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RESEARCH ARTICLE

Effect of Micronutrients in Acid Lime (*Citrus aurantifolia Swingle*) var. PKM-1

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ABSTRACT

The present study aimed to the effect of micronutrients in acid lime var. PKM-1 by observing its growth, yield and quality. The foliar application was given twice in a season *viz.,* the first spray was given during peak flowering stage and the next spray during fruit set stage on selected five trees for each treatment at farmer's field. The trial was laid out in a randomized block design (RBD) with thirteen treatments and replicated thrice. The treatments details are 0.5 % Ferrous sulphate (T_1), 1.0 % Ferrous sulphate (T_2), 0.5 % Zinc sulphate (T_3), 1.0 % Zinc sulphate (T_4), 0.5 % Copper sulphate (T_5), 1.0 % Copper sulphate (T_6), 0.5 % Manganese sulphate (T_7), 1.0 % Manganese sulphate (T_8), 0.1 % borax (T_9), 0.3 % borax (T_{10}), 0.5 % Ferrous sulphate + 0.5 % Zinc sulphate + 0.5 % Copper sulphate + 0.5 % Manganese sulphate + 0.1 % borax (T_{11}), 1.0 % Ferrous sulphate + 1.0 % Zinc sulphate + 1.0 % Copper sulphate + 1.0 % Manganese sulphate + 0.3 % borax (T_{12}) and control (T_{13}). Results revealed that T_{12} recorded the highest values of growth and yield contributing traits such as plant height (5.50 m), number of fruits per plant (652.20), fruit weight (41.50 g), number of seeds (8.11) and yield per plant (15.87 kg/tree) and quality traits *viz.,* TSS (6.48 ^{o}Brix), juice content (35.50 mL), ascorbic acid content (35.02 mg/100g), acidity (9.10 %) and B:C ratio (2.15) and followed by T_{11} whereas the lowest values were observed in control (T_{13}).

Keywords: *Citrus; micronutrients; yield; growth; quality characters; B:C ratio*

INTRODUCTION

Acid lime (*Citrus aurantifolia* Swingle) is an important commercial species of citrus considered to be indigenous to India and is extensively cultivated in many parts of India across tropical and subtropical regions. It is otherwise called as sour lime or Kagzi nimboo. India is the largest producer of acid lime in the world. The area and production of acid lime in India is about 305.0 thousand hectares and 3482.0 thousand MT, respectively (NHB, 2019). In Tamil Nadu, acid lime is cultivated in an area of about 9.88 thousand hectares which accounts for the production of 34.51 thousand MT. In India, Maharashtra, Andhra Pradesh, Assam, Tamil Nadu, Gujarat, Rajasthan, and Bihar are the leading states in acid lime cultivation. In Tamil Nadu, it is widely cultivated in Tirunelveli, Tenkasi, Tuticorin, Dindigul, Madurai, Perambalur, Tiruchirapalli, Theni and Virudhunagar districts under rainfed and irrigated conditions. Fruits are being used for the preparation of pickles and beverages and are rich in citric acid, ascorbic acids, minerals and salts. Among the several factors responsible for the reduction in yield and quality of acid lime, deficiency of soil micronutrients is the major hinder that cause significant loss in economic yield. Generally, acid lime is a micronutrient-loving plant and hence, the application of micronutrient considerably enhances the flowering and fruit quality. Micronutrients such as zinc, iron and boron plays a vital role in acid lime plants. Zinc is essential component of enzymes responsible for nitrogen metabolism, thereby resulting in an increase in uptake of nitrogen by the plant. It has an important role in starch metabolism, and acts as co-factor for many enzymes, affects photosynthesis reaction, nucleic acid metabolism, and protein biosynthesis (Alloway, 2008). Iron plays an important role in the activation of chlorophyll and in the synthesis of many proteins such as different cytochrome, which participate in different functions in plant metabolism (Al- Bamarny *et al.,* 2010; 0' Neil and Ross, 2002). Nutrients play an important role in keeping up the growth, yield and quality of fruit crops through improving flowering, fruit set, fruit drop control, fruit shape and size etc. Nutritional deficiencies are closely associated with poor plant growth and fruit set, heavy fruit drop, inferior quality of produce and also make the tree vulnerable to diseases, pests and other disorders (Vasure *et al.,* 2018). With this background, the present experiment was undertaken to investigate the effect of different combinations of

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micronutrients on growth, fruit yield and quality of acid lime var. PKM-1.

