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Effect of water regime and fertigation on yield and quality of sweet orange (*Citrus sinensis* Osbeck) cv. Mosambi in arid zone

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Abstract

A field experiment was conducted on sweet orange (*Citrus sinensis*) to study the effect of water regime and fertigation on yield and quality at Precision Farming Development Centre, Agricultural Research Station, Swami Keshwanand Rajasthan Agricultural University, Bikaner. The experiment was laid out in split plot design with four replications and consisting twelve treatment combinations, comprised four water regime (0.6, 0.8 and 1.0 volume of water through drip irrigation and another one 1.0 volume of water applied by surface irrigation method) and three levels of recommended dose of NPK (75, 100 and 125%). The results indicated that maximum fruit diameter (7.36 cm), fruit yield (38.17 kg/plant), juice weight (100.4 g), peel weight (47.95 g), reducing sugar (2.33%) and total sugar (8.36%) were recorded in 1.0 volume of water through drip irrigation which was at par with 8.0 volume of water through drip irrigation and significantly superior over 0.6 volume of water. Whereas, maximum acidity (0.76%) was recorded in 0.6 volume of water through drip. Further data showed that among the RDF levels, fertigation with 125% RDF gave maximum fruit diameter (7.20 cm), fruit yield (32.48 kg/plant), juice weight (85.42 g), peel weight (41.59 g), reducing sugar (1.94%) and total sugar (7.63%) which was comparable with 100% RDF and significantly superior over 75% RDF. Whereas, maximum acidity (0.72%) was recorded in 75% RDF followed by 100% RDF and lowest in 125% RDF.

Key words: *Water regime, fertigation, fruit yield, reducing sugar, acidity, juice, RDF*

Introduction

Citrus (*Citrus sinensis* L.) fruits is one the important fruit crop of the world occupied third position among the sub-tropical and rank third in area and production after banana and mango in India. Andhra Pradesh, Maharashtra, Karnataka, Punjab, Haryana and Rajasthan are main sweet orange growing, stages. In India, sweet orange is commercially adopted in citrus fruit crop with an area of 323 thousand ha with production of 3520 thousand lakh tonnes and productivity 10897 kg/ha (Anonymous, 2013). The production of sweet orange is largely favoured by dry, semi-arid to subtropical conditions. Under warmer conditions, the colour development is poor; however, excellent deep orange colour of the skin develops when grown under subtropical conditions. Quality is also very good under dry semi-arid conditions, while under humid conditions fruits insipid. It has great nutritional role in the daily food requirement, being rich source of vitamin C. (Greory, 1993).

In general, most of the farmers apply the fertilizers in single soil application during dormant season and no fertilizer is applied during vegetative, flowering, and fruit growth stages, thus the effectiveness of the applied fertilizers is reduced considerably. Drip irrigation plays a major role in productivity enhancement (Khan *et al.*, 2012). Drip irrigation proved efficiently in providing irrigation water and nutrients to the roots of plants, while maintaining high yield production. Modern drip irrigation has arguably become the world's most valued innovation in agriculture since the invention of the impact sprinkler, which replaced flood irrigation. This is because high water application efficiencies are often possible with drip irrigation, since there is reduced surface evaporation, less surface runoff, as well as minimal deep percolation. Moreover, a drip irrigation system can easily be used for fertigation, through which crop nutrient requirements can be met accurately.

Sweet orange respond very well to the application of nutrients either through soil or through fertigation. The efficient use of water and fertilizers to increase the crop yield and fruit quality is important concern in today's citricultural system (Shirgure 2012). Fertigation offers the best and sometimes the only way for ensuring the nutrients enters the root zone especially in areas with inadequate rainfall. The suitable fertilizers, water soluble fertilizers, ready to mix water soluble fertilizers (19-19-19) are more being used by growers. The application of nitrogen, phosphorus and potassium fertilizers through fertigation system during flower initiation to fruit growth and development is latest technology and no literature as well as work is available on sweet orange under arid regions of Rajasthan. Fertigation enables adequate supplies of water and nutrients with precise timing and uniform distribution to meet the crop nutrient demand. Therefore, this study was carried out to investigate the effect water regime and fertigation on yield and quality of sweet orange under arid region of Rajasthan.

