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Effect of different spacings and nutrient levels on growth, yield and fruit quality of acid lime (*Citrus aurantifolia* Swingle) cv. Phule Sharbati

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Abstract

This field experiment on effect of different spacings and nutrient levels on growth, yield and fruit quality of acid lime (*Citrus aurantifolia* Swingle) cv. Phule Sharbati was conducted at ICAR-All India Coordinated Research Project on Fruits, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during the year 2018. The experiment was conducted in Factorial Randomized Block Design (FRBD) with nine treatments replicated three times. Plant spacings were S₁: 6 x 6 m, S₂: 6 x 5 m and S₃: 6 x 4 m. Nutrient levels were L₁: 75% N (Inorganic source) + 25% N (Organic source-FYM) + 100% P and K (100% Inorganic – P and K supplied through FYM), L₂: 50% N (Inorganic source) + 50% N (Organic source-Vermicompost) + 100% P and K (100% Inorganic – P and K supplied through Vermicompost) and L₃: 100% Inorganic only. There were nine treatment combinations. The study revealed that, the treatment T₂ (S₁ L₂) i. e. recommended spacing 6 x 6 m with 50% N (Inorganic source) + 50% N (Organic source-Vermicompost) + 100% P and K (100% Inorganic – P and K supplied through Vermicompost) proved superior and recorded the maximum canopy volume (36.45 m³), stem girth (49.91 cm), number of fruits/tree (1690.80), fruit weight (47.75 g) and yield (80.73 kg/tree). Whereas, the treatment T₈ (S₃ L₂) i. e. spacing 6 x 4 m with 50% N (Inorganic source) + 50% N (Organic source-Vermicompost) + 100% P and K (100% Inorganic – P and K supplied through Vermicompost) recorded the maximum fruit yield (26.08 t/ha) because of more number of trees per hectare. The treatment T₃ (S₁ L₃) i. e. recommended spacing 6 x 6 m with 100% Inorganic only recorded the maximum juice (45.85%), TSS (7.40 °B), acidity (7.23%), ascorbic acid (35.66 mg/100 ml juice), reducing sugars (0.93%), non-reducing sugars (0.96%) and total sugars (1.88%) with minimum weight of seeds/fruit (0.54 g) and rind thickness (1.23 mm). The general appearance and acceptance of the fruit quality was better in the treatment T₃ (S₁ L₃) than rest of the other treatments.

Keywords: Acid lime, spacings, nutrient levels, organic and inorganic fertilizers

Introduction

Acid lime (*Citrus aurantifolia* Swingle) is one of the most commercially grown citrus fruit crop which is widely grown in tropical and sub-tropical region of India. The acid lime fruits are used for making pickles and refreshing drinks as well as for manufacturing syrup and squash. It belongs to family *Rutaceae*. It is a rich source of vitamin C. It contains 6.3 to 6.6% citric acid. Acid lime is mainly grown in semi-arid climate of Maharashtra and adjoining states like Andhra Pradesh, Telangana, Karnataka and Gujarat in central India. Acid lime is one of the important citrus fruit crop grown in Maharashtra on an area of 33 thousand hectares with total production of 324 thousand MT and productivity of 9.81 MT/ha^[2]. High density planting in acid lime was proven successful in increasing productivity. In high density planting the yield per tree reduces but the total yield per unit area increases because of more number of trees per unit area. Acid lime responds very well to nutrient management. Due to high cost of inorganic fertilizers and increasing trend towards organic farming, use of organic fertilizers like farm yard manure and vermicompost occupies a significant place in today's agriculture. The quick and substantial response to fruit production due to mineral fertilizers eclipsed the use of organic manures, the inadequate supply of the latter sources exacerbated this change by Ghosh, 2000^[6]. The cultivable land under fruit crop is decreasing in the state due to urbanization, there is no scope for increasing area under fruit crop. High density planting is an intensive system of cultivation in acid lime not only provides high production and net returns but also facilitates efficient utilization of solar energy, nutrients and water. To being with and to have guidelines for future work on this aspect, the present investigation was planned to find out the effect of different spacings and nutrient levels on growth, yield and fruit quality of acid lime.

