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# Evaluation of water regime and fertigation on growth, yield and economics of sweet orange (*Citrus sinensis* Osbeck) cv. MOSAMBI

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**ABSTRACT :** A field experiment was conducted during February 2012 to December 2012 at College of Agriculture, under PFDC, ARS located at campus of S.K.R.A.U, Bikaner. The experiment was laid out in split - plot design with four replications and consisted of twelve treatment combinations, comprised of four water regimes (0.6, 0.8 and 1.0 volume of water through drip and another one 1.0 volume of water by surface irrigation method) and three RDF levels of NPK (75, 100 and 125% RDF). The maximum growth of plants was recorded with 1.0 volume of water through drip along with fertigation of 125 per cent RDF. As well as the maximum yield and economics were observed with 0.8 volume of water through drip along with fertigation of 100 per RDF.

**KEY WORDS :** Water regime, Fertigation, Growth, Yield, Economics

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Citrus is the leading fruit crop of the world. The genus Citrus includes more than 162 species belonging to the order Geraniales family Rutaceae and sub family Aurantoidae. In India its rank third in production after banana and mango. Among citrus, the sweet orange (tight skinned orange),commonly known as *mosambi* and *malta* is an important citrus fruit crop in India. It is also grown in many parts of Rajasthan especially in Sriganganagar, Hanumangarh, Kota, Jhalawar, Chittore, Udaipur, and Bikaner district where irrigation facilities are available. It is an economically important sub tropical fruit which has pleasant flavor, juicy, and sour-sweet taste. It is not only delicious, refreshing but also quenches the thirst and provides vitamins, minerals, sugars, energy and many other substances. The main constraint for fruit production in Rajasthan is scarcity of water. The ground water resource is not only limited owing to poor surface and sub-surface drainage but is also generally highly saline. The irrigation resources in the region are limited such as open well, water storage tanks and canal. The average annual rainfall in the arid region is very low and varies from 100mm in north-western sector of Jaisalmer to 450mm in the eastern boundary or arid zone of Rajasthan. The interaction between the two costly inputs like water and fertilizer determines the sustainability of high crop productivity. Higher application of any one input is beneficial only under adequate supply of the other. Judicious use of water and nutrients is necessary to achieve sustainable production. The efficient utilization of these inputs need integrated approach and to promote the techniques of nutrients and water management among farmer to achieve the quality and quantity produce. However, the information regarding drip irrigation and fertigation scheduling in sweet orange under is lacking. Now, it is essential to standardize appropriate quantity of fertilizers through drip irrigation system in sweet orange for Rajasthan.

## RESEARCH METHODS

The experiment was conducted at college of Agriculture under PFDC, Agriculture Research Station located at campus of Swami Keshwanand Rajasthan Agriculture University, Bikaner during February 2012 to December 2012 on 8 year old sweet orange orchard. The experiment consisted of twelve

**Table A : Total water applied calculated as monthly**

| Month | 0.6 V Drip | 0.8 V Drip | 1.0 V Drip | No. of irrigations | 1.0 V Surface irrigation | No. of irrigations |
|---|---|---|---|---|---|---|
| February (6 Feb. to 29 Feb.) | 139.6 | 186.1 | 232.7 | 13 | 258.8 | 4 |
| March (2 March to 30 March) | 341.8 | 455.8 | 569.7 | 15 | 548.0 | 4 |
| April (1 April to 29 April) | 427.0 | 569.3 | 711.6 | 15 | 651.8 | 4 |
| May (1 May to 31 May) | 585.3 | 780.4 | 975.6 | 16 | 1079.3 | 5 |
| June (2 June to 30 June) | 707.5 | 943.4 | 1179.2 | 15 | 1104.1 | 4 |
| July (2 July to 30 July) | 677.9 | 903.9 | 1129.8 | 15 | 1067.9 | 4 |
| August (1 Aug. to 31 Aug.) | 371.1 | 494.8 | 618.5 | 16 | 711.9 | 5 |
| September (2 Sept. to 30 Sept.) | 242.3 | 323.0 | 403.8 | 15 | 377.8 | 4 |
| October (2 Oct. to 30 Oct.) | 258.0 | 344.0 | 430.0 | 15 | 489.9 | 5 |
| November (1 Nov. to 29 Nov.) | 132.1 | 176.2 | 220.2 | 15 | 193.9 | 4 |
| December (2 Dec.) | 7.2 | 9.6 | 12.0 | 1 | | |
| | 3889.9 | 5186.5 | 6483.2 | 151 | 6483.2 | 44 |

