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INTEGRATED USE OF ORGANIC AND INORGANIC FERTILIZERS WITH BIO -INOCULANTS ON PHYSICOLOGICAL CHARACTERISTICS OF ACID LIME (*CITRUS AURANTIFOLIA* SWINGLE)

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Abstract

Acid lime (*Citrus aurantifolia* Swingle) is one of the commercial fruit crops which occupies important place in the fruit industry, but yield levels of citrus orchards are still very low. Alternate nutrient management system could help in achieving high growth, yield and quality of acid lime. Thus, an investigation was undertaken on the "Effect of nutrient management through bio-organic manures on physiological attributes of acid lime **(***Citrus aurantifolia* Swingle**)**" in the Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India during 2016 - 2018. The experiment was conducted with organic manures and biofertilizers along with inorganic fertilizers which were applied with different treatment combinations *viz.*, T_1 – Control, T_2-100% RDF (400:200:220 g/ plant), T_3-75% RDF, T_4-50% RDF, T_5- 75% RDF + 100% FYM (20 kg/plant), T_6- 75% RDF + 100% Vermicompost (10 kg/plant), T_7- 75% RDF + 50% FYM + 50% Vermicompost, T_8-75% RDF + 50% FYM + 50%Vermicompost + Biofertilizers (25g Azotobacter + 25g PSB + 150g VAM), T_9- 50% RDF + 100% FYM, T_{10}- 50% RDF + 100% Vermicompost, T_{11}- 50% RDF + 75% FYM + 75% Vermicompost, T_{12}- 50% RDF + 75% FYM + 75% Vermicompost + Biofertilizers (25g Azotobacter + 25g PSB +150g VAM). There were twelve treatments replicated thrice in Randomized block design (RBD). The physiological characteristics of acid lime fruit are an expression of a plant's vegetative activity which was also significantly influenced by the use of inorganic fertilizers with organic manures and biofertilizers treatment. The maximum in fruit length (5.27 cm), fruit diameter (4.93 cm), fruit volume (54.62 cc), number of seeds (8.17), seed weight (1.24 g), juice percentage (56.94 %), specific gravity (1.36), juice: seed ratio (0.02), peel thickness (1.94 mm), moisture content of peel (84.28 %) and moisture content of pulp (93.89 %) were recorded under T_{12} - 50% RDF + 75% FYM + 75 % Vermicompost + Biofertilizers (25g Azotobacter + 25g PSB + 150g VAM). The lowest values were obtained under control.

Key words: *Citrus aurantifolia,* biofertilizers, vermicompost, organic manures.

Introduction

Acid lime (*Citrus aurantifolia* Swingle) is an important fruit crop in citrus group which belongs to the family Rutaceae. It occupies a vital place in the fruit industry, but yield levels of citrus orchards are still very low. There are several factors responsible for low yield in acid lime and among these the inadequate supply of inorganic fertilizers and organic manures are the major one. Being a high yielding perennial crop, the nutritional requirements of lime is quite high (Banker *et al.,* 2009) but the prices of inorganic fertilizers are ever increasing which forced the farmers to look for the alternative low cost input technology. It was observed that nutrients applied at higher doses without organic manures where less effective in improving the fruit production but more effective when applied with organic manures. Apart from this, the use of biofertilizers to maintain and improve the soil quality and productivity levels are at low input costs. Hence, the concept of alternate nutrient management system came into picture which lays emphasis on continuous improvement in soil productivity on long term basis through appropriate use of organic manures and biofertilizers with inorganic fertilizers for optimum growth and development of acid lime fruits in reference to particular agro ecological situations. The present investigation was carried out to assess the efficacy of organic manure (Farm yard manure and vermicompost) and biofertilizers (Azotobacter, Phosphate Solubilizing Bacteria and Vesicular Arbuscular Mycorrhizae) with

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inorganic fertilizers on physiological characters of acid lime.

Materials and Methods

The experiment was conducted in the Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu, India during 2016 - 2018. The treatment consisted with organic manures and biofertilizers along with inorganic fertilizers which were applied with different treatment combinations *viz.*, T_1 – Control, T_2-100% RDF (400:200:220 g/ plant), T_3-75% RDF, T_4-50% RDF, T_5- 75% RDF + 100% FYM (20 kg/plant), T_6- 75% RDF + 100% Vermicompost (10 kg/plant), T_7- 75% RDF + 50% FYM + 50% Vermicompost, T_8-75% RDF + 50% FYM + 50% Vermicompost + Biofertilizers (25g Azotobacter + 25g PSB + 150g VAM), T_9- 50% RDF + 100% FYM, T_{10}- 50% RDF + 100% Vermicompost, T_{11}- 50% RDF + 75% FYM + 75% Vermicompost, T_{12}- 50% RDF + 75% FYM + 75% Vermicompost + Biofertilizers (25g Azotobacter + 25g PSB +150g VAM). There were twelve treatments replicated thrice in Randomized block design (RBD). The observations were recorded on physiological parameters *viz.,* The maximum fruit length (cm), fruit diameter (cm), fruit volume (cc), number of seeds (No), seed weight (g), juice percentage (%), specific gravity, juice: seed ratio, peel thickness (mm), moisture content of peel (%) and moisture content of pulp (%) The data generated through this investigation was analyzed by the statistical method of Panse and Sukhatme (1985).

