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The effect of nutrients on physico - chemical composition yield and economics of acid lime

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Abstract
The experiment entitled "Effect of macro and micro nutrients on flowering, fruiting and yield of Acid lime" was conducted at fruit research station Imalia, Department of horticulture, JNKVV, Jabalpur (MP) during the 2017-2018. The experiment was laid out in randomized block design (RBD) with 19 treatments and three replications. Twelve years old uniform trees of acid lime fruit research station Imalia (*Citrus aurantifolia* Swingle) were selected for the study. The result revealed that the highest Number of fruit/plant (960), Fruit yield (43.3 kg/plant) and physico - chemical composition *i.e.* Maximum fruit length (39.1mm, 40.0mm, 43.9mm & fruit girth 41.6mm, 43.5mm, 43.6mm at 60, 90 & 120 days, respectively), maximum fruit weight (47.08g) at harvest, juice content (60.46%), minimum 7 seed/ fruit, highest peel thickness (1.65mm), lowest peel/ juice ratio (0.098) & peel/ juice ratio (0.105) and maximum TSS (8.22 0Brix), Ascorbic Acid (34.18 mg/100g) and minimum acidity (6.40%) was recorded with foliar application of T_{15} (Urea (4%) + ZnSO4 (0.8%) was significantly superior than all over treatment. Maximum net return (747548 Rs. /ha $^{-1}$) and Benefit cost ratio 6.21:1 were found with the application of Urea (4%) + $ZnSO_4$ (0.8%) and minimum net return (506027 Rs/ha$^{-1)}$ and Benefit cost ratio was recorded 4.08:1 under control.

Keywords: Nutrient, yield, physio-chemical, bio-chemical and acid lime002E

Introduction
Acid lime (*Citrus aurantifolia* Single), belong to family Rutaceae, probably originated in southern slope of Himalayan region, the entire northeastern region of India and then spread to the Middle East and other tropical & subtropical countries. Acid lime is a third most important citrus crop in India next to mandarins and sweet oranges. It is generally grown under both tropical and subtropical climatic condition in the plains up to 1200 m MSL (Thiruganavel *et al.*, 2007). Fruit of acid lime possess great medical and nutritional value. It is appetizer, stomachic, antioxidant properties (Thirugnanavel *et al.*, 2007) [19]. The nutritional value of acid lime per 100 g energy- 30 Kcal, carbohydrate10.5g, sugar 1.7g, fat 0.2 g, protein 0.7g, vitamin ''C'' 29.1mg, thiamine (B1) 0.03mg, calcium 33 mg. Fruits being acidic in nature, they are largely used for garnishing and flavouring several vegetarian and non- vegetarian dishes. Besides its value-added products like pickle, juice, squash etc. Lime peel oil, peel powder are also in great demand in soap and cosmetic industry (Debaje *et al.*, 2011) [5]. Acid lime is grown commercially in Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat, Bihar and West Bengal (Devi *et al.*, 2011) [6].

Total area and production in India under lime 259 thousand ha with production of 2789 thousand MT. (Anonymous, 2015) [1]. The total area and production of acid lime in Madhya Pradesh are 11.2 thousand hectares and 245.00 thousand tones, respectively (Anonymous, 2016) [2]. In Madhya Pradesh it is cultivated Dhar, Badwani, Khargone, Khandwa, Ujjain, Ratlam Mandsor, Shajapur, Gwalior, Burhanpur, Hosangabed, Murena and Guna districts.

The positive effect of Zn sprays on nutritional status, increase flowering, fruit set, fruit size and control fruit drop and ultimately increase the yield. Foliar application of Zn can improve the citrus fruit yield and quality and control the premature fruit drop (Rodriguez *et al.*, 2005) [16].

Method and materials
The experiment was conducted at fruit research station Imalia, Department of horticulture, JNKVV, Jabalpur (MP) during the 2017-2018. Geographically, Jabalpur is situated in "Kymore plateau and satpura hill" agro climate region of Madhya Pradesh at 2309 "North latitudes and 79058" East longitude and at the altitude of 411.78 meters above the mean sea level. Jabalpur is situated in the semi arid region having subtropical climate with hot dry summer and cold winter. The middle annual rainfall of about 1350 mm, which is mainly distributed from mid-June to September with occasional rain during winter.