treatment combinations comprised of four water regimes ($W_1$ : 0.6, $W_2$ : 0.8 and $W_3$ : 1.0 volume of water through drip and another one $W_4$ : 1.0 volume of water by surface irrigation method) and three RDF levels of NPK ($F_1$ : 75%, $F_2$ : 100% and $F_3$ : 125% RDF). Fertilizer applied as fertigation under drip irrigation treatments and as basal application under surface irrigation method with in fifteen and seven day's interval, respectively. The experiment was laid out in split - plot design with four replications. The RDF was 288 g N, 200 g $P_2O_5$ and 240 g $K_2O$ per plant per year.

The irrigations were applied alternate day interval through drip and water requirement was estimated by using following equation and control was irrigated at weekly interval through surface method.

**Etc = Eto x Kc x No. of days x A**

where, Etc = Volume of water required in litre per day.

**Eto = Ep x Kp**

Eto - Reference evapotranspiration, mm/day.

Kp - Pan co-efficient 0.7 for class A pan].

Kc = Crop co-efficient varies from month to month and place to place.

A = Area to be irrigated, $m^2$ (7.06 $m^2$).

[Wetted diameter for each plant under drip was = 3.0 m

Radius = 1.5 m

Area = $\pi r^2$ = 3.14 x $(1.5)^2$ = 7.06 $m^2$ ]

Daily irrigation through drip based Etc *i.e.* Ep* Kp* Kc considering Kc values to be 0.50 in month January, 0.55 in month November to December and February to March, 0.60 in month April to May and October, 0.65 in month June and September, 0.70 in month of July and August.

Growth parameters *viz.*, height of tree and stem girth were recorded twice in a year, before imposing the treatment (February 2012) and after completion of experiment (December 2012). The difference in two measurements was taken as "gain" for the years. Height of tree was recorded from soil surface to the apex of the longest branch in meters by meter tape. Stem girth was measured on 30 cm above the ground level with the help of thread and meter scale. Canopy volume was calculated by using the values of North-South and East-West plant spread (m) by following formula:

**Canopy volume of plant ($m^3$) = 4/6®$r^2$h**

where, $\pi$ = 22/7

r = Plant spread in meter (N-S) + (E-W)4.

Similarly, yield parameters; a sample of five randomly selected fruits from each tree was weighed with the help of a balance and average fruit weight was computed and expressed in gram per fruit. Total numbers of fruits were counted in October on each plant before harvesting. It was confirmed by again counting the number of fruits per tree at the time of harvesting. Matured fruits were harvested periodically and the, weight was recorded without cracked fruits by summing up the total weight of fruits at different pickings obtained from each tree.

## RESEARCH FINDINGS AND DISCUSSION

The results obtained from the present investigation are summarized below :

### Growth parameters:

Data from Table 1 showed that the plant height (0.61 m), stem girth (6.08 cm), plant canopy volume (0.115 $m^3$), were found maximum with application of 1.0 volume of water through drip. It is well known fact that sufficient soil moisture for progressive plant growth is maintained by drip irrigation, which leads to better development of photosynthetic area and accelerate photosynthetic rate. Thus, as a consequence, plant growth was accelerated. All growth parameters of *mosambi* plants were directly proportional to the amount of irrigation water applied through drip. As the amount of water increased, the growth of plants with respect to height, girth

and canopy spread also proportionately increased and the findings are in consonance with (Castle and Lopez, 1993). This increment might be due to increased availability of soil moisture, nutrients and less weed growth due to drip irrigation, as also reported by Shirgure *et al.* (2003).

Among various growth parameters it was observed from Table 1 that the plant height (0.46 m), stem girth (5.34 cm) and plant canopy (0.07 $m^3$) were found maximum under 125 per cent RDF. The growth of *mosambi* has been affected by fertilizer level because of involvement in most of the physiological activities such as catalytic, synthetic, assimilation, stimuli for oriented growth and development along with certain regulatory processes at cellular levels of plants. This might be due to better nutritional environment in the root zone for the growth and development of the plant as NPK are considered as one of the major nutrients required for proper growth and development of the plant. When, there was enhanced absorption of nitrogen, phosphorus and potassium through fertigation an overall improvement in growth was observed. Similar findings were reported by Shirgure *et al.* (2001) and Suresh *et al.* (2006). Plant growth increased with increase in nitrogen level was obtained by Shirgue *et al.* (1999).

