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Standardization of stage wise requirement of nutrients in acid lime (*Citrus aurantifolia* Swingle)

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Abstract
A field experiment on standardization of stage wise requirement of nutrients in acid lime was carried out at All India Coordinated Research Project on Fruits, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, and Rahuri during 2011-12 to 2014-15. The pooled result of investigation revealed that, the effect of stagewise application of nutrients on growth, yield and fruit quality of acid lime were significant. The maximum plant height (3.38 m), canopy volume (30.30 m^3), average fruit weight (46.77 g), number of fruits (1116 fruits / tree) and yield (40.99 kg / tree and 11.35 t/ha) with higher benefit: cost ratio (1.45) were recorded in the treatment T_2 i.e. 30 % N in stage II and III (March-April and May-June), 20 % N in stage - IV (July-Aug) and 10 % N in stage – V and VI (Sept- Oct and Nov Dec.), while 40 % P_2O_5 in stage - II (March-April), 35 % P_2O_5 in stage - III (May-June) and 25 % P_2O_5 in stage - IV (July-Aug) and 10 % K_2O in stage - II and III (Mar –April and May- June), 30 % K_2O in stage - IV (July-Aug) and 25 % K_2O in stage -V and VI (Sept-Oct. and Nov-Dec). Similarly, significantly the maximum juice content (48.04 %), TSS (8.00 ^{0}Brix), acidity (6.83 %), ascorbic acid (26.13 mg / 100 ml juice) with minimum number of seeds/fruit (7.17), weight of seeds / fruit (0.66 g) and rind thickness (1.12 mm) were also recorded in the same treatment. Hence, split application of nutrient dose is recommended in acid lime for higher yield of quality fruits in medium deep soils

Keywords: TSS, acidity, ascorbic acid, benefit: cost ratio

Introduction
There are four commercially important species of lime namely, *Citrus aurantifolia* (Acid lime), *Citrus latifolia* (Tahiti lime), *Citrus limonia* (Rangpur lime) and *Citurs limettoides* (Sweet lime). Acid lime (*Citrus aurantifolia* Swingle) is a shrubby tree with many thorns and is the member of family Rutaceae. In India, it is cultivated in Andhra Pradesh, Gujrat, Maharashtra, Karnataka, Bihar, Madhya Pradesh, Assam and Chhattisgarh. Acid lime is an important source of vitamin 'C' (Ascorbic acid) for human nutrition. Amount of juice, TSS, titrable acid and vitamin C are the determining factors of quality of acid lime fruits, which may vary according to bearing sides of the trees (Nurbhanej *et al*., 2016) [6]. Nutrient refers to all those compounds which are required by the plant as a source of body building material and for the energy, without which, it will not be able to complete its life cycle. The fruit tree nutrition is concerned with the provision of plant with nutrients as well as nutrient uptake and their distribution in the plant. Plant nutrient management can influence flowering, fruit set, fruit size, vegetative growth and other plant characteristics. There is a need to chalk out nutrition programme by keeping in mind growth as well as phonological cycles of the plant because every shift of growth in association with phonological and growth cycle needs special attention to decide fertilization programme (Yaseen and Ahmed, 2010) [13]. Fruit yield and quality are greatly influenced by N & K supplies in tropical soils because these nutrients are subjected to losses in the environment. Nitrogen is the most important among all the nutrients for tree growth and productivity. It's availability in adequate amount during critical stage of fruit initiation and development is necessary to support optimum yield of good quality fruit (Syvertsen and Smith, 1996) [12]. However, when it is supplied in excess to what is required, it will encourage excessive vegetative tree growth (Schumann *et al.* 2003) [11] or will lead to nitrate leaching and contamination of surface water tables (Alva *et al.* 2006) [1]. The high nitrogen tree demands during the main critical phases of flowering and fruiting process determine tree yield and productivity according to that, fruit set, fruit persistent number and initial fruit size were take place during this period of time. Phosphorous is the essential elements that absorbed as phosphate and play role in the group's photosynthesis, activities regulations and boosts the plant growth (Gholami, 2001) [4]. The effect of phosphorous (P) fertilization on fruit quality to be less clear, even though a decrease in soluble solid

content and total acidity was associated with potassium supply, which was more pronounced during heavy crop years (Anderson, 1966) [3]. Potassium is the second nutrient, which needed in large amount. However, tree potassium requirement are similar to those for N. It will increase fruit size, yield, vitamin C content and fruit quality (Ritenour *et al*. 2002) [12]. Potassium rates increase fruit size and total juice acidity while decrease the total soluble solids content of juice because of increased peel thickness (Quaggio *et al*; 2002) [9].