The soil of the experimental field (pH – 6.9) was medium black with good drainage and uniform texture with medium NPK status. The experiment was laid out in randomized block design (RBD) with 19 treatments and three replications. Treatments such as T_1 (Control), T_2 -Urea (2%), T_3 - Urea (4%), T_4 - Urea (2%) + MgSO4 (0.7%), T_5 - Urea (2%) + MgSO4 (0.8%), T_6 - Urea (4%) + MgSO4 (0.7%), T_7 - Urea (4%) + MgSO4 (0.8%), T_8 - Urea (2%) + FeSO4 (0.4%), T_9 - Urea (2%) + FeSO4 (0.6%), T_{10} - Urea (4%) + FeSO4 (0.4%), T_{11} - Urea (4%) + FeSO4 (0.7%), T_{12} - Urea (2%) + ZnSO4 (0.4%), T_{13} - Urea (2%) + ZnSO4 (0.6%), T_{14} - Urea (4%) + ZnSO4 (0.7%), T_{15} - Urea (4%) + ZnSO4 (0.8%), T_{16} - Urea (2%) + Boron (0.25%), T_{17} - Urea (2%) + Boron (0.50%), T_{18} - Urea (4%) + Boron (0.25%) and T_{19} - Urea (4%) + Boron (0.50%). Twelve years old uniform trees of acid lime fruit research station Imalia (*Citrus aurantifolia* Swingle) were selected for the study.

Result and discussion

The data presented in Table 1 and Table 2. It revealed that application of macro nutrients with combination of micro nutrients significantly influenced the physical, bio-chemical and yield parameters of acid lime.

Table 1: Effect of macro and micro nutrients on Physical parameters in acid lime.

Treat. Symb.	Fruit length (mm) at days after fruit set			Fruit girth (mm) at Days After Fruit Set			Fruit girth (mm) at Days After Fruit Set			Fruit weight at harvest (g)	Juice content (%)	Fruit weight at harvest (g)	No. of seed/fruit
	60	90	120	60	90	120	60	90	120				
T_1	31.0	33.6	34.0	31.3	33.1	34.0	31.3	33.1	34.0	33.8	47.13	33.8	11
T_2	33.4	35.6	36.6	32.0	34.3	36.0	32.0	34.3	36.0	34.9	49.84	34.9	11
T_3	36.0	38.2	40.1	34.0	36.1	38.2	34.0	36.1	38.2	36.2	51.72	36.2	9
T_4	33.4	33.8	36.2	33.3	34.7	35.4	33.3	34.7	35.4	37.4	50.73	37.4	11
T_5	33.4	33.8	36.4	32.0	35.6	36.4	32.0	35.6	36.4	37.0	51.14	37.0	10
T_6	36.0	37.1	38.3	36.08	37.0	37.1	36.08	37.0	37.1	39.3	53.06	39.3	8
T_7	36.4	38.5	40.7	37.09	38.0	38.0	37.09	38.0	38.0	41.4	54.15	41.4	7
T_8	33.1	34.1	41.6	33.08	34.4	35.0	33.08	34.4	35.0	37.2	51.82	37.2	11
T_9	34.1	36.6	41.8	34.07	35.3	36.1	34.07	35.3	36.1	37.3	52.23	37.3	10
T_{10}	36.4	39.3	41.9	38.04	39.6	41.2	38.04	39.6	41.2	41.3	53.58	41.3	8
T_{11}	37.0	39.8	42.6	39.72	41.6	42.0	39.72	41.6	42.0	41.3	55.51	41.3	10
T_{12}	33.0	37.3	38.9	33.42	35.0	36.1	33.42	35.0	36.1	40.4	52.17	40.4	10
T_{13}	33.1	37.6	39.5	33.06	35.5	36.1	33.06	35.5	36.1	40.6	53.14	40.6	10
T_{14}	37	39.1	43.2	40.29	42.3	42.5	40.29	42.3	42.5	44.1	57.08	44.1	8
T_{15}	39.0	40.0	43.9	41.63	43.5	43.6	41.63	43.5	43.6	47.0	60.46	47.0	7
T_{16}	33.1	36.6	37.9	33.06	34.4	35.4	33.06	34.4	35.4	41.3	53.82	41.3	9
T_{17}	34.0	37.0	37.2	34.13	35.5	36.4	34.13	35.5	36.4	40.2	55.04	40.2	9
T_{18}	35	37.8	41.6	39.38	40.3	41.2	39.38	40.3	41.2	41.2	55.15	41.2	8
T_{19}	35.1	38.0	42.5	60	90	120	40.08	41.0	42.1	42.1	56.55	42.1	8
SEm ±	0.84	1.21	2.04	31.3	33.1	34.0	0.684	1.000	0.591	0.95	0.46	0.95	0.58
CD 5%	2.42	3.50	5.89	32.0	34.3	36.0	1.970	2.879	1.701	2.76	1.40	2.76	1.70

Table 2: Effect of macro and micro nutrients on physical, Bio-chemical and Yield in acid lime.

