more availability of macro and micro nutrients by soil and foliar application (Patil *et al.*, 2008) [7]

Number of leaves per plant

The number of leaves per plant was appreciably influenced by the foliar application of macro and micro nutrients along with soil application of recommended dose of fertilizers when compared to the soil application of recommended dose of fertilizers (Fig 1.). Among the various treatments, application of 80 % RDF along with foliar spray of WSF and IIHR vegetable special (T_4) has recorded maximum number of leaves per plant (87.05) which was statistically on par with the treatment that received 100 % RDF + foliar spray of WSF and IIHR vegetable special (84.52). The minimum number of leaves per plant (42.05) was recorded in control (T_1). The increase in number of leaves is attributed to the increased root and shoots growth in early phase which resulted in more number of leaves (Netti Kantaiah, 2008) [6].

Number of branches per plant

Significant variation in number of branches was observed with foliar application of macro and micro nutrients along with soil application of recommended dose of fertilizers at all stages of crop growth (Table 1.). The application of 80 % RDF along with foliar spray of WSF and IIHR vegetable special (T_4) recorded maximum number of branches per plant (4.55) which was statistically on par with the treatment that received 100 % RDF + foliar spray of WSF and IIHR vegetable special (3.95). The number of branches per plant (2.06) was less in control (T_1) (Table. 1). This might be due to higher levels of nitrogen and phosphorus at the early stage may have encouraged higher number of auxiliary buds to sprout and, ultimately, resulted in higher number of primary and secondary branches per plant. Similar results of better branching with foliar application of nutrients were reported by Chaurasia *et al.* (2006) [2].

Table 1: Effect of foliar nutrition of macro and micronutrients on growth of Tomato

Treatments	Plant height (cm)	No. of leaves per plant	No. of branches per plant	No. of flowers per plant
T1 - Control (100 % RDF)	61.02	42.05	2.06	24.03
T2 - 100 % RDF + foliar spray of WSF and IIHR vegetable special	124.10	84.52	3.95	60.55
T3 - 90 % RDF + foliar spray of WSF and IIHR vegetable special	111.95	74.16	3.21	49.77
T4 - 80 % RDF + Foliar spray of WSF and IIHR Vegetable Special	128.06	87.05	4.55	64.01
T5 - 70 % RDF + Foliar spray of WSF and IIHR Vegetable Special	113.43	77.07	3.23	53.40
T6 - 60 % RDF + Foliar spray of WSF and IIHR Vegetable Special	104.68	68.49	3.15	45.75
T7 - 50 % RDF + Foliar spray of WSF and IIHR Vegetable Special	94.84	59.45	2.49	38.36
T8 - 40 % RDF + Foliar spray of WSF and IIHR Vegetable Special	86.95	56.10	2.34	31.45
S Ed	4.43	3.49	0.28	3.23
CD (0.05 %)	9.45	7.44	0.61	6.90

Number of flowers per plant

The highest number of flowers per plant of 64.01 (Fig 1.) was recorded in the treatment that received 80 % RDF along with foliar spray of WSF and IIHR vegetable special (T_4) which was found to be on par with the treatment that received 100 % RDF + Foliar spray of WSF and IIHR vegetable special (60.55). The lowest number of flowers per plant of 24.03 was observed in control. This might be due to better synthesis of cytokinin with optimum supply of N and phosphorus resulting in more number of flowers (Premsekhar and Rajashree, 2009) [8, 9].