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Material and Methods

The present experiment was conducted at ICAR-AICRP on Fruits, Department of Horticulture, MPKV, Rahuri during the year 2018. The experiment was laid out in a Factorial Randomized Block Design (FRBD) with nine treatment combinations each replicated thrice. Treatments comprised of 3 different spacings S_1 : 6 x 6 m, S_2 : 6 x 5 m and S_3 : 6 x 4 m and 3 nutrient levels L_1 : 75% N (Inorganic source) + 25% N (Organic source-FYM) + 100% P and K (100% Inorganic – P and K supplied through FYM), L_2 : 50% N (Inorganic source) + 50% N (Organic source-Vermicompost) + 100% P and K (100% Inorganic – P and K supplied through Vermicompost) and L_3 : 100% Inorganic only. Plant unit used was 4 plants/treatment. Phule Sharbati variety of acid lime was used for study. Tree age was 10 years during study period. The organic and inorganic sources of nutrients as per treatments were applied to acid lime trees by broadcasting method. Care was taken to avoid losses. Observations on growth, yield and fruit quality were recorded. The growth parameter like canopy volume of acid lime tree was calculated based on Castle's [4] formula. The fruit quality parameters like acidity was determined according to the method given in A.O.A.C. [1]. Ascorbic acid, reducing sugars and total sugars content in the fruit was estimated by the procedure described by Ranganna [15]. The data was statistically analysed following the standard procedure suggested by Panse and Sukhatme [10].

Results and Discussion

In the present study, the recommended spacing 6 x 6 m with 50% N (Inorganic source) + 50% N (Organic source-Vermicompost) + 100% P and K (100% Inorganic – P and K supplied through Vermicompost) plays an important role in improvement of growth and yield of acid lime. While, the recommended spacing 6 x 6 m with 100% Inorganic only plays an important role in improvement of fruit quality of acid lime.

The growth and yield data presented in Table 1 revealed that, the differences due to different spacing's on growth and yield were found significant. The maximum canopy volume (34.82 m³), stem girth (48.41 cm), number of fruits/tree (1657.13), fruit weight (45.88 g) and fruit yield (76.09 kg/tree) were recorded by S_1 i. e. recommended spacing 6 x 6 m. The maximum fruit yield (25.18 t/ha) was recorded by S_3 i. e. spacing 6 x 4 m. There was non-significant difference between the spacings for plant height. The differences due to different nutrient levels on growth and yield were found significant. The maximum canopy volume (34.95 m³), fruit weight (43.88 g) and fruit yield (71.85 kg/tree and 24.15 t/ha) were recorded by L_2 i. e. 50% N (Inorganic source) + 50% N (Organic source-Vermicompost) + 100% P and K (100% Inorganic – P and K supplied through Vermicompost). There was non-significant difference between the nutrient levels for plant height, stem girth and number of fruits/tree. The interaction effects due to different spacings and nutrient levels on growth and yield were found significant. The maximum canopy volume (36.45 m³), stem girth (49.91 cm), number of fruits/tree (1690.80), fruit weight (47.75 g) and fruit yield (80.73 kg/tree) were recorded by the treatment T_2 ($S_1 L_2$) i. e. recommended spacing 6 x 6 m with 50% N (Inorganic source) + 50% N (Organic source-Vermicompost) + 100% P and K (100% Inorganic – P and K supplied through Vermicompost). There was non-significant difference between the treatments for plant height. Increase in plant spacing there is incremental

trend of stem girth because plant in normal spacing had more canopy volume as compared to closer spacing by Tachibana and Yahata 1998 [16] in Satsuma mandarin. However, higher concentration of P and K in Vermicompost play an important role in releasing enzyme for higher rooting number which might have higher uptake of nutrients and reflected on bigger size of fruits and fruit weight, more number of fruits and finally reflected on yield were reported by Ramamurthy *et al.* 2006 [14] in Nagpur mandarin and Pawar 2011 [11] in acid lime. These results are in close agreement with the findings of Azhakiamaavalan *et al.* 1996 [3] in mandarin, Pawar *et al.* 2016 [12] in sweet orange and Nurbhane *et al.* 2016 [9] in acid lime. The treatment T_8 ($S_3 L_2$) i. e. spacing 6 x 4 m with 50% N (Inorganic source) + 50% N (Organic source-Vermicompost) + 100% P and K (100% Inorganic – P and K supplied through Vermicompost) recorded the maximum fruit yield (26.08 t/ha) because of more number of trees per hectare. Similar result was obtained by Ghosh *et al.* 2012 [7] in Pomegranate and Rajendra *et al.* 2013 [13] in acid lime.

