



Growth and Yield Response to Application of Organic and Inorganic Nutrient Sources in Lemon [*Citrus limon* (L.) Burm.] cv. Assam Lemon

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Authors' contributions

This work was carried out in collaboration among all authors. Author SWH designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors BS and Kh.AS managed the analyses of the study. Authors KS, RD, JL and Th.N managed the literature searches and helps in field and lab data collection, analysis and compilation as well. All authors read and approved the final manuscript.

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ABSTRACT

Citrus is a perennial fruit crop which is highly responsive to nutrient applied and thus require adequate amount of nutrition for obtaining optimum growth and yield. In recent years, it has been observed that organic in combination with inorganic sources of nutrient have gained popularity due to the negative impact of excessive use of chemical fertilizers on soil and environment. The experiment was conducted with seven treatments and three replications consisting recommended dose of fertilizers (RDF) and RDF in combine with Organic manure and Vermicompost at different percentage during the year 2019. The treatment, T₄ with 60% N of RDF + 40% N from FYM (farm

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yard manure) gave the best result in improving plant growth and yield. The maximum plant height increment (15.04%), highest percentage in canopy spread increment, North-South (22.17%) and East-West (20.35%), maximum fruit set percentage (37.78%), highest number of fruits (40.22) per plant and maximum yield (8.52 kg) per tree were recorded from T₄ (60% N of RDF + 40% N from FYM) which indicated that the application of 60% N of RDF + 40% N from FYM may be recommended to obtain maximum yield and best quality fruit in Assam lemon.

Keywords: Citrus; fertilizers; growth; nutrition; vermicompost; yield.

1. INTRODUCTION

Lemon [*Citrus limon* (L.) Burm.] is one of the most popular fruits in citrus group in India and around the world as well. Lemon is the leading acid citrus fruit and the third most favoured citrus species next to Orange and Mandarin, owing to its appealing color, aroma and flavor [1]. There are number of diverse form of lemon which may slightly differ from each other. It has wide adaptability which makes it one of the most promising fruit crops in the world. Assam Lemon, an important variety of lemon is widely grown in the north-eastern parts of India which is a dwarf cultivar and suitable for high density planting [2]. Assam lemon is the most important lemon cultivar of Assam and other parts of N.E. region of India. It is locally known as 'Kazi Nemu' in Assam, 'Pat Nimboo' in Western India and 'Seville lemon' in Andhra Pradesh [3]. It is also found in the other North Eastern States like Arunachal Pradesh, Nagaland and Meghalaya [4]. Its inception is traced back to as chance seedling which was later propagated by vegetative means as a clonal variety and designated as Assam lemon [5].

It is an evergreen plant with dark green leaves; leaf lamina is lanceolate in shape having 70.2 mm in length and 30.2 mm in width with brevipetiolate attachment and dentate margin. Leaf petiole is 8.6mm in length and its wings are absent. Individual flowers are large, hermaphrodite and purple-tinged in the bud and on the lower surface of petals. Anthers are also yellow in colour [2]. Many flowers are staminate (sterile male) because of pistil abortion, the incidence of which varies greatly from bloom to bloom and season to season [6]. Assam lemon is found to be comparatively bigger in size than the normally grown lemon and hence, contain higher amount of juice. The fruit, zest, roots, leaves and juice are widely used in culinary, beverages, industries and medicines [7]. Assam lemon has the character of being able to bear fruits in many flushes making it available throughout the year with two peak season (February-March and September-October). It is a dwarf cultivar and

suitable for high density planting [2]. This is a specific character of lemon which is not common in other citrus fruits.

Accordingly, to sustain the whole year fruiting and obtain the best quality fruits with maximum yield, it is necessary to maintain the nutrition status of the soil at peak level from where the plant receive nutrients. Hence, proper application of fertilizers and manuring should be practiced to enhance the healthy and sturdy growth of plants on which the yield and quality fruit production solely depends. The fertilizers in combination from organic and inorganic nutrient sources would not only help to overcome the deficits of these vital nutrients in soil and plants, however, it would as well help in enhancing the integrated plant nutrient management program. To stipulate viable alternative solution for long term basis of sustainable plant nutrient system, Verma and Chauhan [8] in 2013 advocate that there is an urgent necessity to evaluate different nutrient systems being followed at present in fruit plants to mitigate nutritional deficiencies along with appropriate combination of urea, single super phosphate, muriate of potash, vermicompost and farm yard manure which will eventually help in fulfilling nutrition needs of the tree for economically profitable production of citrus fruit. Thus, the optimized standards of fertilizer application are of great importance to get good growth. Therefore, the present study were undertaken to find out the best possible combination of organic and inorganic fertilizers which can stimulate the citrus production without adversely affecting the quality of soils.