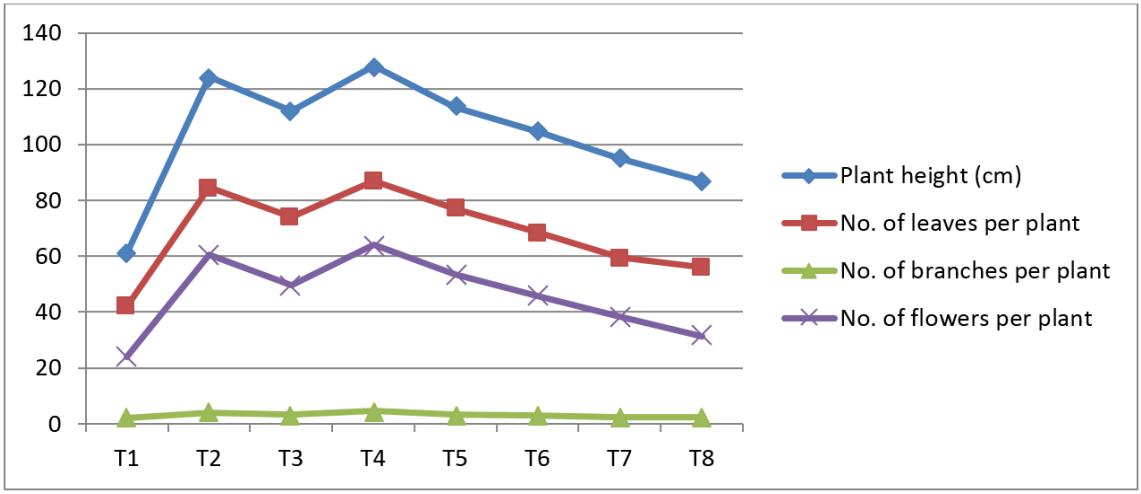

Fig 1: Effect of foliar nutrition of macro and micronutrients on growth of Tomato

Yield attributes

Number of fruits per plant

Significant variation in number of fruits per plant was observed with foliar application of WSF and IIHR vegetable special along with recommended dose of fertilizers (Table 2.). The highest number of fruits per plant of was recorded in the treatment that received 80 % RDF along with foliar spray of WSF and IIHR vegetable special (44.06 per plant) when compared to control (18.02 per plant). This treatment was found to be on par with the treatment that received 100 % RDF along with foliar spray of WSF and IIHR vegetable special (39.24 per plant). This might be due to better synthesis of cytokine with optimum supply of N and phosphorus resulting in more number of fruits (Premsekhar and Rajashree, 2009) [8, 9].

Fruit weight (g)

The effect of various treatments that received different dosage of recommended dose of fertilizers along with foliar spray of macro and micro nutrient sources had a significant effect on fruit weight (Table 2.). The maximum fruit weight of 65.04 g was observed in the treatment that received 80 % RDF along with foliar spray of WSF and IIHR vegetable special (T_4) which was found to be on par with the treatment that received 100 % RDF along with foliar spray of WSF and IIHR vegetable special with a fruit weight of 63.46 g against the lowest fruit weight of 39.02 g in control (T_1). This might be due to better supply of K with its split application and supplementation of secondary and micro nutrients might have enhanced the fruit size. (Batra *et al.*, 2002) [1].

Fruit diameter (mm)

The maximum fruit diameter of 4.90 mm was observed in the treatment that received 80 % RDF along with foliar spray of WSF and IIHR vegetable special (T_4). However, it was found to be on par with the treatment that received 100 % RDF along with foliar spray of WSF and IIHR vegetable special (4.41 mm). Lowest fruit diameter of 2.25 mm in control (T_1). This might be due to increased uptake of nutrients and better utilization of photosynthesis resulting in food accumulation in edible parts (Guievence and Badem, 2000) [4].

Table 2: Effect of foliar nutrition of macro and micronutrients on yield and yield attributes of Tomato

