AU
Agriculture Update
Volume **12** | TECHSEAR-10 | 2017 | 2908-2912
Visit us : *www.researchjournal.co.in*
e ISSN-0976-6847

RESEARCH ARTICLE :

Effect of organic and inorganic nutrient sources on reproductive, yield and economics of acid lime cv. kagzi lime

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ARTICLE CHRONICLE :
Received :
11.07.2017;
Accepted :
25.08.2017

SUMMARY : A field experiment was carried out at *Instructional cum Research Fruit Orchard* Department of Fruit Science, College of Horticulture Mandsaur (M.P.) during the year of 2016-17 on well established ten years old orchard of acid lime planted at 6.0 m X 6.0 m. The experiment comprised fourteen treatments including absolute control *viz.*, T_0 = Control, T_1 = RDF (Recommended dose of fertilizers- 900:400:400 N:P:K g/plant), T_2 = 75 % RDF + 3 Kg Vermicompost + 10 Kg FYM, T_3 = 50 % RDF + 7 Kg Vermicompost + 15Kg FYM, T_4 = 25 % RDF + 10 Kg Vermicompost+ 20 Kg FYM, T_5 = 75 % RDF + 3 Kg Vermicompost + 10 Kg FYM + 150 g VAM, T_6 = 50 % RDF + 7 Kg Vermicompost + 15 Kg FYM + 150 g VAM, T_7 = 25 % RDF + 10 Kg Vermicompost + 20 Kg FYM+ 150 g VAM, T_8 = 75 % RDF+ 3 Kg Vermicompost + 10 Kg FYM + 25 g Azotobactor, T_9 = 50 % RDF + 7 Kg Vermicompost+ 15 Kg FYM + 25 g Azotobactor, T_{10} = 25 % RDF + 10 Kg Vermicompost + 20 Kg FYM + 25 g Azotobactor, T_{11} = 75 % RDF + 3 Kg Vermicompost + 10 Kg FYM + 150 g VAM + 25 g Azotobactor, T_{12} = 50 % RDF +7 Kg Vermicompost + 15 Kg FYM + 150 g VAM + 25 g Azotobactor, T_{13} = 25 % RDF + 10 Kg Vermicompost + 20 Kg FYM + 150 g VAM + 25 g Azotobactor. The results revealed that the soil application of 50 % RDF + 7 Kg vermicompost + 15 Kg FYM + 150 g VAM + 25 g Azotobactor (T_{12}) was significantly increased the value of the fruit setting (62.71%), minimum fruit drop (32.40 %), maximum fruit retention (67.60 %), fruit weight (54.14 g), number of fruit per plant (967.06), yield per plant (52.35 kg). The maximum gross income (Rs. 363439.9) and net income (Rs. 301060.1) was obtained from application of 50 % RDF + 7 Kg Vermicompost + 15 Kg FYM + 150 g VAM + 25 g Azotobactor (T_{12}). Whereas, the most appropriate benefit cost ratio (5.15) was registered in T_{11} (75 % RDF + 3 kg vermicompost + 10 kg FYM + 150 g VAM + 25 g Azotobactor).

KEY WORDS :
Acid lime, Inorganic, organic, Biofertilizer, Yield

How to cite this article : Bhandari, J., Kanpure, R.N., Kachouli, B., Haldar, A. and Vasure, N. (2017). Effect of organic and inorganic nutrient sources on reproductive, yield and economics of acid lime cv. kagzi lime. *Agric. Update*, **12** (TECHSEAR-10) : 2908-2912.

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BACKGROUND AND OBJECTIVES

Acid lime (*Citrus aurantifolia* Swingle) belongs to the family Rutaceae, is one of the most important citrus fruit as a major source of vitamin- "C" grown throughout the world (Souci *et al.*, 2000). It is a medium statured shrubby thorny plant, which grows up to 5 m height. The flowers are yellowish white 2.5 cm in diameter with a light purple tinge on the margins. Flower and fruit appears throughout the year but most abundantly during the rainy season (May- September). Plants raised through seedlings take generally 4 to 8 years come into blooming. It reaches the maximum yield potential at the age of 8 to 10 years.

Citrus occupies an important place among the fruit industry, but yield potential of citrus orchards are still very low. Out of many factors, poor nutrient status of the soil as well as malnutrition is considered to be the major factors responsible for citrus decline and low yield. Chemical fertilizers are mostly in use for their cultivation, which have some deleterious effects on fruit quality besides adverse effect on soil, water and environmental pollution. An integrated approach the use of organic manures, biofertilizers and chemical fertilizers could help in achieving the goal of obtaining safer food and environment for the people (Lal and Dayal, 2014).

