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Research Article

Interactive Effect of Water Regime and Fertigation on Nutrient Availability in Soil, Fruit Yield, Economics and Leaf Nutrient Content in Sweet Orange (*Citrus sinensis* Osbeck) cv. *Mosambi*

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Abstract

A field experiment was conducted at PFDC, ARS located at campus of S.K.R.A.U, Bikaner on eight year old plants during February 2012 to December 2012. The experiment consisted twelve treatment combinations comprising four water regimes 0.6 (w_1), 0.8 (w_2) and 1.0 (w_3) volume of water through drip, respectively given at alternate day interval and another one 1.0 (w_4) volume of water by surface irrigation method given on every seventh day interval. For fertilization, Three RDF levels of NPK *viz.* 75% (F_1), 100% (F_2) and 125% (F_4) were taken. Fertilizer applied as fertigation (ten split doses) under drip irrigation treatments at fifteen days interval and in surface irrigation treatment apply whole dose of recommended fertilizer as basal in the starting of experiment. The experiment was laid out in split - plot design with four replications. The interaction effect of 0.8 volume of water through drip + fertigation of 100 per cent RDF recorded significantly higher fruit yield, B:C ratio, P and K content in leaf whereas maximum N content in leaf found under same volume of water with fertigation of 125% RDF. The ascorbic acid content in fruit was found highest under 0.8 volume of water through drip + fertigation of 100 per cent RDF but it was at par with 0.8 volume of water through drip + fertigation of 125 per cent RDF. Further, the significantly higher available N, P and K content in soil were found under 0.6 volume of water through along with fertigation of 100 per cent RDF whereas it remains at par with same volume of water + fertigation of 125 per cent RDF.

Keywords: water regime, fertigation, sweet orange

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Introduction

The use of irrigation water is more important to enhance total production and area under irrigated agriculture [1]. It can be achieved by introducing advance method of irrigation like micro-irrigation coupled with other improved water management in fruit crops [2]. Recent advances in agro technology maken it possible to apply fertilizer materials through the irrigation systems, a practice referred to as fertigation. This practice has several advantages including savings in cost of fertilizer application and labor. Fertilizer elements are already in solution and become available to plant roots more quickly than dry materials placed on soil surface and the high flexibility in irrigation timing makes it easier to schedule fertilization. This is especially true with drip irrigation system that only a portion of ground is irrigated. It is well established fact that growth and yield of plant is greatly influenced by a wide range of nutrients. Among them Nitrogen, phosphorus and potassium are essential macro nutrients which have great significance in plant growth, development, metabolism and yield. In Rajasthan, soils are very poor in fertility and water holding capacity. These soils described as 'desert soils'. Economic and environmental concerns require more precise management of irrigation and nutrition of citrus produced on the well-drained sandy soil in Rajasthan. Moreover, judicious use of water and nutrients is necessary to achieve sustainable production. There is an urgent need to use the scares source of water and optimum level of nutrients for the fruit production. Keeping these in view the present experiment was carried out.

Material Methods

A field experiment was conducted on eight year old plant during February 2012 to December 2012 at PFDC, ARS

located at campus of S.K.R.A.U, Bikaner. The experiment consisted twelve treatment combinations comprising four water regimes 0.6 (w_1), 0.8 (w_2) and 1.0 (w_3) volume of water through drip, respectively and another one 1.0 (w_4) volume of water by surface irrigation method and three RDF levels of NPK *viz.* 75% (F_1), 100% (F_2) and 125% (F_4) of RDF. Fertilizer applied in ten split doses as fertigation under drip irrigation treatments with in every fifteen days interval whereas drip irrigation follows at alternate day. Under surface irrigation treatment whole dose of recommended dose of fertilizer was given by basal application method at starting the experiment (February) and irrigate as surface on every seven day's interval. The experiment was laid out in split - plot design with four replications. The use of method for Estimation of plant samples for Nitrogen by [3], Phosphorus by [4] and potassium by [5]. The available nitrogen content in the soil was determined by alkaline permanganate method [6] and Available P_2O_5 content in the soil was estimated by Olsen's method [7] and the mechanical analysis was estimated by International pipette method [8]. The Available potassium was determined by Flame photometer method [9]. The soil and plant nutrient status before treatment application was as follow.