Treat. Symb	Physical Parameters			Bio-chemical paramters			Yield Parameters	
	Peel thickness (mm)	peel and pulp ratio	Peel and juice ratio	Total Soluble Solids (^{0}Brix)	Ascorbic Acid (mg/100g)	Acidity (%)	Number of fruit/plant	Fruit yield (kg) /plant
T_1	1.42	0.08	0.140	6.52	24.8	6.8	750	31.5
T_2	1.46	0.08	0.136	6.78	26.9	6.6	795	34.4
T_3	1.52	0.08	0.136	7.35	30.3	6.6	858	37.0
T_4	1.48	0.07	0.136	6.90	26.7	6.5	810	35.3
T_5	1.49	0.08	0.135	6.98	26.6	6.5	828	36.0
T_6	1.53	0.07	0.128	7.42	30.2	6.5	880	38.0
T_7	1.55	0.07	0.122	7.52	29.9	6.5	900	39.1
T_8	1.46	0.07	0.125	6.58	26.5	6.6	837	36.5
T_9	1.47	0.07	0.121	6.72	26.4	6.6	847	37.0
T_{10}	1.54	0.07	0.120	7.52	30.4	6.4	920	40.0
T_{11}	1.56	0.07	0.116	7.72	30.6	6.4	930	40.5
T_{12}	1.46	0.07	0.120	6.75	27.4	6.5	862	38.0
T_{13}	1.50	0.07	0.117	6.97	28.5	6.4	875	38.5
T_{14}	1.63	0.07	0.105	8.05	32.3	6.4	909	40.5
T_{15}	1.65	0.06	0.098	8.22	34.1	6.4	960	43.4
T_{16}	1.47	0.07	0.115	6.78	28.4	6.6	862	37.4
T_{17}	1.49	0.07	0.114	7.35	29.5	6.6	882	40.0
T_{18}	1.48	0.07	0.117	7.37	30.2	6.5	896	39.0
T_{19}	1.49	0.07	0.116	7.45	30.5	6.5	905	39.4
SEm ±	0.03	0.003	0.009	0.12	0.39	0.05	1.309	1.010
CD 5%	0.09	0.008	0.023	0.36	1.13	0.16	3.769	2.909

Physical parameter

Analysis of data from preceding chapter clearly indicate that application of various macro and micro nutrients significantly improve fruit length & fruit girth or diameter, fruit weight at harvest (g), juice (%), number of seed/fruit Peel thickness (mm), Peel Pulp ratio, Peel Juice ratio. Maximum fruit length 39.1mm, 40.0mm, 43.9mm & fruit girth 41.6mm, 43.5mm, 43.6mm at 60, 90 & 120 days respectively., maximum fruit weight (47.08g) at harvest, (%) of juice content (60.46%), minimum 7 seed/ fruit, highest peel thickness (1.65mm), lowest peel/ juice ratio (0.098) & peel/ juice ratio (0.105) was recorded with foliar application of T_{15} (Urea (4%) + ZnSO4 (0.8%) which was superior than all over treatment.

This might be due to adequate and balanced supply of nutrients and reduction in losses of nutrients, which are indispensible for growth and development. The findings of present investigation are in confirmation with the findings of, Permar *et al*., (2014) and Khan *et al.*, (2009) [9].

Similarly Zn application increase the fruit length & girth, fruit size ultimately increase the fruit weight. This might be due to regulate the semi-permeability of cell wall thus mobilizing more water into the fruits, thereby increasing the size of fruit. The enlargement of fruit size is caused by drawing of photosynthesis to the fruit as consequence of intensification of the sink, it helps in cell division and elongation process. (Rath *et al.*, 1978) [14] and (singh and rajput, 1976). Higher juice content observed by the spray of spray of micronutrients (Rama and Bose, 2000) [13] and (Moslehi *et al.*, 2011) [10].

Bio-Chemical parameters

Analysis of data from preceding chapter clearly indicate that application of various macro and micro nutrients significantly improve the fruit quality in terms of TSS, acidity, TSS/acid ratio, ascorbic acid content of acid lime.

Maximum TSS (8.22 0Brix), Ascorbic Acid (34.18 mg/100g) and minimum acidity (6.40%) was recorded with foliar application of T_{15} (Urea (4%) + ZnSO4 (0.8%) was significantly superior than all over treatment.

