



Research Article

EFFECT OF INTEGRATED NUTRIENT MANAGEMENT (INM) ON GROWTH, YIELD AND QUALITY OF ACID LIME (*Citrus aurantifolia* SWINGLE) CV. KAGZI

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Abstract- A field experiment was conducted to study the "Effect of integrated nutrient management (INM) on growth, yield and quality of acid lime cv. Kagzi" during the year 2012-13 at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand. The experiment was laid out in a Randomized Block Design (RBD) with nine treatments. The growth parameters of acid lime viz., tree height, East-West canopy spread (m), North- South canopy spread (m), days to fruit set and days to fruit maturity gave non-significant responses. Whereas, yield attributing characters like fruit volume (53.87 cc), fruit weight (53.20 g), fruit diameter (4.52 cm) and fruit yield per tree (46.92 kg) as well as quality attributing characters like total soluble solids (8.85 °Brix.) and ascorbic acid content (29.63 mg/100g juice) and minimum acidity (7.32 %) were recorded significantly highest value with the application of 75% RDF + Vermicompost 9 kg/tree + AAU PGPR Consortium 3.5 ml/tree in treatment T₇.

Keywords- Acid lime, Ascorbic acid, Nutrient management, Quality, Vermi-compost, Kagzi, AAU PGPR, Acidity.

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Introduction

Citrus, one of the most important fruits of the world, is cultivated widely in the tropical and sub-tropical regions. It ranks third among the sub-tropical fruits of the world with different varieties. There are four commercially important species of lime namely, *Citrus aurantifolia* (Acid lime), *C. latifolia* (Tahiti lime), *C. limonia* (Rangpur lime) and *C. limettoides* (Sweet lime). Acid lime (*Citrus aurantifolia* Swingle) is the member of family Rutaceae. It is believed to be a native of Malaya, Assam and China. The major lime producing states are Andhra Pradesh, Maharashtra, Gujarat, Karnataka, Tamil Nadu, Assam and Chhattisgarh. In India, acid lime is cultivated on 2, 86,400 ha with annual production of 2.83 lakh MT. [1]. In Gujarat, area of acid lime is about 41,100 ha with annual production of 4,49,200 MT of fruits covering leading districts of Mehsana, Ahmadabad, Kheda and Bhavnagar [1].

Acid lime is an important source of vitamin "C" (ascorbic acid) for human nutrition. Amount of juice, TSS (Total soluble solids), TA (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. The cultivation practices of acid lime for getting higher yield leads to use of higher dose of fertilizers. Since continuous use of inorganic fertilizers is hazardous to the soil health in respect of physical, chemical and biological properties of soil. Therefore, it is necessary to minimize the application of inorganic fertilizer by substituting with the organics. Integrated use of nutrient supplements viz., organic, inorganic and microbial in combination holds a good potential to overcome some of soil physical constraints. The integrated nutrient management (INM) is considered to be the best module with regard to efficient use of manure and fertilizers.

It was observed that nutrients applied without an organic matter were less effective in citrus fruit production even at high doses and more effective when applied with organic matter [7]. Hence, the concept of integrated nutrient

management (INM) came in picture which lays emphasis on continuous improvement in soil fertility on long term basis through appropriate use of fertilizer, bio-fertilizer and green manures and their scientific management for optimum growth, yield and quality of crop in specific agro-ecological situation.

Integrated use of nutrient supplements viz., organic, inorganic and microbial in combination holds a good potential to overcome some of soil physical constraints [3]. The integrated nutrient management (INM) is considered to be the best module with regard to efficient use of manure and fertilizers.

Bio-fertilizers are microbial preparations containing living cells of different microorganisms, which have the ability to mobilize plant nutrients of soil from unusable to usable form through biological process. They are environmental friendly and play significant role in crop production. It is mainly used for field crops but now-a-days it is also used for fruit crops. Bio-fertilizers are used in live formulation of beneficial microorganism which on application to seed, root or soil, mobilize the availability of nutrients particularly by their biological activity and help to build up the lost micro flora and in turn improve the soil health in general [8].

Vermicompost increase soil organic matter and nutrient content, improves the soil structure and increase cation exchange capacity. The earthworms utilize organic wastes as food and the undigested material excreted by them has gained the name 'vermicompost'. Farmyard manures are very important components of nutrient management and they have been maintaining soil fertility and quality of fruits. By considering these facts, the present study was conducted to study the effect of different organic and inorganic fertilizers on yield and quality of acid lime.