S. No.	Particulars	Soil depth (0-15 cm)
A.	**Mechanical analysis**	
1.	Sand (%)	85.21
2.	Silt (%)	7.35
3.	Clay (%)	7.95
4.	Texture	Loamy sand
B.	**Chemical properties**	
5.	Available nitrogen(kg ha^{-1})	83.15
6.	Available P_2O_5 (kg ha^{-1})	18.94
7.	Available potash (kg ha^{-1})	189.36
8.	Nitrogen content in sweet orange leaves (%)	2.24
9.	Phosphorus content in sweet orange leaves (%)	0.08
10.	Potassium content in sweet orange leaves (%)	0.76

Water requirement was estimated by using following equation:

$$Etc = Eto \times Kc \times No.\ of\ days \times A$$

Where, Etc = Volume of water required in liter per day, Eto = Ep x Kp, [Eto - Reference evapotranspiration, mm/day. Kp - Pan coefficient 0.7 for class A pan], Kc = Crop coefficient 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 = $\pi r^2 = 3.14 \times (1.5)^2 = 7.06\ m^2$]

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.

Monthly water applied (in litre)						
Month	**0.6 V Drip**	**0.8 V Drip**	**1.0 V Drip**	**No. of irrigation**	**1.0 V Surface irrigation**	**No. of irrigation**
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 30Sept.)	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**

The Recommended dose of fertilizer which was follow: The recommended doses of Nitrogen (288 g/plant), phosphorus (200 g/plant) and potassium (240 g/plant) as per recommendation of [10] were applied through Urea, water soluble fertilizer (17:44:0 grade) and Murate of Potash (white grade).

Scheduling of fertigation					
Water soluble fertilizers	**Rate of fertigation g/plant/15 days**			**Total fertigations**	**Date of given the Fertigation**
	75%	100%	125%		
Urea + Water soluble fertilizer 17:44:0 grade + Murate of potash	34.35 + 34.09 + 30	45.81 + 45.45 + 40	57.26 + 56.81 + 50	10	11-2-2012 27-2-2012 14-3-2012 30-3-2012 15-4-2012 1-5-2012 17-5-2012 2-6-2012 18-6-2012 4-7-2012

Results and Discussion

Interactive effect of water regime and fertigation on fruit yield and B:C ratio

Data from **Table 1** showed that the interaction effect of 0.8 volume of water through drip + fertigation of 100 per cent RDF recorded highest fruit yield (40.75 kg tree^{-1}) with maximum B:C ratio (2.60) which was significantly superior as compared to other treatments, followed by 38.00, 35.75 kg per tree yield and 2.30, 2.41 of B:C ratio were found by the treatment combination of 0.8 volume of water through drip + fertigation of 125 per cent RDF and 0.8 volume of water through drip + fertigation of 75 per cent RDF, respectively. However, combination of 0.8 volume of water + fertigation of 125 per cent RDF was at par with 0.8 volume of water through drip + fertigation of 75 per cent RDF. This might be due to fact 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 gives the better development and maturation of fruit.

Table 1 Effect of water regime and fertigation levels on Fruit yield, economics, ascorbic acid content in fruit, nutrient content in leaf and available nutrients in soil