Combined effect of water regime and fertigation was observed (Table 2). The plant height (0.75 m) and plant canopy volume (0.163 $m^3$) were found maximum under 1.0 volume of water through drip along with fertigation of 125 per cent RDF. Due to the fact that sufficient soil moisture along with NPK application through fertigation led to better development of photosynthetic area and accelerated photosynthetic rate, cell turgidity, cell and tissue growth accompanied with better nutritional environment in the root zone for the growth and development of the plant. Thus, as a consequence, plant growth was accelerated. The similar

**Table 1 : Effect of water regime and fertigation on growth, yield and economics of sweet orange**

| Treatments | Gain in plant height (m) | Gain in stem girth (cm) | Canopy volume ($m^3$) | Weight of fruit (g) | Number of fruit per tree | Fruit yield per tree (kg) | Net returns (Rs./ ha) | B:C ratio |
|---|---|---|---|---|---|---|---|---|
| $W_1$ | 0.28 | 4.15 | 0.015 | 156.00 | 192.56 | 30.03 | 72927.93 | 1.94 |
| $W_2$ | 0.44 | 5.13 | 0.047 | 164.45 | 232.10 | 38.17 | 112557.27 | 2.44 |
| $W_3$ | 0.61 | 6.08 | 0.115 | 169.17 | 211.98 | 35.84 | 100266.60 | 2.27 |
| $W_4$ | 0.25 | 3.37 | 0.010 | 150.08 | 145.45 | 21.86 | 50565.10 | 1.86 |
| S.E.± | 0.02 | 0.22 | 0.004 | 1.50 | 4.69 | 0.71 | 3539.74 | 0.05 |
| C.D. (P=0.05) | 0.06 | 0.70 | 0.013 | 4.80 | 15.01 | 2.26 | 11322.53 | 0.16 |
| $F_1$ | 0.33 | 4.14 | 0.024 | 157.38 | 186.38 | 29.58 | 78060.35 | 2.09 |
| $F_2$ | 0.39 | 4.56 | 0.046 | 160.44 | 201.10 | 32.48 | 89137.29 | 2.19 |
| $F_3$ | 0.46 | 5.34 | 0.070 | 161.96 | 199.09 | 32.36 | 85040.04 | 2.10 |
| S.E.± | 0.01 | 0.21 | 0.004 | 0.62 | 2.93 | 0.43 | 2151.47 | 0.03 |
| C.D. (P=0.05) | 0.04 | 0.60 | 0.013 | 1.82 | 8.57 | 1.26 | 6278.74 | 0.08 |

**Table 2 : Combined effect of water regime and fertigation on growth, yield and economics of sweet orange**

| Treatments | Gain in plant height (m) | Gain in stem girth (cm) | Canopy volume ($m^3$) | Weight of fruit (g) | Number of fruit per tree | Fruit yield per tree (kg) | Net returns (Rs./ ha) | B:C ratio |
|---|---|---|---|---|---|---|---|---|
| $W_1F_1$ | 0.23 | 3.65 | 0.005 | 155.25 | 178.46 | 27.70 | 65482.35 | 1.90 |
| $W_1F_2$ | 0.29 | 3.98 | 0.012 | 156.25 | 199.32 | 31.14 | 78472.85 | 2.02 |
| $W_1F_3$ | 0.32 | 4.83 | 0.029 | 156.50 | 199.89 | 31.25 | 74828.60 | 1.92 |
| $W_2F_1$ | 0.39 | 4.65 | 0.015 | 160.00 | 223.39 | 35.75 | 104668.35 | 2.41 |
| $W_2F_2$ | 0.44 | 4.93 | 0.053 | 164.75 | 247.49 | 40.75 | 125473.85 | 2.60 |
| $W_2F_3$ | 0.47 | 5.80 | 0.073 | 168.60 | 225.43 | 38.00 | 107529.60 | 2.30 |
| $W_3F_1$ | 0.52 | 5.68 | 0.073 | 168.75 | 207.95 | 35.10 | 100769.35 | 2.35 |
| $W_3F_2$ | 0.58 | 6.05 | 0.110 | 169.25 | 217.33 | 36.80 | 105062.35 | 2.33 |
| $W_3F_3$ | 0.75 | 6.50 | 0.163 | 169.50 | 210.65 | 35.62 | 94968.10 | 2.14 |
| $W_4F_1$ | 0.20 | 2.58 | 0.006 | 145.50 | 135.70 | 19.75 | 41321.35 | 1.72 |
| $W_4F_2$ | 0.26 | 3.28 | 0.010 | 151.50 | 140.25 | 21.25 | 47540.10 | 1.81 |
| $W_4F_3$ | 0.30 | 4.25 | 0.015 | 153.25 | 160.39 | 24.57 | 62.833.85 | 2.05 |
| S.E.± | 0.02 | 0.41 | 0.009 | 1.25 | 5.87 | 0.86 | 4302.94 | 0.06 |
| C.D. (P=0.05) | 0.07 | NS | 0.026 | 3.64 | 17.13 | 2.51 | 12557.49 | 0.16 |