Materials and Methods

The field experiment carried out at Precision Farming Development Centre, Agricultural Research Station, S.K. Rajasthan Agricultural University, Bikaner during February 2010 to December 2013 on eight years old sweet orange. The experiment laid out in split plot design with four water regimes (0.6, 0.8, 1.0 volume of water through drip irrigation and another one 1.0 volume of water by surface irrigation method) and three levels of recommended dose of fertilizers of NPK (75, 100 and 125% RDF). RDF was applied as fertigation under drip irrigation and as basal for surface irrigation method with in fifteen and seven days interval, respectively. The RDF was 288 g, 200 g and 240 g/plant, N, P_2O_5 and K_2O, respectively. Physical and chemical properties of the soil for the orchard are presented in Table 1. The data on yield attributes like fruit diameter (cm), juice weight (g), peel weight (g), peel: juice ratio, fruit yield (kg/plant) and fruit quality parameters like reducing sugar (%), total sugar (%) and acidity (%) were recorded at harvest. Fruit diameter measured in centimeter using vernier calipers. At harvest, the fruits were weighed and counted separately for each plant, and then the yield (kg/plant) was calculated in each treatment. Total sugar, reducing sugar and acidity were determined by as per methodology suggested Dubois *et al.* (1951), Nelson's modified of Somagyi method (Somogyi *et al.* 1952) and A.O.A.C (1990), respectively. All plant protection and intercultural operations were done whenever necessary. The statistical analyses of data was done as per the method prescribed by Panse and Sukhatme (1985).

Results and Discussions

Effect of water regime

Data presented in Table 1 showed that yield attributes, yield and quality of sweet orange as influenced by different water regimes. Higher fruit diameter (7.36 cm), juice weight (30.17 g) and peel weight (100.40 g) were recorded with 1.0 volume of water through drip which was comparable to 0.8 volume of water through drip and significantly superior over 0.6 volume of water through drip. However the lower values of these attributes were recorded in 1.0 volume of water through surface. Similarly higher yield (38.17 kg/plant) was also recorded in 1.0 volume of water through drip which was at par with 0.8 volume of water through drip and significantly superior over 0.6 volume of water through drip and 1.0 volume of water through surface. The per cent yield increases of sweet orange by 27.11 and 6.50 higher over 0.6 and 0.8 volume of water through drip, respectively. Peel: juice ratio did not influenced significantly by different volume of drip irrigation. This might be due to more frequent irrigation and maintenance of constant soil moisture under the plant. Patel and Patel (1998) reported that the increase in yield was mainly because of better growth of the plant under optimum amount of nutrients in pomegranate crop. The results are in conformity with the findings of Biswas *et al.* (1999) who obtained higher yields from drip-irrigated plots at an IW: CPE ratio of 0.8 compared with those irrigated using a conventional system in papaya. Similar findings were also made by Sharma and Mursaleen (2014) in guava.

Quality parameters of sweet orange like reducing sugar (%), total sugar (%) and acidity (%) influenced significantly by various volume of irrigation water through drip (Table 2). High reducing sugar (2.33%) and total sugar (8.36%) were recorded with 1.0 volume of water through drip which was statistically similar to 0.8 volume of water and significantly higher than 0.6 volume of water irrigation. Whereas, the lower values of these parameters were found under 1.0 volume of water through surface. The high acidity (0.78%) was recorded in 1.0 volume of water through surface irrigation which was significantly superior over rest of volume of water. The results are in the confirmation with Prasad *et al.* (2003) found that fruit quality in terms of juice content, acidity and total sugar was better in drip-irrigated pomegranate plants than that in the basin irrigated plants.