MATERIAL AND METHODS

The present experiment on the effect of micronutrients on the growth, yield and quality of acid lime var. PKM-1 was conducted at farmers' field at Vannikonenthal, Sankarankovil block of Tirunelveli district, Tamil Nadu. The present study aims to find out the suitable micronutrient combination for increasing flowering, yield and quality of acid lime fruits. The experiment was conducted during 2020 – 2021. Seven years old trees of acid lime var. PKM-1 was selected at farmers' field for the experiment. Five trees were used for each replication. Trees were planted at a spacing of 6 × 6 m. Foliar application of micronutrients sprayed during September - October and March – April every year. Each treatment was imposed on five uniform trees. The spray was given twice in a season. The first spray was given during peak flowering stage (October) and the next spray was given during the fruit set stage (15 days after the first spray). Micronutrients such as ferrous sulphate, copper sulphate, zinc sulphate, manganese sulphate and borax were prepared by dissolving in water and then the volume was made up. The experiment was laid out in a Randomized Block Design (RBD) with thirteen treatments and replicated thrice. The quality characters such as juice content of ten fruits from each treatment weighted and mean were calculated and expressed in per cent. TSS recorded by using hand Refractometer and expressed as ^{o}Brix. Ascorbic acid and acidity content were calculated by using AOAC (1975) method. The observations such as plant height, number of fruits per plant, tree spreading, fruit girth, fruit circumference, fruit volume, fruit weight, yield per plant, B:C ratio, ascorbic acid content, acidity, TSS and fruit juice content was recorded and analyzed statistically as per the methods suggested by Panse and Sukhatme (1967).

T_1 - 0.5 % Ferrous sulphate

T_2 - 1.0 % Ferrous sulphate

T_3 - 0.5 % Zinc sulphate

T_4 - 1.0 % Zinc sulphate

T_5 - 0.5 % Copper sulphate

T_6 - 1.0 % Copper sulphate

T_7 - 0.5 % Manganese sulphate

T_8 - 1.0 % Manganese sulphate

T_9 - 0.1 % borax

T_{10} - 0.3 % borax

T_{11} - 0.5 % Ferrous sulphate + 0.5 % Zinc sulphate + .5 % Copper sulphate + 0.5 % Manganese sulphate + 0.1 % borax

T_{12} - 1.0 % Ferrous sulphate + 1.0 % Zinc sulphate + 1.0 % Copper sulphate + 1.0 % Manganese sulphate + 0.3 % borax

T_{13} - Absolute control

RESULTS AND DISCUSSION

The effect of growth and yield characters are presented in Table 1. The present study results revealed that T_{12} recorded the highest values of the traits like plant height (3.90 m) and the number of fruits per tree (650.50) followed by T_{11} (3.85; 637.50) whereas T_{13} (control) observed the lowest values in plant height (3.02 m) and the number of fruits per tree (490.30). This might be due to the foliar application of micronutrients along with nutrients which increased the plant height and number of fruits per tree. Application of boron increases the fruit set and thereby increases the number of fruits in acid lime var. PKM-1 (Kaviprasanth *et al.,* 2021). This is in accordance with the findings of Alka *et al.* (2020); Jagtap *et al.,* (2013) in acid lime and Neware *et al.* (2017) in sweet orange.

Traits such as fruit weight (41.50 g) fruit diameter (14.97 cm), fruit circumference (5.40 cm) and fruit volume (43.75 cc) were recorded the highest in T_{12} followed by T_{11} (40.90 g; 14.08 cm; 5.15 cm; 42.90 cc). The lowest fruit characters were noticed in control (T_{13}) (35.60 g; 11.45 cm; 3.30 cm; 32.65 cc). The plants treated with micronutrients especially zinc increased the size/volume/girth of fruits as it regulates the semi-permeability of the cell wall which mobilizes more water into fruits thereby increasing the size of fruits in kagzi lime (Babu *et al.,* 1982). Singh and Kaur (2018) found that foliar application of borax @ 1.5 % increased fruit weight, fruit girth and yield per tree in Baramasi lemon under Punjab conditions.

T_{12} treatment exhibited the highest yield per tree (15.87 kg/tree) followed by T_{11} (14.65 kg tree^{-1}) whereas the lowest yield was found in T_{13} (11.21 kg tree^{-1}). This might be due to foliar application of micronutrients increasing the more fruit set, fruit retention and the number of fruits per plant which leads to increasing the yield per tree. Zinc plays a major role to increase the flowering, fruit set and fruit size, control the fruit drop and ultimately increasing the yield as well as increasing source and sink relationship which results in the translocation of accumulated carbohydrates to the sink which ultimately regulates the yield of acid lime (Awasthi *et al.,* 1975). This result in accordance with the findings of Alka *et al.* (2020); Jagtap *et al.* (2013); Kavinprashanth *et al.* (2021); Kachava and Bhosle (2007) in acid lime. Neware *et al.* (2017) observed that

foliar application of 2,4-D (20 ppm) + $ZnSO_4$ (1 %) + $FeSO_4$ (1 %) + $MnSO_4$ (1 %) was found to be more effective in increasing the number of fruits per tree, average fruit weight and yield in sweet orange.