Results and Discussion

The physiological characteristics of acid lime fruit are an expression of a plant's vegetative activity which was also significantly influenced by the use of inorganic fertilizers with organic manures and biofertilizers treatment. The maximum in fruit length (5.27 cm), fruit diameter (4.93 cm), fruit volume (54.62 cc), number of seeds (8.17), seed weight (1.24 g), juice percentage (56.94%), specific gravity (1.36), juice: seed ratio (0.02), peel thickness (1.94 mm), moisture content of peel (84.28%) and moisture content of pulp (93.89%) were recorded under T_{12} - 50% RDF + 75% FYM + 75% Vermicompost + Biofertilizers (25g Azotobacter + 25g PSB + 150g VAM). The lowest values were obtained under control.

The marked effect of nitrogen on various characters of fruits was due to fact that, it increased the efficiency of metabolic processes of the tree and thus encouraged the growth of the plant in general and consequently the various parts of the plant including fruit. N, P and K fertilizer application, which might have resulted in high rate of photosynthesis results in higher carbohydrate accumulation in fruit thereby increasing in fruit diameter and weight. As the application of NPK significantly enhanced the plant growth and through its beneficial effects, which in turn resulted in an increased in fruit size (Singh *et al*., 2003) in guava. These observations are in agreement with findings of Sharma *et al.,* (2012) and Godage *et al*., (2013) in guava.

The higher uptake of nutrients in the tissues of Nagpur mandarin with recommended dose of NPK might have occurred due to stimulation of the rates of various physiological and metabolic processes resulting in better size, weight and fruit yield of Nagpur mandarin. These results are in accordance with the findings of Treder (2007) in apple and Hadole *et al.,* (2015) in Nagpur mandarin.

The potassium is known to be a vital element for the development of fruit, movement of sugar and indirectly photosynthesis. The findings are in accordance with those of Yasin Ashraf *et al.,* (2010) in kinnow mandarin and Pawar *et al*., (2014) in acid lime.

The ample increase in the juice content in case of combination of organic and inorganic sources of nitrogen appears to be due to the added benefits of organic matter which improves the soil structure, penetration, retention of moisture etc. and root proliferation by biofertilizer. Since water is the chief constituent of fruit juice, its increased availability within certain limits was apt to affect the juice percentage favourably. There is enough evidence in literature to support these findings. Madhavi (2001) also elaborated similar results in sweet orange.

Dey *et al.,* (2005) who reported an increase in the physical characteristics of guava with the application of biofertilizer and organic manure alone. Beneficial effect of integrated sources on yield of guava could be attributed to the fact that FYM after proper decomposition and mineralization supplied available nutrients directly to the trees, which had solublizing effect on fixed forms of nutrient in soil and had improved physico-chemical and microbial environment leading to better expression of response to applied chemical fertilizers these are important constituents of nucleotides, protein, chlorophyll and enzymes, taking part in various metabolic processes and having direct impact on vegetative and reproductive phases of fruits. The increase in average fruit weight due to the integration of organic sources of nutrients occurred due to accelerated mobility of photosynthates from source to sink as influenced by the growth hormones, released or synthesized due to organic sources of nutrients. The

increase in fruit volume was attributed to the corresponding increase in length and diameter. Similar results were also observed by Yadav *et al.,* (2011) in mango and Sharma *et al.,* (2013) in guava.

Organic manures and biofertilizers have direct role in nitrogen fixation, production of phytohormones like substances and increased uptake of nutrients hence quality improvement reflected in fruit character. These observations are in agreement with the findings of Madhavi *et al*., (2008) in mango and Baviskar *et al.,* (2011) in sapota.

Fruit weight and fruit size are highly correlated with dry matter content and balance level of hormones. Superior physical fruit quality may be due to fact that, organic manures and microbial fertilizers enhances the nutrient availability by enhancing the capability of plants to better solute uptake from rhizosphere, also these nitrogen fixers are known for accumulation of dry matter and their translocation as well as favour synthesis of different growth regulators. The above findings are in accordance with Gawande *et al.,* (1998) and Baviskar *et al.,* (2011) in sapota.

The organic matter also helps in more uptake of water in plant tissue and retention of moisture in soil. The application of biofertilizer might have lead to secretion of some organic acids such as acetic acid, formic acid, propionic acid, lactic acid, glycolic acid etc. and converted insoluble form of minerals of soil into soluble forms. The acids lower the pH and bring about dissolution of bound forms of nutrients. Some of the hydroxy acids may chelate with Ca and Fe resulting in effective solubilization of crops (Asokan *et al*., 2000) and Savreet Khehra, (2014) in lemon.