Treatments	No. of fruits per plant	Fruit weight (g)	Fruit diameter (mm)	Fruit yield per plant (kg)	Fruit yield (t/ha)
T_1 - Control (100 % RDF)	18.02	39.02	2.25	1.21	29.06
T_2 - 100 % RDF + foliar spray of WSF and IIHR vegetable special	39.24	63.46	4.41	3.05	46.64
T_3 - 90 % RDF + foliar spray of WSF and IIHR vegetable special	33.56	56.81	3.35	2.40	43.74
T_4 - 80 % RDF + Foliar spray of WSF and IIHR Vegetable Special	44.06	65.04	4.90	3.20	48.06
T_5 - 70 % RDF + Foliar spray of WSF and IIHR Vegetable Special	34.14	57.80	3.56	2.49	44.94
T_6 - 60 % RDF + Foliar spray of WSF and IIHR Vegetable Special	29.95	54.63	3.24	2.38	42.15
T_7 - 50 % RDF + Foliar spray of WSF and IIHR Vegetable Special	24.95	49.03	2.52	1.88	38.54
T_8 - 40 % RDF + Foliar spray of WSF and IIHR Vegetable Special	23.24	47.13	2.44	1.62	36.92
S Ed	2.31	2.55	0.30	0.23	0.72
CD (0.05 %)	4.94	5.45	0.65	0.49	1.54

Fruit yield (kg plant^{-1})

Significant difference in the fruit yield was observed due to various treatments that received different dosage of recommended dose of fertilizer along with foliar spray of macro and micro nutrients (Table 2.). The maximum fruit yield of 3.20 kg per plant was recorded in the treatment that received 80 % RDF along with foliar spray of WSF and IIHR vegetable special (T_4) which was found to be on par with the treatment that received 100 % RDF along with foliar spray of WSF and IIHR vegetable special with a fruit yield of 3.05 kg per plant as against the lowest fruit yield of 1.21 per plant in control (T_1). This might be due to increased uptake of nutrients and better utilization of photosynthesis resulting in food accumulation in edible parts (Guievence and Badem, 2000) [4]

Fruit yield (t ha^{-1})

The maximum fruit yield of 48.06 t ha^{-1} (Fig 2.) was recorded in the treatment that received 80 % RDF along with foliar spray of WSF and IIHR vegetable special (T_4) which was

found to be on par with the treatment that received 100 % RDF along with foliar spray of WSF and IIHR vegetable special (T_4) with a fruit yield 46.64 t ha^{-1} as against the lowest fruit yield of 29.06 t ha^{-1} in control (T_1). This might be due to better synthesis of cytokinin with optimum supply of N and phosphorus resulting in more number of fruits (Premsekhar and Rajashree, 2009) [8, 9]. There are also reports on higher fruit setting by soil or foliar supplementation of secondary and micro nutrients which may be attributed to supply of nutrients at critical stage i.e. at flowering and fruit set (Naik *et al*., 2002) [5].

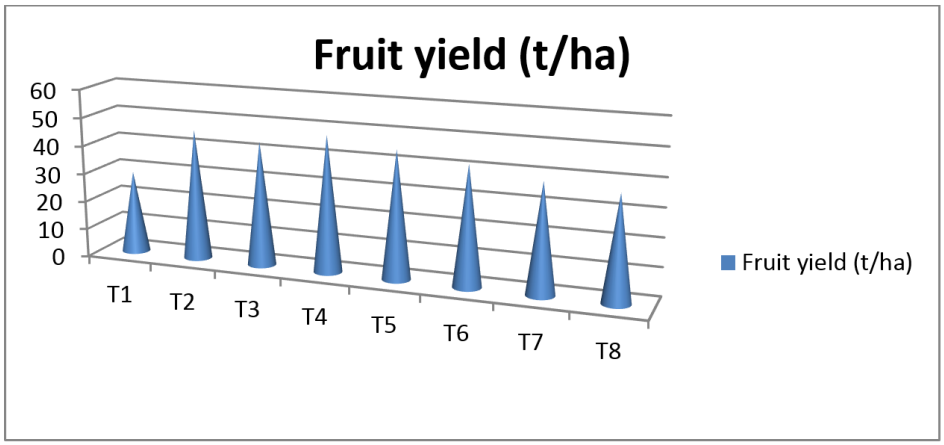

Fig 2: Effect of foliar nutrition of macro and micronutrients on yield of Tomato

Conclusion

Over all, from the experimental results, it could be concluded that foliar spray of WSF and IIHR vegetable special along with 80 % of recommended dose of fertilizer could be considered as a better option for achieving higher productivity and profitability and improved quality of Tomato (*Solanum lycopersicum* L.).

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