Urea helped to increased TSS due to its action on converting complex substances into simple ones, which enhances the metabolic activity in fruits and it results in increased TSS of fruit (Parmar *et al*., 2014) [11, 12]. Similarly results achieved by Dasderg *et al*., (1984) [4]. It was noted that foliar spray of urea decreased the acidity due to increased in TSS (Singh and Rajput, 1976). Foliar application of ZnSO4 increased the TSS contents by increasing photosynthetic activity of the plants resulting into the production of more sugars. It is an established fact that zinc is credited with definite role in the hydrolysis of complex polysaccharides into simple sugars, synthesis of metabolites and rapid translocation of photosynthetic products and minerals from other parts of the plants to developing fruits leading to increase in fruit weight, volume and size (Rawat *et al.*, 2010) [15]. Similar results are also found by Parmar *et al.*, (2014) [11, 12].

The maximum reduction in acid content was also obtained under zinc sulphate treatment. It is reported that zinc sulphate being a major substrate of respiration, the decline in the malic acid during fruit ripening might be the results of an increase in membrane permeability which allows acids to be stored in the respiring cells result in decreasing acidity of fruits (Rawat *et al.*, 2010) [15].

Yield parameters

Under present investigation the yield parameter such as number of fruits per plant and fruit yield (kg) per plant significantly increased over control. Maximum 960 fruits per plant and yield 43.4 kg per plant were found with foliar spray of T_{15} (Urea (4%) + ZnSO4 (0.8%) which was significantly superior than all over treatment. The result indicates that the number of fruits per plant was significantly increased due to different levels of urea. The urea has helped in more fruit retention per shoot, which resulted in increasing number of fruits per plant (Syamal *et al*., 2008) [18]. Similar results were found by (Dudi *et al*., 2004) [7].

The cumulative effect of nitrogen on photosynthetic as well metabolic activities has helped to increase the fruit size and fruit weight and thereby increase the fruit yield (Jat and Kacha, 2014) [8].

Zinc play important role in auxin synthesis, resulted into better photosynthesis, greater accumulation of starch in fruits. Balance of auxin in plant regulates the fruit drop or retention in plants, which altered the control of fruit drop and increased the total number of fruit per plant (Venu *et al.*, 2014) [20]. Similar result is obtained by Banik *et al.*, (1997) [3].

Economic analysis

The data presented in Table 3, the application of Urea, ZnSO4, $MgSO_4$, $FeSO_4$ and B plants increased the net returns and B:C ratio. Maximum net return (747548 Rs. /ha $^{-1}$) and Benefit cost ratio 6.21:1 were found with the application of Urea (4%) + $ZnSO_4$ (0.8%) and minimum net return (506027 Rs/ha$^{-1)}$ and Benefit cost ratio was recorded 4.08:1 under control.

Table 3: Effect of foliar application of Urea, ZnSO4, $MgSO_4$, $FeSO_4$ and Borax on economic of the different treatments (per ha).

Treatment	fruit yield (kg/ ha^{-1})	Gross Income (Rs ha^{-1})	Expenditure (Rs ha^{-1})	Net Income (Rs ha^{-1})	B:C ratio
T_1	31.5	630000	123973	506027	4.08:1
T_2	34.4	688000	118095	569905	4.83:1
T_3	37.0	740000	118200	621800	5.26:1
T_4	35.3	706000	118997	587003	4.93:1
T_5	36.0	720000	119997	600003	5.00:1
T_6	38.0	760000	119922	640078	5.34:1
T_7	39.1	782000	120022	661977	5.52:1
T_8	36.5	730000	119705	610295	5.10:1
T_9	37.0	740000	120009	619991	5.17:1
T_{10}	40.0	800000	119730	680270	5.68:1
T_{11}	40.5	810000	120111	689889	5.74:1
T_{12}	38.0	760000	120027	639973	5.33:1
T_{13}	38.5	770000	120227	649773	5.40:1
T_{14}	40.5	810000	120327	689673	5.73:1
T_{15}	43.4	868000	120452	747548	6.21:1
T_{16}	37.4	748000	118527	629473	5.31:1
T_{17}	40.0	800000	119127	680873	5.72:1
T_{18}	39.0	780000	118576	661424	5.58:1
T_{19}	39.4	788000	119152	668848	5.61:1

Conclusion

On the basis of results obtained in present investigation it is Concluded that foliar spray of urea, ZnSo4, Mgso4 & B was found to be the best as compared to control treatment. Among the treatment the foliar application of T_{15} (Urea (4%) + ZnSO4 (0.8%) was effective in enhancing Physical Parameters *viz*. Fruit length & girt, Fruit weight, Juice (%), number of seed/fruit, Peel thickness (mm), biochemical parameter *viz*. TSS, Ascorbic acid & acidity and yield of summer crop in acid lime. On the basis of economic analysis, 4% Urea + 0.8% ZnSO4 found to be economically viable as compare to all other treatments.

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