The effect of micronutrients on quality traits is presented in Table 2. The treatment T_{12} registered the highest values of the quality traits such as TSS (7.25 ^{o}Brix), fruit juice content (35.50 mL), ascorbic acid (35.02 mg/100g) and acidity (9.10 %) followed by T_{11} (7.05 ^{o}Brix; 33.10 mL, 32.92 mg/100 g; 8.90 %), whereas the lowest values were observed in T_{13} (5.05 ^{o}Brix; 23.90 ml, 25.08 mg/100 g; 7.35 %). The increased juice content due to the application of micronutrients might be due to the role of zinc in plant metabolism. Zinc regulates the semi-permeability of cell wall by which more water was mobilized into the fruits, thereby increasing the percentage of juice. TSS with the application of micronutrients especially zinc might be due to increased photosynthetic activity and chlorophyll content of leaves which resulted in production of more TSS in fruit juice (Tagad *et al.,* 2018). Singh and Rethy (1985) observed that application of different micronutrient and their combinations along with NAA improved the TSS and titrable acidity content of fruit juice in acid lime.

Regarding benefit-cost ratio, T_{12} recorded the highest ratio of 2.15 followed by T_{11} (2.13) whereas the lowest B:C ratio was observed in control (T_{13}) (1.90). This might be due to highest net profit, number of fruits per tree and yield per tree which enhanced the benefit-cost ratio compared to the control.

Table 1. Table 1: Effect of micronutrients on growth and yield of acid lime var. PKM-1

Treatment details	Plant height (m)	Tree spread (m)		Number of fruits per plant	Fruit diameter (cm)	Fruit circumference (cm)	Fruit weight (g)	Fruit volume (cc)	Number of seeds	Fruit yield (kg/tree)	B:C ratio
		East - West	North - South								
T_1	3.66	4.20	4.60	490.30	13.11	3.95	39.50	38.55	6.21	13.02	1.98
T_2	3.85	4.15	4.26	501.70	13.21	4.30	40.70	38.90	6.30	13.25	2.02
T_3	3.97	4.60	4.96	520.10	12.96	3.70	40.20	36.56	6.45	13.87	2.05
T_4	4.01	4.65	5.50	535.20	11.91	4.00	40.50	35.25	6.50	13.89	2.10
T_5	4.02	4.50	5.32	550.20	12.62	3.55	36.65	41.49	7.50	12.58	2.00
T_6	3.48	4.55	4.64	561.15	12.42	3.60	35.50	34.65	7.58	12.67	2.08
T_7	3.82	5.05	4.59	628.60	13.83	3.45	38.20	41.39	6.72	13.25	2.05
T_8	3.95	4.60	4.74	631.40	13.72	4.55	40.00	41.75	7.15	13.46	2.03
T_9	4.05	4.70	4.31	614.50	13.07	3.85	34.10	35.75	7.60	13.55	2.08
T_{10}	4.08	4.75	4.83	621.10	13.16	4.05	35.45	42.20	7.71	13.86	2.10
T_{11}	4.10	5.25	5.11	637.50	14.08	5.15	40.90	42.90	7.99	14.65	2.13
T_{12}	4.15	5.50	5.09	652.20	14.97	5.40	41.50	43.75	8.11	15.87	2.15
T_{13}	3.42	4.10	4.05	478.20	11.45	3.30	35.60	32.65	5.45	11.21	1.90
SEd	**0.143**	**NS**	**NS**	**18.139**	**0.469**	**0.148**	**1.426**	**1.419**	**0.187**	**0.497**	
CD (P= 0.05 %)	**0.290**			**38.670**	**0.960**	**0.300**	**2.94**	**2.92**	**0.394**	**0.985**	

Table 2. Effect of micronutrients on fruit quality of acid lime var. PKM-1

Treatment details	TSS (^{o}Brix)	Juice content (mL)	Ascorbic acid content (mg/100g)	Acidity (%)
T_1	6.15	30.90	27.88	7.45
T_2	6.25	31.10	29.39	7.58
T_3	5.80	26.65	26.91	7.64
T_4	5.85	24.50	25.79	7.69
T_5	5.60	25.15	26.57	7.62
T_6	5.85	24.90	26.21	7.68
T_7	6.35	36.25	31.60	8.75
T_8	6.40	35.05	30.15	8.78
T_9	5.95	28.70	27.50	8.69
T_{10}	6.35	32.30	28.22	8.72
T_{11}	6.39	33.30	32.92	8.90
T_{12}	6.48	35.50	35.02	9.10
T_{13}	5.05	23.90	25.08	7.35
SEd	**0.220**	**1.040**	**1.010**	**0.290**
CD (P= 0.05 %)	**0.450**	**2.140**	**2.090**	**0.620**

CONCLUSION

Based on the results of the present investigation, it can be concluded that T_{12} registered the highest values of growth, yield and quality characters. Foliar application of micronutrients will increased yield of 21 per cent with the B:C ratio (2.15) over the control.

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