In acid lime, very less work was carried out on stage wise requirement of nutrients for quantitative and qualitative production. Therefore, attention should be given for to establishing nutrient management strategies to improve growers profitability. Hence, the present investigation was planned with an objective to standardize the stage wise requirement of nutrients in acid lime.

Materials and Methods

A field experiment was carried out during 2011-12 to 2014-15 on the research farm of All India Coordinated Research Project on Fruits, Department of Horticulture, MPKV., Rahuri on light to medium soil in randomized block design with four treatments replicated five times having two plant unit with recommended RDF. Observations on growth, yield and quality parameters like juice content, TSS (Hand Refractometer), titrable acidity and ascorbic acid (AOAC. 2005) [2] were recorded at harvest. All data were subjected to statistical analysis by the method of Panse and Sukhatme (1995) [7].

Treatment details

Treatment	Percent RDF to be supplied through soil application																	
	Stage - I (Jan-Feb)			**Stage - II** (March-April)			**Stage - III** (May-June)			**Stage - IV** (July-Aug)			**Stage -V** (Sept-Oct)			**Stage -VI** (Nov-Dec)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1	0	0	0	40	50	0	40	50	0	20	0	50	0	0	25	0	0	25
T_2	0	0	0	30	40	10	30	35	10	20	25	30	10	0	25	10	0	25
T_3	0	0	0	30	40	0	30	35	0	40	25	30	0	0	35	0	0	35
T_4 Control: 600:300:600 g NPK+15 kg FYM + 15 kg Neem Cake/ plant / year																		

Results and Discussion

The pooled data (2011-12 to 2014-15) presented in Table 1 revealed that, stage wise application of nutrients have significant effect on plant height, canopy volume, average fruit weight, number of fruits / tree and yield of acid lime. Significantly the maximum plant height (3.38 m), canopy volume (30.30 m^3), average fruit weight (46.77 g), number of fruits (1116 fruits / tree) and yield (40.99 kg / tree and 11.35 t/ha) were recorded in treatment T_2 i. e. 30 % N in stage - II and III (March-April and May- June), 20 % N in stage - IV (July-Aug) with 10 % N in stage – V and VI (Sept - Oct and Nov - Dec.) while 40 % P_2O_5 in stage - II (March-April), 35 % P_2O_5 in stage - III (May-June) and 25 % P_2O_5 in stage -IV (July-Aug) and 10 % K_2O in stage -II and III (Mar –April and May- June), 30 % K_2O in stage - IV (July-Aug) and 25 % K_2O in stage - V and VI (Sept-Oct. and Nov-Dec) followed by treatment T_1 i. e. 40 % N in stage - II and III (March – April and May- June), 20 % N in stage - IV (July-Aug) and 50 % P_2O_5 in stage - II and III (March- April and May- June) and 50 % K_2O in stage - IV (July- Aug) and 25 % K_2O in stage - V and VI (Sept - Oct and Nov-Dec). The minimum plant height (2.87 m), canopy volume (23.91 m^3), average fruit weight (35.43 g), number of fruits (1026 fruits / tree) and yield (28.16 kg / tree and 7.79 t/ha) were recorded in treatment T_4 i.e. control: 600:300:600 g NPK + 15 kg FYM + 15 kg Neem cake / plant / year. This result is in conformity with the findings of Ritenour *et al.,* (2002) [10]. Fruit yield of acid lime was largely regulated by nitrogen (N) supply because it affects photosynthesis and carbohydrates production, specific leaf weight and carbon allocation to tree plants. Although optimal N availability results in green foliage color and increased crop yields, excess N can lead to luxury consumption by the tree, negative impacts on fruit size and composition and recorded commercial value for harvested products (Mattos *et al*., 2005) [5].