2. MATERIALS AND METHODS

The study was executed with the aim of evaluating and standardizing the influence of organic and inorganic nutrient sources on growth and yield of Assam lemon. The work of research was conducted on three years old Assam lemon, a cultivar of lemon which is dwarf and spreading type, planted in 3x3m spacing during the year 2019 at citrus orchard, Department of Fruit Science, College of Horticulture and Forestry, CAU, Pasighat, Arunachal Pradesh. The

experimental design was laid out in Randomized block design (RBD) with seven treatments, each replicated three times. The total number of plant units subjected to the study was forty-two (42). The inorganic sources of N (Nitrogen), P (Phosphorus) and K (Potassium) were urea, single super phosphate (SSP) and muriate of potash (MOP) and organic sources were FYM (farm yard manure) and vermicompost. Nitrogenous fertilizer i.e urea was applied in two split doses. Firstly, FYM was applied 15 days prior to fertilizers application and vermicompost was applied a week before the application of fertilizers [9]. The fertilizers were incorporated in a ring basin made around each tree at 60 cm away from the trunk. Half dose of nitrogen and full dose of phosphorus and potassium from inorganic sources were applied in the first week of February, 2019 by mixing the respective doses thoroughly into a certain depth of soil. The remaining half dose of nitrogen from inorganic source was applied in the last week of April, 2019 to boost up the growth of the developing fruits.

Plant height and canopy spread of trees under study were measured using measuring tape. For canopy spread, two observations, one each on east-west and north-south directions were recorded by using a scaled pole with the help of measuring tape. Stem girth was recorded circumferentially at 15 cm from the ground. Plant height and canopy spread were expressed in centimeters and stem girth was expressed in mm and percentage increase over initial value was calculated. The fruit set (%) was calculated by dividing total number of fruit set by the total number of flowers and then multiplied by 100. The number of fruits harvested per plant at the time of harvesting was recorded. Fruits from each plant were harvested separately for all the treatments and the yield/plant was calculated by multiplying total number of fruits/plant with average fruit weight. Observations recorded during field experiment were subjected to the statistical analysis of variance for RBD. Significance and non-significance of the variance due to different treatments were determined by calculating the respective 'F' values according to the method described by Gomez and Gomez [10].

2.1 Treatment Details

T1 : Control (RDF from inorganic sources) (N:P:K=210:140:210 g/plant) [11]

T2 : 75% N of RDF + 25% N from FYM
 T3 : 75% N of RDF + 25% N from Vermicompost
 T4 : 60% N of RDF + 40% N from FYM
 T5 : 60% N of RDF + 40% N from Vermicompost
 T6 : 50% N of RDF + 50% N from FYM
 T7 : 50% N of RDF + 50% N from Vermicompost

Where, RDF is recommended dose of fertilizers and N is Nitrogen. In all the treatments, Phosphorous (P) and Potassium (K) will be applied through inorganic sources at the same rate as mentioned in Control.

3. RESULTS AND DISCUSSION

Data presented in Table 1. with regards to growth parameters showed huge variance before application and after application of the nutrients. Maximum percentage of plant height increment (15.04%) and canopy spread East-West (20.35%) and North-South (22.17%) were showed by T₄ [60% N of RDF + 40% N from FYM]; for stem girth, the influence of the treatment was found to be non-significant. The minimal vegetative growth of Assam lemon was observed in T₁ [Control (RDF from inorganic sources) (N:P:K=210:140:210 g/plant)]. It seems that growth parameters were significantly influenced by the application of organic and inorganic nutrient sources and their combination. In Table 2. the data presented denote that yield and its attributes were significantly influenced by the application of organic and inorganic nutrient sources in combination where, the peak fruit set (37.78%), maximum fruit yield (8.52 kg/tree) and largest number of fruits (40.22 fruits/tree) harvested per plant were recorded in treatment T₄ [60% N of RDF + 40% N from FYM].

