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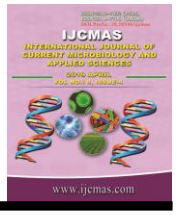

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Effect of Fertigation on Growth, Phenology and Nutrient Status in Leaves under High Density Orchard of *Citrus sinensis* Osbeck cv. Mosambi

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A B S T R A C T

The experiment was conducted during three consecutive year i e, 2013-14, 2014-15, 2015-16 to show the effect of fertigation on phenology and vegetative growth of the plants and nutrients uptake by the leaves. Result of three years pooled data showed that increase in plant height (35.81 cm), trunk girth (4.42 mm) canopy volume (1.94 m^3), growth of current season shoot (9.08 cm), leaf area (31.52 cm^2) and leaf area index (5.54) were responses more under higher doses of fertigation i e 120 % RDF followed by 100 % RDF. The phenological observations like bud emergence period, full bloom period, fruit set, date of maturity, etc. were also affected by the doses of fertilizers. On the basis of above findings it may be concluded that the different doses of fertilizers affect on vegetative growth as well as phenological parameters of the plant.

Introduction

Citrus is a leading fruit crop of the world. It is successfully grown in tropical and sub-tropical climate. It belongs to family Rutaceae. According to (Shirgure, 2012) it is grown in more than 140 countries in the world. India has different types of climate which permits to grow almost all types of horticultural crops. In India citrus is grown in almost all parts of the country. Land is limited so there is little scope of area expansion under any crops. To fulfill the demand of increased population our country has a major task to increase production and productivity of each crop without expansion of their area. There are several technologies to increase the yield of any crop per unit area. Technologies like modern method of irrigation, controlled condition structure (polyhouse, net house, green house, etc.), high density orcharding, fertigation, improved varieties etc. Citrus crops are highly nutrient loving plants. Under fertilizer management, fertigation is one of the improved and efficient methods of fertilizer application through which nutrients applied directly to root zone of the plants. By this practice fertilizer may be applied in number of split doses which increase efficiency use of water and fertilizer because this technique prevents leaching of nutrients. This practice also saves fertilizer and its

application cost (Solaimalai *et al.,* 2015 and Singh *et al*., 2010).

Out of 16 essential elements of the plant, NPK are very critical elements for the plants. It takes part in many metabolic activities in the plants. Nitrogen is a prime element for vegetative growth which is a constituent of amino acids, amino sugars, amines, nucleoprotein, polypeptide. Phosphorus is also a constituent of phospholipids, nucleic acids and many energy releasing compounds etc. Potassium in plants acts as a co-factor for various metabolic activities. According to Sah *et al.,* (2014) potassium acts as catalyst in enzymatic reaction and also coupling with amino acids and form peptides. Citrus are more responsive crop in respect to show the deficiency symptoms. So, about this crop more information is required for proper growth of the plant. Fertigation is a new technique for application of fertilizer along with irrigation water and have potential to save water and fertilizer (Koo, 1981; Haynes, 1985 and Shirgure, 2013). In Bihar condition *Citrus sinensis* Osbeck cv. Mosambi have no commercial orchard but scattered planting performing good in respect of yield and quality. Orchardists have lack of knowledge about fertilizer doses as well as fertigation scheduling to keep the plants healthy for proper yield and quality. Keeping the above facts in view the present experiment was laid out to study the "Effect of fertigation for better health of plants, yield and quality under high density orchard of *Citrus sinensis* Osbeck cv. Mosambi".

Materials and Methods

The experiment was conducted at Bihar Agricultural University Sabour, Bihar, under high density orchard during 2013-14, 2014-15, and 2015-16. The weather of Bihar is sub-tropical in nature. It is slightly arid in summer, rainfall moderate and cold winter was depicted in (Table 1). The initial soil data were recorded and depicted in (Table 2). Normally the experimental plot had leveled surface with good fertility level.