Materials & Methods

A field experiment was conducted at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during the year 2012-13 on loamy sand soil under middle Gujarat conditions. The

climate of Anand region is semi-arid and sub-tropical type. Winter is mild cool and dry, while summer is hot and dry. October to May is sunny months generally receiving an average of eight hours sunshine per day. Temperature during hot weather commences by about end of February and ends by about middle of June. Winter sets in the middle of October and continues till the end of February.

Monsoon is warm and moderately humid. It commences by the end of June and ends by the middle of September. The meteorological data on the average weekly maximum and minimum temperature, rainfall and relative humidity recorded at the Meteorological observatory AAU, Anand (during experimental period i.e. Oct-2012 to Sept-2013) are given in Appendix-I.

Appendix-I Mean weekly weather parameters during the experiment period (2012-13)

Month	Std. Week	Date	Temperature (°C)		Mean RH (%)	Bright Sunshine (hrs/day)	Rainfall (mm)
			Max.	Min.			
Oct 2012							
	40	01-07	36.2	25.0	73.9	8.0	0
	41	08-14	36.1	20.7	66.5	8.8	0
	42	15-21	36.0	19.7	65.9	9.6	0
	43	22-28	35.3	18.8	58.3	9.8	0
	44	29-04	33.4	15.7	53.4	8.8	0
Nov 2012							
	45	05-11	25.6	13.9	57.8	9.6	0
	46	12-18	33.0	15.1	61.5	9.5	0
	47	19-25	31.4	12.6	60.7	9.3	0
	48	26-02	30.4	13.3	65.4	9.7	0
Dec 2012							
	49	03-09	31.3	16.1	63.4	8.5	0
	50	10-16	30.9	13.9	69.8	9.2	0
	51	17-23	29.2	13.9	66.4	8.6	0
	52	24-31	28.3	10.3	62.2	8.9	0
Jan 2013							
	01	01-07	25.9	8.9	67.6	8.3	0
	02	08-14	27.9	9.9	62.3	9.5	0
	03	15-21	26.9	11.2	68.1	8.5	0
	04	22-28	26.3	11.1	55.7	9.3	0
	05	29-04	30.5	14.2	69.4	10.2	0
Feb 2013							
	06	05-11	28.2	12.7	64.4	9.1	0
	07	12-18	31.1	14.9	65.9	8.9	0
	08	19-25	31.8	14.0	59.8	10.1	0
	09	26-04	32.7	12.8	50.9	10.7	0
March 2013							
	10	05-11	37.2	15.4	46.2	10.2	0
	11	12-18	35.4	17.7	56.7	9.4	0
	12	19-25	36.0	19.0	51.3	9.2	0
	13	26-01	35.4	20.1	52.7	8.2	0
April 2013							
	14	02-08	37.4	19.3	52.3	10.3	0
	15	09-15	38.0	20.3	48.1	9.7	0
	16	16-22	36.3	22.7	67.1	9.4	0
	17	23-29	39.3	24.6	44.1	10.5	0
	18	30-06	41.1	24.6	46.9	11.5	0
May 2013							
	19	07-13	40.2	23.9	51.7	10.8	0
	20	14-20	40.2	26.4	55.4	11.0	0
	21	21-27	40.9	26.1	55.3	11.0	0
	22	28-03	40.2	28.2	57.7	10.7	0
June 2013							
	23	04-10	38.1	27.7	72.8	6.8	0
	24	11-17	33.9	25.0	86.3	4.0	72.4
	25	18-24	33.7	26.0	80.1	4.6	59.6
	26	25-01	34.4	26.8	78.5	5.4	0
July 2013							
	27	02-08	32.4	25.6	84.8	1.6	106.0
	28	09-15	31.8	25.1	87.1	1.3	161.3
	29	16-22	31.0	25.5	87.6	2.1	52.0
	30	23-29	29.9	25.3	94.6	0.5	172.2
	31	30-05	29.2	24.8	92.1	0.5	79.4
Aug 2013							
	32	06-12	30.6	24.8	88.9	2.7	68.0
	33	13-19	31.2	25.0	89.6	2.3	164.7
	34	20-26	30.8	24.8	85.6	2.3	18.6
	35	27-02	32.7	24.7	77.4	7.0	0.3
Sept 2013							
	36	03-09	33.4	24.7	77.6	7.3	62.4
	37	0-16	35.1	25.4	76.8	8.9	3.8
	38	17-23	34.4	25.7	80.2	6.6	45.4
	39	24-30	29.1	24.4	90.3	1.3	288.8

The tree height was measured by metric scale from the tree base to the tip of the main shoot of the tree at the start of experiment and 6 months of first dose of fertilizers application. The East-West canopy spread (m) and North – South canopy spread (m) were measured by metric scale at the start of experiment and after 6 months of first dose of fertilizers application.