Treatments	**fruit yield (kg tree-1)**	**Ascorbic acid (mg/100g)**	**NPK Content (%) in Leaf**			**Available NPK (kg ha-1) in soil**			**B:C ratio**
			N Content	**P Content**	**K Content**	**Available N**	**Available P**	**Available K**	
$W_1 F_1$	27.70	44.22	2.19	0.08	1.25	83.95	21.00	194.03	1.90
$W_1 F_2$	31.14	45.30	2.30	0.12	1.57	87.45	25.03	196.05	2.02
$W_1 F_3$	31.25	45.62	2.50	0.15	1.60	88.98	25.20	197.10	1.92
$W_2 F_1$	35.75	47.13	2.40	0.16	1.50	82.96	20.88	193.75	2.41
$W_2 F_2$	40.75	47.65	2.60	0.24	1.82	86.10	22.75	195.48	2.60
$W_2 F_3$	38.00	47.77	2.76	0.20	1.70	86.95	23.68	194.53	2.30
$W_3 F_1$	35.10	47.18	2.52	0.13	1.58	82.74	19.63	191.35	2.35
$W_3 F_2$	36.80	47.78	2.63	0.15	1.75	83.65	21.60	193.16	2.33
$W_3 F_3$	35.62	47.87	2.81	0.16	1.78	84.91	21.78	193.50	2.14
$W_4 F_1$	19.75	45.34	1.88	0.06	0.09	80.73	18.43	188.99	1.72
$W_4 F_2$	21.25	45.38	2.10	0.09	0.99	81.25	19.31	189.43	1.81
$W_4 F_3$	24.57	45.46	2.34	0.11	1.28	81.88	19.88	191.00	2.05
S.Em. ±	**0.86**	**0.15**	**0.02**	**0.012**	**0.07**	**0.63**	**0.46**	**0.40**	**0.06**
C.D. (5%)	**2.51**	**0.45**	**0.06**	**0.034**	**0.21**	**1.85**	**1.34**	**1.17**	**0.16**

The well developed fruit gives the good price with low cost under fertigation. The combined interaction between drip irrigation and fertigation level fetched higher B:C ratio. Similar findings were observed by [11] in Nagpur mandarin; [12] in mango; [13] in pomegranate and [14] in Nagpur mandarin. Further, the minimum fruit yield of 19.75 kg tree^{-1} was recorded under 1.0 volume of water through surface irrigation + 75 per cent RDF as basal application.

Interactive effect of water regime and fertigation on ascorbic acid content

Fertigation and drip irrigation improves the fruit quality by using the maximum nutrient and water use efficiency. Ascorbic acid content (47.13 mg/100 g) was significantly higher with 0.8 volume of water through drip along with fertigation of 100 per cent RDF but it was at par with 125 per cent RDF. As well as ascorbic acid increase with optimum and timely supply of the water and fertilizer reported by [15]. As water is essential constituent of plants, so, plants having sufficient water, forms bigger fruits. At the same time, plants get more nutrients due to fertigation, thus plants grow well and fruit quality increases. Similar results were observed by [11] in Nagpur mandarin and [16] in mango.

Interactive effect of water regime and fertigation on NPK content in leaf

Data from **Table 1** revealed the significantly higher N content (2.76 %) in leaf was found with 0.8 volume of water through drip along with fertigation of 125 per cent RDF whereas maximum P (0.24 %) and K (1.82 %) were found with same volume of water along with fertigation of 100 per cent RDF. This might be due to sufficient, optimum and timely supply of fertilizer with optimum level of water resulted in better uptake of nutrients and higher accumulation of dry matter with higher concentration of nutrients in plant leaf. Similar results were finds by [11] in Nagpur mandarin and [17] in sweet cherry. Further, the minimum N, P and K content in leaf were found with basal application of fertilizer with flood method of irrigation.

Interactive effect of water regime and fertigation on NPK content in soil

Data from table indicate that the significantly higher available N, P and K in soil were found under 0.6 volume of water through along with fertigation of 100 per cent RDF whereas it remains at par with same volume of water + fertigation of 125 per cent RDF. This might be due to frequent fertigation as timely application resulted in better utilization by plant as well as these requirements. Second fact is that the proper supply of fertilizer with adequate water application resulting in less leaching losses of soluble nutrients compare to conventional application of fertilizer and water. Similar results were found by [18] and [19].

Conclusion

The treatment combination W_2F_2 (0.8 volume of water through drip irrigation + fertigation of 100 per cent RDF) recorded the higher magnitude of yield attributes, better quality as ascorbic acid and fetched maximum net returns with B:C ratio. It is also be superior on conventional method of irrigation and fertilizer application because of it gives yield just about two times compared to conventional method.

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