The fruit quality data presented in Table 2 revealed that, the differences due to different spacings on juice, TSS, acidity, ascorbic acid, non-reducing sugars and rind thickness were found significant. The maximum juice (43.57%), TSS (7.30 °B), acidity (7.10%), ascorbic acid (32.99 mg/100 ml juice) and non-reducing sugars (0.95%) with minimum rind thickness (1.64 mm) were recorded by S_1 i. e. recommended spacing 6 x 6 m. There was non-significant difference between the spacings for reducing sugars, total sugars, number of seeds/fruit and weight of seeds/fruit. The differences due to different nutrient levels on reducing sugars and rind thickness were found significant. The maximum reducing sugars (0.92%) with minimum rind thickness (1.57 mm) were recorded by L_3 i. e. 100% Inorganic only. There was non-significant difference between the nutrient levels for juice, TSS, acidity, ascorbic acid, non-reducing sugars, total sugars, number of seeds/fruit and weight of seeds/fruit. The interaction effects due to different spacings and nutrient levels on fruit quality were found significant except number of seeds/fruit. The maximum juice (45.85%), TSS (7.40 °B), acidity (7.23%), ascorbic acid (35.66 mg/100 ml juice), reducing sugars (0.93%), non-reducing sugars (0.96%) and total sugars (1.88%) with minimum weight of seeds/fruit (0.54 g) and rind thickness (1.23 mm) were recorded by the treatment T_3 ($S_1 L_3$) i. e. recommended spacing 6 x 6 m with 100% Inorganic only. Because of wider spacing of 6 x 6 m, there was increase in more canopy volume as a result there was more photosynthesis rate so more accumulation of dry matter as a result there was improved in fruit quality parameters. Also the application of inorganic fertilizers i. e. optimum dose of NPK may be explained by the fact that phosphorus enters into the composition of phospholipids and nucleic acids, later combines with proteins and results in the formation of nucleo-proteins which are important constituents of the nuclei of the cell. Potassium acts as a catalyst in the formation of more complex substances and in the acceleration of enzyme activity. These carbohydrates and coenzyme have increased the fruit quality of acid lime. Similar results were reported by Dalal *et al.* 2009 [5] in sweet orange, Vadak *et al.* 2014 [17] in sweet orange and Hadole *et al.* 2015 [8] in Nagpur mandarin. There was non-significant difference between the treatments for number of seeds/fruit.

Table 1: Effect of different spacing's and nutrient levels on growth and yield of acid lime

Treatment	Plant height (m)	Canopy volume (m ³)	Stem girth (cm)	Number of fruits / tree	Fruit weight (g)	Fruit yield (kg/tree)	Fruit yield (t/ha)
Spacing's – S ₁	3.48	34.82	48.41	1657.13	45.88	76.09	21.07
S ₂	3.46	33.70	46.66	1604.71	42.50	68.21	22.70
S ₃	3.45	30.63	44.13	1565.96	38.70	60.54	25.18
S. E. (m) ±	0.08	0.94	1.10	22.15	0.73	1.41	0.45
C. D. at 5%	NS	2.82	3.29	66.41	2.20	4.24	1.35
Nutrients – L ₁	3.47	32.95	46.05	1602.38	42.70	68.49	23.08
L ₂	3.51	34.95	48.22	1634.96	43.88	71.85	24.15
L ₃	3.41	31.25	44.94	1590.46	40.50	64.49	21.73
S. E. (m) ±	0.08	0.94	1.10	22.15	0.73	1.41	0.45
C. D. at 5%	NS	2.82	NS	NS	2.20	4.24	1.35
T ₁ (S ₁ L ₁)	3.47	34.80	47.66	1650.40	45.80	75.61	20.94
T ₂ (S ₁ L ₂)	3.56	36.45	49.91	1690.80	47.75	80.73	22.36
T ₃ (S ₁ L ₃)	3.43	33.20	47.66	1630.20	44.10	71.94	19.92
T ₄ (S ₂ L ₁)	3.46	33.05	47.58	1592.45	43.30	68.89	22.93
T ₅ (S ₂ L ₂)	3.48	35.80	48.08	1639.00	44.00	72.11	24.00
T ₆ (S ₂ L ₃)	3.43	32.25	44.33	1582.70	40.20	63.63	21.18
T ₇ (S ₃ L ₁)	3.47	31.00	42.91	1564.30	39.00	60.99	25.37
T ₈ (S ₃ L ₂)	3.50	32.60	46.66	1575.10	39.90	62.72	26.08
T ₉ (S ₃ L ₃)	3.38	28.30	42.83	1558.50	37.20	57.91	24.08
S. E. (m) ±	0.14	1.63	1.90	38.36	1.27	2.45	0.78
C. D. at 5%	NS	4.90	5.71	115.03	3.82	7.36	2.34