Conventional (chemical based) farming is non-sustainable because of many problems such as loss of soil health and productivity from excessive erosion and low farm income from high production costs etc. In view of these, there is an increasing awareness about alternate agriculture system known as integrated plant nutrient management. The basic concept of integrated nutrient management (INM) is the adjustment of plant nutrient supply with proper combination of chemical fertilizers, organic manure and biofertilizers suitable to the system of land use and ecological, social and economic conditions (Binepal *et al.*, 2013).

RESOURCES AND METHODS

The experiment was conducted during 2016-17 at *Instructional cum Research Fruit Orchard* Department of Fruit Science, College of Horticulture Mandsaur (M.P.) on ten years old acid lime tree cv. Kagzi lime. The farm is geographically located at 23.45^0 to 24.13^0 N latitude and 74.44^0 to 75.18^0 E longitudes with at an altitude of 435 m Mean Sea Level. The experiment was laid out in Randomized Block Design (RBD) with three replications. The plants having uniform vigour and size were selected for the study. The experiment comprised of fourteen treatments *viz.*, T_0 = Control, T_1 = RDF (Recommended dose of fertilizers- 900:400:400 N:P:K g/plant), T_2 = 75 % RDF + 3 Kg Vermicompost + 10 Kg FYM, T_3 = 50 % RDF + 7 Kg Vermicompost + 15Kg FYM, T_4 = 25 % RDF + 10 Kg Vermicompost+ 20 Kg FYM, T_5 = 75 % RDF + 3 Kg Vermicompost + 10 Kg FYM + 150 g VAM, T_6 = 50 % RDF + 7 Kg Vermicompost + 15 Kg FYM + 150 g VAM, T_7 = 25 % RDF + 10 Kg Vermicompost + 20 Kg FYM+ 150 g VAM, T_8 = 75 % RDF+ 3 Kg Vermicompost + 10 Kg FYM + 25 g Azotobactor, T_9 = 50 % RDF + 7 Kg Vermicompost+ 15 Kg FYM + 25 g Azotobactor, T_{10} = 25 % RDF + 10 Kg Vermicompost + 20 Kg FYM + 25 g Azotobactor, T_{11} = 75 % RDF + 3 Kg Vermicompost + 10 Kg FYM + 150 g VAM + 25 g Azotobactor, T_{12} = 50 % RDF +7 Kg Vermicompost + 15 Kg FYM + 150 g VAM + 25 g Azotobactor, T_{13} = 25 % RDF + 10 Kg Vermicompost + 20 Kg FYM + 150 g VAM + 25 g Azotobactor. The nitrogen was supplied through urea, containing 46 per cent nitrogen. The phosphorus was met out through single super phosphate, containing 16 per cent P_2O_5. While potassium was given by muriate of potash, containing 60 per cent K_2O. The whole quantity of the organic manure was applied as a basal dose on the onset of monsoon. The remaining required doses of fertilizers were applied in two split doses in the month of July and August and bio-fertilizers were applied one week after each application of inorganic fertilizers.

The data was recorded on various reproductive parameters *viz.*, fruit setting per cent, fruit drop per cent and fruit retention per cent were calculated by following formulae:

Fruit setting (%) :

Total numbers of flower at the full bloom were counted manually to determine the fruit set. Fruits were counted after two week at full bloom and again at stage of fruit setting were calculated with following formula:

Fruit setting (%) = (Number of set fruits/ Number of flowers) x100

$$\text{Fruit drop}(\%) = \frac{\text{Total number of fruit set} - \text{total number of fruits at harvest time}}{\text{Total number of fruit set}} \times 100$$

(Formula by Khattab *et al.*, 2011)

$$\text{Fruit retention}(\%) = \frac{\text{Number of fruits at harvest}}{\text{Initial number of fruit set}} \times 100$$

Fruit weight was recorded by using electronic weigh balance. Numbers of fruits per plant were recorded separately for each plant at each picking. Average yield per plant was calculated by the following formula: Yield/ plant (kg) = no. of fruit/plant x fruit weight.

Economic analysis :

The cost of cultivation was worked out taking into account of various inputs used for cultivation during the entire experimental period. The following economic analyses were carried out during the study.