The data in respect to juice content, TSS, acidity and ascorbic acid were presented in Table 2 revealed that, stage wise application of nutrients have significant effect on juice content, TSS, ascorbic acid and acidity with minimum number of seeds / fruit, weight of seeds / fruit and rind thickness. Significantly the maximum juice content (48.04 %), TSS (8.00 ^oBrix), acidity (6.83 %) and ascorbic acid (26.13 mg /100 ml juice) with minimum number of seeds (7.17 seeds / fruit), weight of seeds / fruit (0.66 g) and rind thickness (1.12 mm) were recorded in Treatment T_2 i. e. 30 % N in stage - II & III (March- April and May - June), 20 % N in stage - IV (July- Aug) and 10 % N in stage - V and VI (Sept-Oct and Nov- Dec.) while 40 % P_2O_5 in stage – II (March-April), 35 % P_2O_5 in stage - III (May-June) and 25 % P_2O_5 in stage - IV (July- Aug) with 10 % K_2O in stage - II and III (March-April and May- June), 30 % K_2O in stage – IV (July-Aug) and 25 % K_2O in stage - V and VI (Sep- Oct and Nov- Dec) as compared to all other treatments. Quaggio *et al.* (2006) [9] reported that, nitrogen rates decreased fruit mass which resulted in increased TSS and juice content of fruits. Nitrogen promoted an accentuated increase in yield of soluble solids per area due to either increased fruit yield or improved fruit characteristics such as juice content and TSS in Valencia sweet orange.

Table 1: Effect of stage wise application of nutrients on growth and yield in acid lime (Pooled mean 2011-12 to 2014-15)

Treatment	Plant height (m)	Canopy volume (m^3)	Av. Fruit weight (g)	Number of fruits/tree	Yield(kg/ tree)	Yield(t/ha)
T_1	3.24	26.20	42.40	1089	36.37	10.07
T_2	3.38	30.30	46.77	1116	40.99	11.35
T_3	3.13	24.80	38.10	1043	30.87	8.54
T_4	2.87	23.91	35.43	1026	28.16	7.79
S. E.±	0.06	0.82	0.97	6.51	0.96	0.26
C. D. at 5 %	0.18	2.34	2.75	18.46	1.90	0.52

Table 2: Effect of stage wise application of nutrients on quality parameters in acid lime (Pooled mean 2011-12 to 2014-15).

Treatment	Juice (%)	TSS (ºBrix)	Acidity (%)	Ascorbic acid (mg/100ml juice)	Number of seeds / fruit	Weight of seeds/fruit (g)	Rind thickness (mm)
T_1	46.67	7.69	6.62	24.53	8.52	0.77	1.24
T_2	48.04	8.00	6.83	26.13	7.17	0.66	1.12
T_3	45.51	7.40	6.71	22.70	9.20	0.80	1.24
T_4	44.59	7.20	6.34	22.48	9.30	0.91	1.32
S. E.±	0.19	0.08	0.12	0.11	0.32	0.03	0.04
C. D. at 5 %	0.40	0.23	0.41	0.23	0.91	0.08	0.14

Economics

The economics of stage wise application of nutrients on benefit: cost ratio is shown in Table 3. The application of 30 % N in stage - II & III (March-April and May-June), 20 % N in stage IV (July- August) and 10 % N in stage - V & VI (Sept- Oct and Nov-Dec) while 40 % P_2O_5 in stage - II (March- April), 35 % P_2O_5 in stage – III (May- June) and 25 % P_2O_5 in stage –IV (July-August) and 10 % K_2O in stage - II & III (March-April and May-June), 30 % K_2O in stage - IV (July - Aug) and 25 % K_2O in stage - V & VI (Sept - Oct and Nov- Dec) was found superior for growth, yield and fruit quality over other treatments and recorded the higher benefit: cost ratio (1.45).

Table 3: Economics on effect of different treatments in acid lime (2014-15).

Treatment	Total Expenditure (Rs/ha)	Yield (t/ha) Pooled mean	Gross monetary return (Rs/ha)	Net Profit (Rs/ha)	B: C ratio
T_1	1,66,617=50	10.07	2,21,540=00	54,922=50	1.32
T_2	1,71,310=83	11.35	2,49,700=00	78,389=17	1.45
T_3	1,61,007=50	8.54	1,87,880=00	26,872=50	1.16
T_4	1,57,844=77	7.79	1,71,380=00	13,535=23	1.08

Conclusion

Split application of nutrient dose is recommended in acid lime for higher yield of quality fruits in medium deep soils.

- March – 30 % N (180 g N) + 40 % P_2O_5 (120 g P_2O_5) + 10 % K_2O (60 g K_2O)
- May - 30 % N (180 g N) + 35 % P_2O_5 (105 g P_2O_5) + 10 % K_2O (60 g K_2O)
- July - 20 % N (120 g N) + 25 % P_2O_5 (75 g P_2O_5) + 30 % K_2O (180 g K_2O)
- September - 10 % N (60 g N) + 25 % K_2O (150 g K_2O)
- November - 10 % N (60 g N) + 25 % K_2O (150 g K_2O)

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