During the period of flowering, the experimental trees were regularly visited and total five flowers in all direction were tagged. Fruiting take place from tagged flowers at that time days was counted from flower initiation to fruit set and after fruit, set total five fruits in all direction were tagged. When fruits were mature their rind colour began to turn yellow take place from tagged fruits at that time days was counted from fruit set to fruit maturity.

The volume of five randomly selected fruits of each treatment was recorded by water replacement method in which water removed by the fruits was measured by using measuring cylinder and values were expressed in cubic centimeter (cc). From each of the treatment five marketable fruits were selected randomly and their weight was recorded separately and average fruit weight worked out in gram. The diameter of the fruit was determined with the help of Vernier Calipers at mature stage and expressed in centimeter.

There were total 20 pickings during experiment (Oct-2012 to Sep-2013). The numbers of fruits was weighted treatment wise at each picking. The all picked fruits were summed up and result was expressed in kilogram.

There were nine treatments embedded in a Randomized Block Design with three replications, two trees considered as treatment. Trees in the orchard have same age of 10 years. The details of the treatments applied in the present investigation are as under:

Sr. No.	Treatment No.	Treatment
1	T ₁	100% RDF (50 kg FYM, 900 g : 750 g : 500 g NPK/tree)
2	T ₂	75% RDF + 5 kg Castor cake/tree
3	T ₃	T ₂ + AAU PGPR Consortium (3.5 ml/tree)
4	T ₄	50% RDF + 10 kg Castor cake/tree
5	T ₅	T ₄ + AAU PGPR Consortium (3.5 ml/tree)
6	T ₆	75% RDF + 9 kg Vermicompost/tree
7	T ₇	T ₆ + AAU PGPR Consortium (3.5 ml/tree)
8	T ₈	50% RDF + 18 kg Vermicompost/tree
9	T ₉	T ₈ + AAU PGPR Consortium (3.5 ml/tree)

Organic manure (FYM, castor cake & vermicompost) and Anand Agricultural University Plant Growth Promoting Rhizobacteria (AAU PGPR) Consortium were applied on 15th June 2013 and after 1st rain, respectively. While, chemical fertilizers were applied in two splits on 4th October 2012 and 12th March 2013. The chemical fertilizers were applied in the form of urea, single super phosphate and muriate of potash. These nutrients were applied as per treatments. While, well decomposed FYM, vermicompost and castor cake were applied as per treatment requirement. Bio-fertilizer i.e. AAU PGPR Consortium was obtained from Bio-fertilizer Project, A.A.U, Anand. It was applied 1 m away from main stem of acid lime tree as drenching method in the soil as per treatments.

Results & Discussion:

The experimental findings obtained from the present study have been discussed here in following heads:

Growth parameters:

The result of the present investigation [Table-1] revealed that effect of organic and inorganic fertilizers with biofertilizer on various growth characters viz., tree height, East-West and North- South canopy spread as well as days to fruit set after flower initiation and days to fruit maturity after fruit set observed non-significant response.

Yield parameters:

Data presented in [Table-2] showed significant differences among the treatments on yield and yield attributing characters like fruit volume, fruit weight, fruit diameter. It is clear from the results that treatment T₇ (75% RDF + Vermicompost 9 kg/tree + AAU PGPR Consortium 3.5 ml/tree) recorded significantly highest fruit volume (53.87 cc) and it was at par with T₉ (50% RDF + Vermicompost 18 kg/tree + AAU PGPR Consortium 3.5 ml/tree) and T₅ (50% RDF + Castor cake 10 Kg/tree + AAU PGPR Consortium 3.5 ml/tree) as compared to 100 % RDF (T₁). Similar trend was observed in case of fruit weight (53.20 g) and it was at par with T₉ (51.92 g), T₅ (50.17 g), T₃ (49.23 g) and T₄ (48.68 g) and the lowest fruit weight (40.25 g) was observed in treatment T₁ (100% RDF).

Table-1 Effect of integrated nutrient management (INM) on growth attributing characters of acid lime

Treatments	Tree Height (m)		East West canopy spread (m)		North South canopy spread (m)		Fruit set after flower initiation (days)	Fruit maturity after fruit set (days)
	Initial	At 6 month	Initial	At 6 month	Initial	At 6 month		
T ₁	3.35	3.73	4.29	4.75	4.25	4.72	27.67	144.50
T ₂	3.33	3.70	4.27	4.71	4.21	4.68	27.00	142.00
T ₃	3.40	3.81	4.39	4.78	4.28	4.75	25.67	140.33
T ₄	3.35	3.77	4.29	4.77	4.26	4.73	26.67	140.50
T ₅	3.46	3.88	4.45	5.02	4.39	4.90	24.83	134.00
T ₆	3.40	3.82	4.39	4.85	4.33	4.79	24.50	137.33
T ₇	3.60	3.91	4.49	5.11	4.45	4.93	23.67	130.17
T ₈	3.45	3.85	4.35	4.87	4.36	4.82	25.17	135.33
T ₉	3.55	3.96	4.53	5.13	4.54	5.08	24.83	132.83
S.Em ±	0.12	0.11	0.16	0.17	0.16	0.14	1.30	6.66
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	6.32	5.00	6.58	6.07	6.56	5.18	8.84	8.39