NS=Non-significant

results were also reported earlier by Shirgure *et al.* (2001) and Thakur and Singh (2004).

**Yield parameters:**

The significantly higher fruit weight of 164.45 g (Table 1) was recorded with the 0.8 volume of water through drip but it was at par with 1.0 volume of water through drip. Larger fruit size in drip irrigated plants may be due to constant available soil moisture during fruit development stage reported by Brestler (1977). As well as the maximum number of fruits per plant (232.10) and yield per plant (38.17 kg), were recorded (Table 1) with the treatment 0.8 volume of water through drip irrigation as compared to other water regime. This might be due to drip irrigation provides a consistent moisture regime in the soil due to which root remains active throughout the season resulting in optimum availability of nutrients and proper translocation of food materials which accelerates the fruit growth and development. Similar, result was found by Shirgure *et al.* (2001). Regular and appropriate amount of moisture supply is essential for retention of more number of fruits in sweet orange as compared to sudden application of high amount of water reported by Ghosh and Pal (2010).

Data from Table 1 showed that the application of 100 per cent recommended dose of fertilizer on the basis of NPK recorded maximum the number of fruits per tree (201.10), yield per plant (32.48 kg) whereas average fruit weight (160.44) was recorded significantly higher with 100 per cent recommended dose of fertilizer however, it remained at par with 125 per cent recommended dose of fertilizer. Broad casting of fertilizers generally tends to cause uneven distribution of fertilizers in the root zone. Alternatively, soluble N, P and K fertilizer can be applied via fertigation through drip system, to obtain proper distribution in soil. This is the evidence for the longer activity in fertigation where nutrients were applied to match the nutrient uptake by the crop. This enhanced the current photosynthesis for fruit development leading to the development of fruit to marketable size and producing more number of fruits per plant and fruit weight in fertigation treatments compared to soil application treatments. Similar, results were found by Thakur and Singh (2004), Singh *et al.* (2006) and Yadav *et al.* (2012).

The interaction effect of drip and fertigation was found to be significant on yield attributes. Boosting up of overall vegetative growth and biological efficiency of the plant which have finally leads to the enhancement in yield attributes and total yield. Data from Table 2 revealed that the highest yield per tree (40.75 kg) and number of fruit (247.49) were recorded under the treatment combination 0.8 volume of water through drip along with fertigation of 100 per cent RDF and the fruit weight (168.60 g) was recorded significantly higher under same volume of water along with fertigation of 125 per cent RDF. This might be due to that the fertigation provides a consistent moisture regime and nutrients in the soil due to which root remain active throughout the season resulting proper translocation of food material and give the opportunity to retain maximum of fruits on the tree. This fact also gave the better development and maturation of fruit. Similar findings were observed by Shirure *et al.* (2001) and Pavel and Villiers (2004).

**Economics:**

Data from Table 1 revealed that the maximum net returns (112557.27 Rs./ ha) and B:C ratio (2.44) was observed under 0.8 volume of water through drip followed by 1.0 volume of water through drip. Whereas, these were recorded minimum with 1.0 volume of water through surface irrigation. Similar, findings were reported by Panigrahi and Srivastava (2011). The treatment 100 per cent RDF recorded maximum net returns (89137.29 Rs./ ha) and B:C ratio (2.19) compared to rest treatments. These results are in accordance with the results reported by Singh *et al.* (2006).

The evaluation of Table 2 resulted that the interaction of 0.8 volume of water through drip along with fertigation of 100 per cent RDF recorded highest net returns (125473.85 Rs./ ha) and B:C ratio (2.60). Due to this fact it gave the better development and maturation of fruit. The well developed fruit gives the good price with low cost under fertigation (Singh *et al.*, 2006).

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