The trial was carried out on four years of plants with seven fertigation level in randomized block design based on recommended dose of fertilizer (RDF) *i.e.* 300:90:90 gram/plant/year during first year and doses increased @ 100g,75g,75g NPK/year respectively upto three years. The treatments were T_1- 120% of RDF; T_2- 100% of RDF; T_3- 80% of RDF; T_4- 60% of RDF; T5- 40% of RDF; T_6- 100% RDF in basal with drip irrigation and T_7- 100 % RDF in basal without drip irrigation. The treatment T_1, T_2, T_3, T_4, T_5 were applied in split doses whereas, treatment T_6 and T_7 applied directly in plant basin. Fertigation scheduling was done at monthly interval starting from November. The sources of fertilizer were urea for nitrogen and mono potassium phosphate and sulfate of potash for phosphorus and potassium. The experiment was started on four years old Mosambi plants which were planted under high density planting (HDP), at a spacing of 3.0 × 2.5 m.

Procedure

The phenological observations like growth of current season shoot, plant height, canopy volume and trunk girth were measured form four selected shoots in four directions of the plants, before and after fertigation with the help of measuring tape during August. Canopy volume was calculated according to formula given by Roose *et al.,* (1986). The leaf area index (LAI) of selected plants was measured by using the instrument canopy analyser (LP-80, PAR/LAI Ceptometer, Decagon Devices, Inc., WA, USA). The reproductive parameters were recorded by visiting the experimental orchard frequently after bud emergence to fruit maturity. The

physiological parameter in terms of leaf area of fifty fully expanded leaves from each treatment was recorded using leaf area meter (CI-203 CA, CID Biosciences, Camas, USA). For leaf nutrient analysis leaf samples were collected from each treatment at maturity stage i.e in August –September. The nitrogen content was estimated by Kjeltec 2300 (Fose Tecator) and phosphorus was determined by vanado-molybdate color reaction method. The potassium content in leaves was estimated by flame photometer. Total micronutrients present in leaves were estimated by Atomic Absorption Spectrophotometer with the help of different candled present in it. Boron content in leaves was estimated as per method given by Adhikari *et al.,* (1993). The parameters related to yield characters were calculated just after harvesting of fruits as well as by frequently visiting the orchard.

Statistical analysis

The experimental data were subjected to statistical analysis in order to find out which of the treatments showed significant variation in different parameters studied under investigation. The technique of analysis of variance (ANOVA) for randomized block design (RBD) was adopted as suggested by Panse and Sukhatme (1967).

Results and Discussion

Reproductive parameters

The results obtained by the effect of various fertigation treatments on reproductive parameters of Mosambi under Bihar condition were carefully recorded and depicted in Table 3. These parameters might be helpful to the orchardist as well as scientist of Bihar condition (sub-tropical) for time of all cultural practices imposed in the field as well as in hybridization programme. Although, no much more variations were observed among the treatments in the field. This might be due to the influence of environmental factors on these parameters. In this experiment as the nitrogen levels were increased the tendency of emergence of bud showed delayed because nitrogenous fertilizer favours vegetative growth condition for a longer period that's why delayed bud emergence whereas phosphate helps in flowering. So, a balance proportion of NPK helps in flowering as well as fruit setting in citrus. Wassel *et al.,* (2007) observed that higher dose of nitrogen application favours in increase in number of fruits in the plant. A better combination of phosphate and potash may result to enhance the anthesis period. Hence, a balance combination of NPK fertilization may results in early fruit setting. The same findings in relation to early flowering and fruiting through right proportion of NPK fertilization was observed by Sah *et al.,* (2014) in pear. Date of maturity also influenced by nitrogenous fertilizer as dose of nitrogen increased the maturity period delayed and this might be due to excess nitrogen makes fruit skin thick and leathery (Jacob and Uexkull, 1958). Contrary to this, it is more pronounced that phosphorus decreases the maturity period (Lekvinadze, 1972 and Ghosh *et al.,* 1981). So, all major nutrients play an important role in maturity of fruits and this result are in confirmation with the findings of Choudhary (1984) and Nirgude *et al.,* (2016) in Mosambi.

Vegetative parameters

Data related to vegetative characteristics have been significantly differed by different fertilizer doses through fertigation are presented in Table 4. The treatment T_2 showed the maximum length of current season shoot (9.11 cm) whereas minimum (7.24 cm) was recorded under T_4 which was at par with rest of the treatments. In respect of increase in plant height maximum (35.81 cm)

was observed in T_1 followed by T_2 while minimum (20.74 cm) in T_5. Data regarding to increase in trunk girth was significantly differed among treatments. Highest increase in trunk girth was recorded in T_1 and T_2 (4.42 mm) which was followed by T_3, T_4 and T_6 whereas lowest in T_5 and T_7. Leaf area was found highest in T_1 (31.52 cm^2) followed by T_2 (29.98 cm^2) and T_7 (28.63 cm^2). The lowest leaf area (26.23 cm^2) was showed in T_5 which was at par with T3, T4 and T_6. The maximum LAI (Leaf Area Index) was observed in T_1 (5.54) followed by T_2 (5.22) which intern at par with T_3 (5.08) while minimum (4.04) under T_5 followed by T_4, T_5 and T_7. Significantly maximum canopy volume (1.94 m3) was recorded in T_1 which was at par with T_2 and T_6 followed by T_4, T_7 and T_3 while lowest in T_5.