Table-2 Effect of integrated nutrient management (INM) on yield attributing characters of acid lime

Treatments	Average fruit volume (cc)	Average fruit weight (g)	Average fruit diameter (cm)	Fruit yield (kg/tree)
T ₁	40.22	40.25	3.97	33.41
T ₂	42.33	42.67	4.13	35.09
T ₃	49.93	49.83	4.32	36.13
T ₄	48.08	48.68	4.27	34.90
T ₅	50.20	50.17	4.40	42.42
T ₆	46.58	47.00	4.35	37.53
T ₇	53.87	53.20	4.52	46.92
T ₈	44.90	45.75	4.38	41.68
T ₉	52.88	51.92	4.43	46.68
S.Em ±	1.26	1.73	0.10	1.65
CD at 5 %	3.80	5.19	0.30	4.95
C.V. %	4.61	6.28	4.05	7.25

An increase in fruit volume and fruit weight is highly correlated with dry matter content balance level of hormones there by capability of plants to better solute uptake from rhizosphere [10, 9 and 4]. Simultaneously, the highest fruit diameter (4.52 cm) was also recorded significantly with T₇ (75% RDF + Vermicompost 9 kg/tree + AAU PGPR Consortium 3.5 ml/tree) as compared to other treatments but it was at par with T₉, T₅, T₈, T₆, T₃ and T₄. Similarly the highest fruit yield (46.92 kg/tree) was recorded significantly with T₇ (75% RDF + Vermicompost 9 kg/tree + AAU PGPR Consortium 3.5 ml/tree) and it was at par with T₉ and T₅. Where as, the lowest fruit yield was recorded with 100 % RDF (T₁). This may be attributed due to the improved fertilizer use efficiency with the application of organic sources of nutrients and bio-fertilizers and also helps in increasing fruit volume, diameter and weight ultimately the fruit yield per tree was obtain maximum. [12, 5, 4 and 11].

Quality parameters:

Data presented in [Table-3] showed significant differences among the treatments on quality attributing characters like total soluble solids, ascorbic acid and acidity. It is clear from the results that treatment T₇ (75% RDF + Vermicompost 9 kg/tree + AAU PGPR Consortium 3.5 ml/tree) had recorded significantly the highest total soluble solid (8.85 °Brix.) and it was at par with T₉, T₅ and T₈. Similar trend was observed in case of ascorbic acid (29.63 mg/100 g juice) and it was at par with T₉, T₅ and T₈. The increase in total soluble solids and ascorbic acid might be due to FYM supply major and some essential micronutrients and proper supply of nutrients induced the photosynthesis carbohydrate and sugar metabolisms which improves the quality of fruits. [6 and 12]. Similarly the minimum acidity (7.32 %) was recorded significantly with T₇ (75% RDF + Vermicompost 9 kg/tree + AAU PGPR Consortium 3.5 ml/tree) and it was at par with T₉, T₅, T₈, T₆ and T₄. Where as, the maximum acidity was recorded with 100 % RDF (T₁). Acidity decreases due to increase in the total soluble solids [10, 2, 13 and 14].

Table-3 Effect of integrated nutrient management (INM) on quality parameters of acid lime

Treatments	TSS (°Brix)	Ascorbic Acid (mg/100 g juice)	Acidity (%)
T ₁	6.88	24.10	7.95
T ₂	7.42	25.13	7.87
T ₃	7.73	26.90	7.82
T ₄	7.57	26.20	7.73
T ₅	8.60	28.03	7.40
T ₆	7.92	27.67	7.50
T ₇	8.85	29.63	7.32
T ₈	8.37	27.83	7.43
T ₉	8.72	28.53	7.35
S.E.m ±	0.19	0.62	0.14
CD at 5 %	0.57	1.88	0.43
C.V. %	4.14	4.01	3.33

Conclusion

In the light of the results obtained from this investigation, it can be concluded that 37.5 kg FYM, 675 g : 563 g : 375 g NPK/tree + Vermicompost 9 kg/tree + AAU PGPR Consortium 3.5 ml/tree was found beneficial for getting higher fruit yield and good quality of fruits in acid lime.

Conflict of Interest: None declared

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