This notable influence might be the result of improved physical and chemical properties as well as nutritional status of the soil caused due to the organic manures addition eventually helping the plant in better uptake of minerals, water and nutrients, resulting in its increased rate of growth. Nitrogen too has an obvious effect on increase in growth. Organic and inorganic fertilizer in combined application led to maximal increase over the initial one as observed in plant height, canopy spread and trunk growth. The reason behind this effect could be due to enhancement in expansion of leaf and its dark green colour

Table 1. Effect of organic and inorganic nutrient sources on growth of Assam lemon

Treatments	Height				Stem girth				Canopy spread (E-W)				Canopy spread (N-S)			
	Initial (cm)	Final (cm)	Increase (cm)	Increase (%)	Initial (mm)	Final (mm)	Increase (mm)	Increase (%)	Initial (cm)	Final (cm)	Increase (cm)	Increase (%)	Initial (cm)	Final (cm)	Increase (cm)	Increase (%)
T ₁	175.33	186.17	10.83	6.17	126.67	137.17	10.50	8.30	161.00	169.33	8.33	5.16	168.33	180.13	11.80	7.09
T ₂	165.67	180.67	15.00	9.82	139.00	154.00	15.00	10.96	180.00	192.90	12.90	7.28	180.83	195.83	15.00	8.33
T ₃	171.00	191.50	20.50	12.09	126.17	143.03	16.87	13.39	172.50	195.33	22.83	13.48	166.17	196.50	30.33	*18.47
T ₄	176.83	203.17	26.33	*15.04	130.67	152.30	21.63	16.88	184.00	220.93	36.93	*20.35	193.33	235.50	42.17	*22.17
T ₅	164.67	188.33	23.67	*14.43	121.83	140.07	18.24	15.43	152.50	179.26	26.76	*17.54	155.50	188.00	32.50	*21.47
T ₆	159.67	173.83	14.17	8.69	120.50	136.17	15.67	13.34	152.83	171.03	18.20	12.22	155.00	180.83	25.83	17.08
T ₇	171.50	188.67	17.17	10.17	138.83	157.00	18.17	13.64	112.00	121.20	9.20	11.30	152.17	173.83	21.67	14.44
C.D. _(0.05)				3.77				NS				7.69				4.64
SE(m)				1.21								2.47				1.49

*significant, NS-non-significant

Table 2. Effect of organic and inorganic nutrient sources on yield of Assam lemon

Treatments	Fruit set (%)	No. of fruits /plant	Yield /plant (kg)
T ₁	29.68	25.65	3.61
T ₂	32.33	*34.96	6.25
T ₃	30.39	*36.40	7.24
T ₄	*37.78	*40.22	*8.52
T ₅	36.56	*36.03	5.74
T ₆	34.48	32.45	5.67
T ₇	30.07	29.54	4.82
C.D. _(0.05)	1.19	6.35	1.17
SE(m)	0.38	2.04	0.38

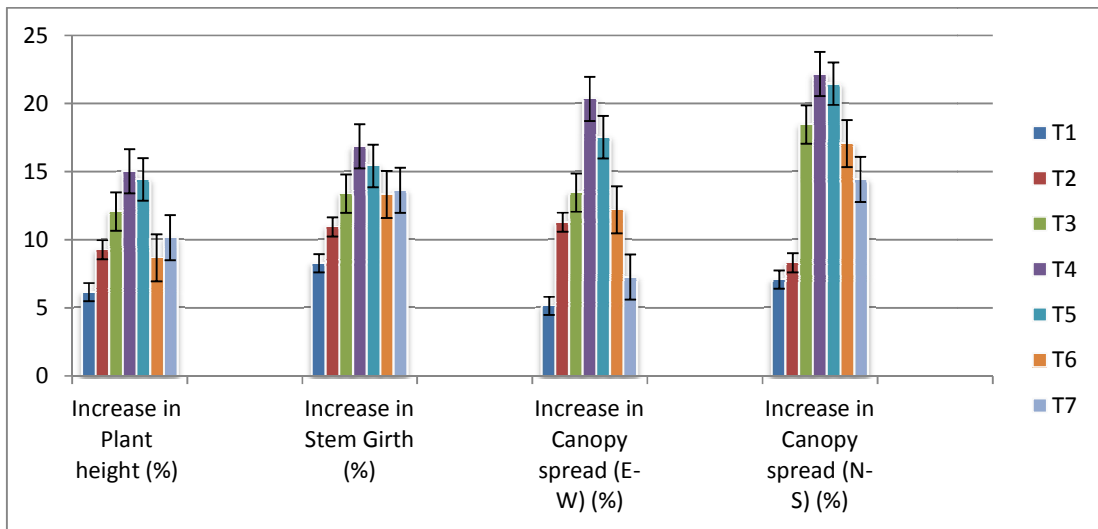


Fig. 1. Effect of organic and inorganic nutrient sources on growth of Assam lemon