Table.1 Four years average meteorological data from 2014 to 2017

Months	Temperature (^oC)		Relative Humidity (%)		Rainfall (cm)	Wind speed (Km/hr.)
	Max.	Min.	7.00 AM	2.00 PM		
January	21.4	8.6	94.6	64.5	20.1	2.8
February	25.6	10.7	89.2	53.6	11.4	2.5
March	30.8	15.7	81.0	47.8	9.2	4.1
April	35.7	20.7	72.1	42.3	26.6	6.4
May	36.1	23.9	77.3	52.4	106.5	7.5
June	34.4	25.4	83.1	64.9	113.8	5.9
July	32.0	25.4	89.5	77.6	353.6	6.1
August	32.4	25.5	89.4	76.5	242.0	5.3
September	32.3	24.8	89.2	76.3	203.4	3.6
October	30.4	20.1	89.2	67.7	91.1	2.1
November	28.9	14.5	87.9	54.9	0.0	1.3
December	23.1	9.6	94.4	64.5	0.1	2.1

Table.2 Initial soil nutrient status of experimental plot before fertigation of different fertilizer

Soil depth (cm)	pH (1:2.5)	EC (ds/m)	Organic C (%)	N (Kg/ha.)	P_2O_5 (Kg/ha.)	K_2O (Kg/ha.)
0 -15	7.21	0.43	0.48	200.7	28.08	128.1
15 - 30	7.18	0.40	0.41	326.1	29.99	136.8

Table.3 Effect of fertigation on phenology of *Citrus sinensis* cv. Mosambi

Pooled data of 2013-14, 2014-15 and 2015-16										
Treatments	Duration of bud emergence		Days	Duration of anthesis		Days	Duration of fruit set		Days	Date of maturity
T_1- 120 % RDF	11th Feb	21st Feb	11	3rd March	10th March	08	6th March	14th March	09	18th October
T_2- 100 % RDF	13th Feb	22nd Feb	10	2nd March	10th March	09	5th March	15th March	11	18th October
T_3- 80 % RDF	13th Feb	21st Feb	09	27th Feb	11th March	13	4th March	15th March	12	20th October
T_4- 60 % RDF	14th Feb	21st Feb	08	28th Feb	13th March	14	4th March	17th March	14	22nd October
T_5- 40 % RDF	14th Feb	22nd Feb	09	27th Feb	12th March	14	3rd March	16th March	14	23rd October
T_6- 100 % RDF with drip irrigation	13th Feb	21st Feb	09	3rd March	13th March	11	6th March	18th March	13	25th October
T_7- 100 % RDF without drip irrigation	15th Feb	24th Feb	10	6th March	15th March	10	9thMarch	19th March	11	30th October

Table.4 Effect of fertigation on vegetative parameters of *Citrus sinensis* cv. Mosambi

Pooled data of 2013-14, 2014-15 and 2015-16						
Treatments	Current season shoot (cm)	Increase in plant height(cm)	Increase in trunk girth (cm)	Leaf area (cm^2)	LAI	Canopy volume (cm^3)
T_1- 120 % RDF	9.08	35.81	4.42	31.52	5.54	1.94
T_2- 100 % RDF	9.11	30.39	4.42	29.98	5.22	1.81
T_3- 80 % RDF	7.91	27.73	4.22	26.99	5.08	1.60
T_4- 60 % RDF	7.24	24.87	4.14	26.63	4.60	1.62
T_5- 40 % RDF	7.45	20.74	3.89	26.23	4.04	1.38
T_6- 100 % RDF with drip irrigation	8.09	28.24	4.19	27.73	4.48	1.75
T_7- 100 % RDF without drip irrigation	7.31	27.66	4.08	28.63	4.48	1.62
CD (P = 0.05)	0.40	4.38	0.09	0.95	0.13	0.20
SEm (+)	0.87	2.01	0.18	1.93	0.26	0.11