Total expenditure (Rs. ha^{-1}):

The cost incurred right from field preparation to harvest was worked out for each treatment of the study and expressed as Rs. ha^{-1}.

Gross income:

The crop yield was computed per hectare and the total income (Rs. ha^{-1}) was worked out based on the minimum market rate prevalent during the period of study.

Net income:

Net income was obtained by subtracting total expenditure from gross return as detailed below and expressed as Rs. ha^{-1}.

Net income (Rs. ha^{-1}) = Gross income (Rs. ha^{-1}) – Total expenditure (Rs. ha^{-1}).

Benefit cost ratio:

BCR was calculated based on net income and total expenditure as given below :

$$\text{BCR} = \frac{\text{Net income (Rs. ha}^{-1})}{\text{Total expenditure (Rs. ha}^{-1})}$$

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads :

Reproductive and yield parameters:

The results clearly indicated from table-1 that the soil application of organic manure and inorganic fertilizers along with biofertilizers were significantly increased the

Table 1: Effect of organic and inorganic nutrient sources on reproductive and yield attributing characters of acid lime cv. Kagzi lime.

Treatments		Fruit setting (%)	Fruit drop (%)	Fruit retention (%)	Fruit weight (g)	Number of fruit/plant	Yield per plant (kg)
T_0	Absolute control	36.70	57.43	42.57	711.12	22.20	9.74
T_1	RDF (Recommended dose of fertilizers- 900:400:400 N:P:K g/plant)	44.70	52.21	47.79	821.66	34.78	9.10
T_2	75 % RDF + 3 Kg VC + 10 Kg FYM	54.51	44.73	55.27	840.11	38.77	8.84
T_3	50 % RDF + 7 Kg VC + 15Kg FYM	55.92	42.39	57.61	855.12	40.69	8.87
T_4	25 % RDF + 10 Kg VC+ 20 Kg FYM	46.83	50.65	49.35	779.14	33.24	9.65
T_5	75 % RDF + 3 Kg VC + 10 Kg FYM + 150 g VAM	57.19	40.24	59.76	877.59	43.42	8.73
T_6	50 % RDF + 7 Kg VC+ 15 Kg FYM + 150 g VAM	58.39	38.36	61.64	890.57	45.31	8.79
T_7	25 % RDF + 10 Kg VC+ 20 Kg FYM+ 150 g VAM	48.42	49.13	50.87	788.61	35.23	9.62
T_8	75 % RDF+ 3 Kg VC+ 10 Kg FYM + 25 g Azotobactor	59.53	37.26	62.74	909.16	46.23	8.53
T_9	50 % RDF + 7 Kg VC + 15 Kg FYM + 25 g Azotobactor	60.38	36.05	63.95	930.41	48.92	8.61
T_{10}	25 % RDF + 10 Kg VC + 20 Kg FYM + 25 g Azotobactor	50.34	48.38	51.62	809.45	36.73	9.45
T_{11}	75 % RDF + 3 Kg VC+ 10 Kg FYM + 150 g VAM + 25 g Azotobactor	61.26	34.22	65.78	959.88	50.48	8.20
T_{12}	50 % RDF + 7 Kg VC + 15 Kg FYM + 150 g VAM + 25 g Azotobactor	62.71	32.40	67.60	967.06	52.35	8.41
T_{13}	25 % RDF + 10 Kg VC+ 20 Kg FYM + 150 g VAM + 25 g Azotobactor	52.98	47.31	52.69	822.36	37.97	9.37
S.E. ±		0.46	0.56	0.56	0.41	3.30	0.43
C.D. (P=0.05)		1.33	1.63	1.62	1.18	9.59	1.24

productivity of acid lime. Maximum fruit setting (62.71%), minimum fruit drop (32.40), maximum fruit retention (67.60%), fruit weight (54.14 g), number of fruits per plant (967.06) and highest yield per plant (52.35 kg) were recorded with the soil application of 50 % RDF +7 Kg Vermicompost + 15 Kg FYM + 150 g VAM + 25 g Azotobactor (T_{12}). Increased nutrient availability from NPK, FYM, the organic phosphorus from phosphobacteria and Azotobacter which may have increased various endogenous hormonal levels in plant tissue which might be responsible for enhancing flowering pollen germination and pollen tube which might have ultimately increased fruit set and higher fruit retention. The results of present findings are confirmed with the findings of earlier workers Dheware and Waghmare (2009) in sweet orange and Godage *et al.* (2013) in guava. The optimum dose of nutrient combinations (NPK) accelerates the metabolic activities of the plant by increasing the meristematic activities which in turn increases the vegetative growth and ultimately lead to increase flowering, maximum fruit setting per cent and maximum fruit retention per cent (Shankar *et al.*, 2002). Presence of B group vitamins, plant hormones and chemical exudates released during biological activity promoted by the vermicompost in the soil and retention of nutrients for longer period of time in combination with recommended dose of NPK accelerates the process of synthesis and accumulation of food materials and application of biofertilizers increased nutrient status as well as their uptake by the plants, they promote hormonal activity and induce their synthesis, reduce the flower and fruit drop caused by hormonal imbalance, hence maximizing fruit setting and fruit retention percentage which ultimately leads to increase in yield and other yield parameters. The present findings are in accordance with the results reported by Mitra *et al.* (2010), Rubee *et al.* (2011) and Yadav *et al.* (2011).