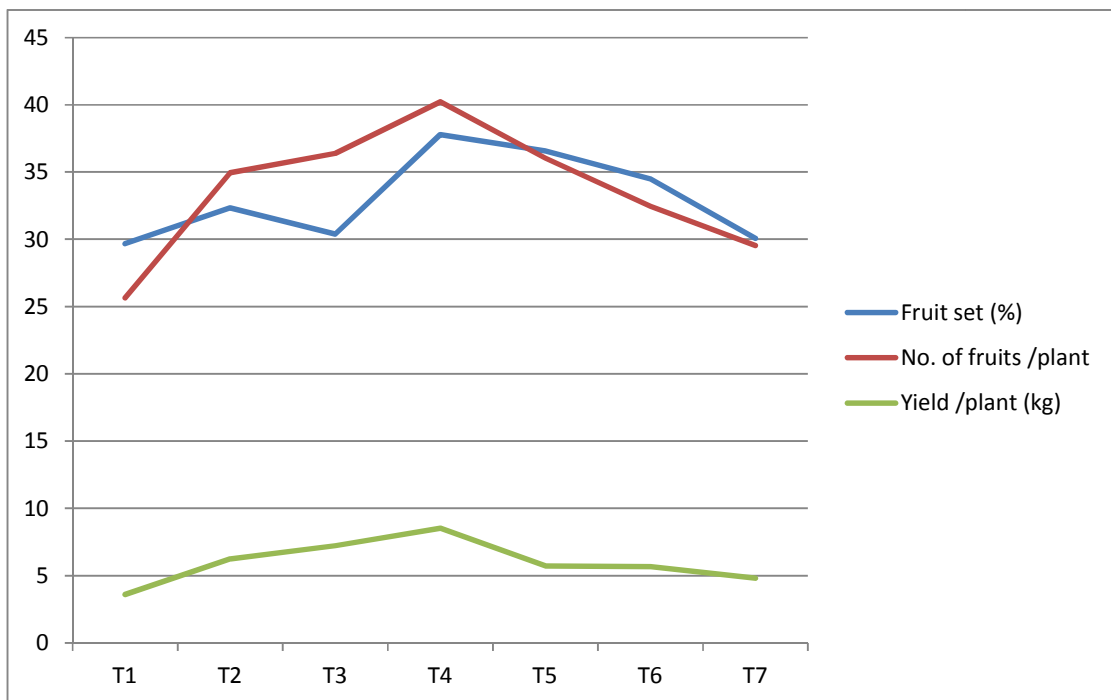


Fig. 2. Effect of organic and inorganic nutrient sources on yield of Assam lemon

by the combined application of organic and inorganic fertilizer which subsequently improves respiration and photosynthesis of the plant; thus, it is clear that nitrogen from inorganic source and FYM balanced the nutrition and enhanced the growth of the plant. FYM improves physico-chemical properties of soil, which provides better conditions for plant growth and development. Dudi et al. [12]; Kaul and Bhatanagar [13]

obtained the results in Kinnow which are in line with the present results. The same findings had also been reported in acid lime by Lal and Dayal, [14] in which the use of organic and inorganic nutrients in combination improved the soil texture and porosity, causing plant root development, nutrient uptake which resulted in faster cell elongation and consequently enhanced plant height. T₄ [60% N of RDF + 40% N from FYM]

showing rise in fruit set, number of fruits and fruit yield might be due to the fact that plant receive optimum supply of nutrients and adequate amount of growth hormones during the entire course of fruit growth, ultimately leading to more accumulation of photosynthates resulting in more development of fruits and fruit yield. Rise in nutrients level in crop assimilation area causing the enhancement of dry matter production might be the reason that leads to the multiplication of fruit number and weight of fruit. Likewise, dry matter partitioning to economic sink rationally leads to improvement in yield attributes. The present findings are in total accord with the results reported by Dalal et al. [15]. Organic manures along with inorganic fertilizers enhanced the nutrients availability by soothing the plants capability to uptake solute from the rhizosphere which might be the reason of obtaining superior quality of fruit. The current report is in conformity with result presented by Gawande et al. [16] and Patel and Naik [17] in lemon.

4. CONCLUSION

From the results of the study conducted, the treatment, T₄ with 60% N of RDF + 40% N from FYM generated the best outcome among various treatments in majority of the parameters. Henceforth, it can be concluded that the treatment T₄ [60% N of RDF + 40% N from FYM] may be recommended for efficient nutrients supply to the plants for better yield, growth and developments of Assam lemon.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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