Table.5 Effect of fertigation on nutrient status in leaves of *Citrus sinensis* cv. Mosambi

Pooled data of 2013-14, 2014-15 and 2015-16								
Treatments	N	P	K	Zn	Cu	Fe	Mn	B
T_1- 120 % RDF	2.08	0.14	0.84	23.45	4.99	243.57	52.33	45.19
T_2- 100 % RDF	2.16	0.15	0.84	23.57	4.51	221.97	47.66	42.88
T_3- 80 % RDF	1.97	0.15	0.80	21.01	5.00	204.50	50.60	40.36
T_4- 60 % RDF	1.89	0.13	0.77	20.56	5.75	188.31	42.96	40.91
T_5- 40 % RDF	1.77	0.14	0.78	20.30	5.16	186.96	38.72	32.02
T_6- 100 % RDF with drip irrigation	1.94	0.14	0.83	21.91	5.60	200.37	35.87	34.42
T_7- 100 % RDF without drip irrigation	1.88	0.12	0.75	19.81	3.95	163.62	36.15	25.86
CD (P = 0.05)	0.16	0.05	0.08	1.51	2.19	27.91	11.05	5.10
SEm (+)	0.08	0.02	0.04	0.69	1.00	12.81	5.07	2.34

Almost all vegetative parameters showed better under higher doses of fertilizer in treatment T_1 and this might be due to high fertilizer use efficiency because NPK were applied to the plants in many split doses from vegetative growth to maturity of the fruits which helped to overcome the requirements of essential nutrients during critical growth periods. These data also supported by the findings of Ramana *et al.,* (2014) who found maximum plant growth when higher NPK dose were supplied in the sweet orange. The

results of Kachwaya and Chandel (2015) are also in agreement with the findings of above results. Ahmad *et al.,* (2010) also reported that nitrogenous fertilizers are positively correlated to vegetative growth in sweet cherry. The growth parameters like canopy volume in Valencia trees were found highest under higher dose of fertilizer i.e. 720 g N (Menino *et al.*, 2003). The data related to LAI was also supported by Chatterjee (2013) who worked on tomato and found that highest nitrogen application among various treatments are responsible for highest value of LAI.

Nutritional parameters

Three years of pooled data related to *Citrus sinensis* cv. Mosambi of leaf nutrient status have been analyzed and presented in Table 5. The highest nitrogen content (2.16 %) was recorded in T_2 which was at par with T_1 followed by T_3 and T_6 whereas minimum (1.77 %) in T5 which was at par with T_4 and T_7. Data related to phosphorus content in leaves of Mosambi was found non-significant differences among treatments but the value of phosphorus in leaves were found sufficient in range. Potassium content in leaves was also found non-significant differences. It was ranged between 0.75 to 0.84 % and it was found insufficient in range from reference value. Highest Zn content (23.57 ppm) in Mosambi leaves was found in T_2 which was at par with T_1 followed by T_6 while lowest (19.81 ppm) in T_7 which was at par with T_3, T_4 and T_5. Data regarding to Cu content showed non-significant effect among the treatments. Fe content was found maximum (243.57 ppm) in T_1 which was at par with T_2 (221.97 ppm) while minimum (163.62 ppm) in T_7 which showed parity to T4 and T5. Data in respect to Mn content in leaves, highest (52.33 ppm) under T_1 which was at par with T_2, T_3 and T_4 whereas lowest (35.87 ppm) in T_6. Likewise, B content was highest (45.19 ppm) in T_1 which was at par with T_2, T_3 and T_4 while lowest (25.86 ppm) in T_7. It may be concluded that the higher doses of NPK leaves contain higher amount of micro-nutrient and this might be due to the regular supply of balanced dose of NPK and water throughout the growing period resulted in maintaining the physical properties of soil to absorb more nutrient Ramana *et al.,* (2014) and Shirgure and Srivastava (2013).

On the basis of above results and discussion it may be concluded that higher dose i.e 120 % of RDF was found best in respect of all parameters like reproductive parameters, vegetative parameters as well as nutritional parameters in leaves in Mosambi. It might be due to plants were in growing period and response of fertilizer doses were positively showed in the field.

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