Vermicompost could reduce requirement of chemical fertilizers by 25-50 per cent in addition to its role in improving soil condition (Lee, 1985). These results are agreement with Musmade *et al.* (2009) in acid lime and Pawar *et al.* (2014) in acid lime.

A treatment adjudged effective technically might not be economical if costs are more than benefits obtained. Therefore, economic analysis is the ultimate yardstick to recommend a technology. The economics worked out for this experiment indicated (Table-2) that maximum gross income (Rs. 363439.9) and net income (Rs. 301060.1) was obtained from application of 50 % RDF + 7 Kg Vermicompost + 15 Kg FYM + 150 g VAM + 25 g Azotobactor (T_{12}) followed by T_{11} (75 % RDF + 3 kg Vermicompost + 10 kg FYM + 150 g VAM + 25 g

Table 2: Economics of the different treatments

Treatments		Total expenditure (Rs)	Gross income (Rs)	Net income (Rs)	Benefit Cost ratio
T_0	Absolute control	30000.00	154123.5	124123.5	4.13
T_1	RDF (Recommended dose of fertilizer- 900:400:400 N:P:K g/plant)	40333.22	241460.2	201126.9	4.98
T_2	75 % RDF + 3 kg vermicompost + 10 kg FYM	44695.88	269160.7	224464.8	5.02
T_3	50 % RDF + 7 kg vermicompost + 15kg FYM	49050.22	282490.3	233440.1	4.75
T_4	25 % RDF + 10 kg vermicompost + 20 kg FYM	52018.83	230768.7	178749.9	3.43
T_5	75 % RDF + 3 kg vermicompost + 10 kg FYM + 150 g VAM	49694.48	301443.4	251748.9	5.06
T_6	50 % RDF + 7 kg vermicompost + 15 kg FYM + 150 g VAM	54048.82	314564.7	260515.9	4.82
T_7	25 % RDF + 10 kg vermicompost + 20 kg FYM+ 150 g VAM	57017.43	244584.3	187566.8	3.28
T_8	75 % RDF+ 3 kg vermicompost + 10 kg FYM + 25 g Azotobactor	53026.88	320951.8	267924.9	5.05
T_9	50 % RDF + 7 kg vermicompost + 15 kg FYM + 25 g Azotobactor	57381.22	339627.1	282245.9	4.91
T_{10}	25 % RDF + 10 kg vermicompost + 20 kg FYM + 25 g Azotobactor	60349.83	254998	194648.2	3.22
T_{11}	75 % RDF + 3 kg vermicompost + 10 kg FYM + 150 g VAM + 25 g Azotobactor	58025.48	357191.6	299166.1	5.15
T_{12}	50 % RDF + 7 kg vermicompost + 15 kg FYM + 150 g VAM + 25 g Azotobactor	62379.82	363439.9	301060.1	4.82
T_{13}	25 % RDF + 10 kg vermicompost + 20 kg FYM + 150 g VAM + 25 g Azotobactor	65348.43	263606.7	198258.3	3.03

Azotobacter). The benefit cost ratio was higher (5.15) recorded with 75 % RDF + 3 kg Vermicompost + 10 kg FYM + 150 g VAM + 25 g Azotobactor (T_{11}) which is economically viable as compare to other treatments. The highest cost: benefit ratio obtained in T_{11} was due to the higher fruit production and reduced cost of chemical fertilizers. Similar result was also been reported by Singh (2009) in bael. Similarly, by using organic manures Bhavidoddi Rahul kumar (2003) and Kurubar (2007) registered higher net returns and benefit cost ratio in banana and fig, respectively.

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