Table 2: Effect of different spacings and nutrient levels on fruit quality of acid lime

Treatment	Juice (%)	TSS (°B)	Acidity (%)	Ascorbic acid (mg / 100 ml juice)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Number of seeds / fruit	Weight of seeds / fruit (g)	Rind thickness (mm)
Spacings – S ₁	43.57	7.30	7.10	32.99	0.90	0.95	1.86	10.35	0.74	1.64
S ₂	40.82	7.15	6.91	30.99	0.90	0.90	1.82	10.33	0.64	1.85
S ₃	41.86	7.26	7.07	32.39	0.91	0.92	1.83	10.13	0.70	1.66
S. E. (m) ±	0.70	0.04	0.05	0.37	0.006	0.014	0.016	0.40	0.03	0.06
C. D. at 5%	2.11	0.13	0.16	1.12	NS	0.044	NS	NS	NS	0.18
Nutrients – L ₁	43.03	7.26	7.01	31.81	0.91	0.91	1.84	10.20	0.66	1.78
L ₂	42.05	7.21	7.08	32.35	0.89	0.92	1.82	10.04	0.74	1.82
L ₃	41.17	7.24	6.98	32.21	0.92	0.93	1.85	10.57	0.68	1.57
S. E. (m) ±	0.70	0.04	0.05	0.37	0.006	0.014	0.016	0.40	0.03	0.06
C. D. at 5%	NS	NS	NS	NS	0.018	NS	NS	NS	NS	0.18
T ₁ (S ₁ L ₁)	41.79	7.20	7.18	29.82	0.92	0.94	1.86	10.33	0.66	1.61
T ₂ (S ₁ L ₂)	40.03	7.06	6.89	30.40	0.87	0.95	1.83	9.80	0.86	2.09
T ₃ (S ₁ L ₃)	45.85	7.40	7.23	35.66	0.93	0.96	1.88	9.66	0.54	1.23
T ₄ (S ₂ L ₁)	40.65	7.20	6.74	32.74	0.90	0.90	1.80	10.86	0.74	1.83
T ₅ (S ₂ L ₂)	43.34	7.36	7.22	32.74	0.89	0.93	1.82	11.60	0.73	1.75
T ₆ (S ₂ L ₃)	41.53	7.33	6.74	30.57	0.91	0.88	1.79	9.80	0.63	1.98
T ₇ (S ₃ L ₁)	41.47	7.20	7.07	32.89	0.92	0.90	1.82	10.06	0.69	1.89
T ₈ (S ₃ L ₂)	42.78	7.20	7.11	30.98	0.91	0.89	1.80	10.00	0.64	1.61
T ₉ (S ₃ L ₃)	41.34	7.20	7.04	33.32	0.91	0.94	1.85	10.33	0.76	1.48
S. E. (m) ±	1.22	0.08	0.09	0.65	0.010	0.02	0.027	0.69	0.06	0.10
C. D. at 5%	3.65	0.24	0.27	1.95	0.031	0.07	0.083	NS	0.20	0.32

Conclusion

The study thus revealed that, the recommended spacing 6 x 6 m with 50% N (Inorganic source) + 50% N (Organic source-Vermicompost) + 100% P and K (100% Inorganic – P and K supplied through Vermicompost) proved superior and recorded the best results with respect to growth and yield. While, the recommended spacing 6 x 6 m with 100% Inorganic only proved superior and recorded the best result with respect to fruit quality of acid lime.

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