Biofertilizers enhances the nutrient availability by enhancing the capability of plants to attribute to better solute uptake from rhizosphere and also helped in mitigating minimum stress in acid lime Pawar *et al*., (2014). Moreover, the biofertilization improve the root system resulting in increased availability of enzymes which lead to strengthening of cells and improve cell metabolism. Similar results have also been reported by Ibrahim *et al.,* (2010) and Savreet Khehra (2014) in lemon.

VAM fungi to interact with other soil microbes like the free-living nitrogen fixers and phosphate solubilisers to improve their efficiency for the biochemical cycling of elements and supply the host plants with their nutrients requirements. These results are in agreement with those of Ba *et al*., (2001) who reported that the use of *B. megaterium* and VAM fungi as biofertilizers enhanced grape vines growth and increased the fruit yield.

Table 1: Efficacy of organic and inorganic fertilizers with bio-inoculants on Fruit length (cm), Fruit diameter (cm), Fruit volume (ml), Number of seeds per fruit (Nos), seed weight (g), Juice content (%), Specific gravity, Juice: Seed ratio, Peel thickness (mm), Moisture content of peel (%) and Moisture content of Acid lime (*Citrus aurantifolia* Swingle)

Tr. No	Fruit length (cm)	Fruit diameter (cm)	Fruit volume (ml)	No. of seeds per fruit(Nos)	Seed weight (g)	Juice content (%)	Specific gravity	Juice: Seed ratio	Peel thickness(mm)	Moisture content of peel(%)	Moisture content of pulp(%)
T_1	3.69	3.56	28.95	9.50	3.23	35.60	1.09	0.050	1.09	67.16	71.56
T_2	4.17	3.97	36.01	9.16	2.67	41.20	1.15	0.042	1.32	71.79	77.60
T_3	4.00	3.85	33.60	9.27	2.86	39.19	1.13	0.045	1.23	70.22	75.58
T_4	3.84	3.70	31.22	9.38	3.05	37.35	1.11	0.047	1.15	68.68	73.57
T_5	4.54	4.26	40.91	8.90	2.27	44.88	1.21	0.036	1.52	74.99	81.70
T_6	4.84	4.43	45.16	8.71	1.96	48.39	1.25	0.031	1.62	78.09	85.61
T_7	5.04	4.54	47.75	8.57	1.76	50.76	1.28	0.028	1.70	79.74	87.83
T_8	5.33	4.76	51.94	8.36	1.46	54.47	1.32	0.023	1.82	82.38	91.63
T_9	4.36	4.10	38.44	9.04	2.47	43.01	1.18	0.039	1.43	73.41	79.67
T_{10}	4.63	4.32	42.63	8.84	2.16	46.10	1.22	0.034	1.55	76.38	83.47
T_{11}	5.26	4.72	50.36	8.41	1.55	53.17	1.31	0.025	1.79	81.60	90.01
T_{12}	5.57	4.93	54.62	8.17	1.24	56.94	1.36	0.020	1.94	84.28	93.89
S.Ed	0.05	0.03	0.99	0.05	0.15	0.80	0.01	0.0012	0.02	0.76	0.98
CD(P=0.05)	0.12	0.08	1.97	0.08	0.074	1.63	0.02	0.0026	0.04	1.50	1,94

Treatment Details: T_1 – Control, T_2-100% RDF (400:200:220 g/ plant), T_3-75% RDF, T_4-50% RDF, T_5- 75% RDF + 100% FYM (20 kg/plant), T_6- 75% RDF + 100% Vermicompost (10 kg/plant), T_7- 75% RDF + 50% FYM + 50% Vermicompost, T_8-75% RDF + 50% FYM + 50%Vermicompost + Biofertilizers (25g Azotobacter + 25g PSB + 150g VAM), T_9- 50% RDF + 100% FYM, T_{10}- 50% RDF + 100% Vermicompost, T_{11}- 50% RDF + 75% FYM + 75% Vermicompost, T_{12}- 50% RDF + 75% FYM + 75% Vermicompost + Biofertilizers (25g Azotobacter + 25g PSB +150g VAM).

Thus, it could be seen that the application of organic manures at the rate of 15kg FYM+ 7.5 kg Vermicompost and Biofertilizers at the rate of 25g Azotobacter + 25g PSB + 150g VAM can reduce the inorganic fertilizations to at extent of 50 percent (200g nitrogen,100g phosphorus and 110g potassium per tree) increasing the physiological parameters of acid lime.

Conclusion

The physiological characteristics of fruit are an expression of a plant's vegetative activity which was also significantly influenced by the nutrient management through bio-organic manures. The maximum fruit length, fruit diameter, fruit volume, number of seeds, seed weight, juice percentage, specific gravity, juice: seed ratio, peel thickness, moisture content of peel and moisture content of pulp were recorded with the application of 50% RDF + 75% FYM + 75% Vermicompost + Biofertilizers (25g Azotobacter + 25g PSB + 150g VAM) were significantly superior to control. This may be due to optimum supply of plant nutrients and synthesis of growth hormones in right amount during the right time stimulates cell division, cell elongation and production of more photosynthates which leads to better development of the fruit.

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