Effect of fertigation

The data as regard to yield attributes *viz.*, diameter, juice weight, peel weight, fruit and yield (kg/plant) as influenced significantly by different levels of fertigation (Table 2). Among various level of fertigation, maximum fruit diameter (7.20 cm), juice weight (85.42 g) and peel weight (41.59 g) were recorded in 125% RDF which was statistically similar with 100% RDF and significantly superior over 75% RDF. Among various fertigation levels, higher doses showed better vegetative growth of the plant. It might be due to application of higher dose of fertilizers attributed to better nutritional environment in the root zone as well as in plant system. Nitrogen, phosphorus and potassium are most indispensable of all mineral nutrients for growth and development of the plant as these are the basis of fundamental constituents of all living matter (Ramniwas *et al.*, 2012). Mahalaxmi *et al.* (2001) reported that increase in fruit size and weight with increasing levels of NPK under fertigation. Similarly, maximum fruit yield (32.48 kg/plant) was also found under 125% RDF which was par with 100% RDF and significantly superior to 75% RDF. This might be due to longer activity in fertigation where nutrients were applied to match the nutrient uptake by crop. This enhanced the photosynthesis of fruit development which help in development of fruit marketable size and producing more number of fruits/plant and fruit weight and finally on fruit yield/ha as compared to soil application. The results obtained are in accordance with the earlier findings as quoted by Ramniwas *et al.* (2012) and Kumar *et al.* (2013).

Fruit quality parameters like reducing sugar, total sugar and acidity as influenced significantly by different levels of fertigation (Table 2). High reducing sugar of 1.94% and total sugar of 7.63% were recorded under fertigation with 125% RDF which was comparable to 100% RDF and significantly superior to 75% RDF. Whereas the higher acidity (0.72%) was recorded in fertigation with 75% RDF followed by 100% RDF and lowest was in 125% RDF. These findings are similar to the findings of Ramana *et al.* (2014) in sweet orange.

Interaction effect

The interaction effect of water regime and fertigation was found to be significant on yield of sweet orange. Data from the Table 3 reveals that maximum yield (40.75 kg/plant) was recorded with combination application of 1.0 volume of water through drip along with 100% RDF. This might be due to that the fertigation provided a consistent moisture regime and nutrient in the soil due to which root remain active throughout the season resulting proper translocation of food material and give opportunity to retain maximum of fruits on the plant. The drip irrigation maintained higher as well as continuous soil moisture along with NPK availability influenced by the water and nutrient uptake resulting into high yields. It is also proved that NPK fertigation is essential for high yields in sweet orange and similar results were also observed by Pavel and Villiers (2004) in mango, Kumar *et al.* (2013) and Ramana *et al.* (2014) in sweet orange.

Table 1. Physical and chemical properties of the orchard soil used in the study (compound soil samples from depths of 0-30 and 31- 60 cm)

S.No.	Particulars	Soil depth
1.	Texture	Loamy sand
2.	pH (1:2 soil water suspension)	8.30
3.	EC dS/m (1:2 soil water suspension)	0.16
4.	Organic carbon (%)	0.09
5.	Available nitrogen (kg/ha)	83.15
6.	Available P_2O_5 (kg/ha)	18.94
7.	Available potash (kg/ha)	189.36
8.	Available Fe (mg/kg)	3.15
9.	Available Zn (mg/kg)	0.38

Table 2. Effect of water regime and fertigation levels on yield attributes, yield and quality of sweet orange

Treatment	Fruit diameter (cm)	Fruit yield/plant (kg/ha)	Juice weight (g)	Peel weight (g)	Peel : Juice	Reducing sugar (%)	Total sugar (%)	Acidity (%)
Water regime								
0.6 V water through drip	6.81	30.03	71.20	36.42	0.51	1.42	6.76	0.76
0.8 V water through drip	7.20	35.84	92.31	45.12	0.49	2.26	8.08	0.66
1.0 V water through drip	7.36	38.17	100.40	47.95	0.48	2.33	8.36	0.60
1.0 V water through surface	6.38	21.86	63.20	31.40	0.50	1.30	6.43	0.78
SEm±	0.06	0.71	1.76	0.97	0.02	0.05	0.16	0.006
CD (P=0.05)	0.18	2.26	5.64	3.11	NS	0.16	0.51	0.020
Fertigation level								
75 % RDF	6.66	29.58	77.16	38.13	0.50	1.66	7.08	0.72
100 % RDF	6.96	32.36	82.75	40.95	0.50	1.88	7.50	0.70
125 % RDF	7.20	32.48	85.42	41.59	0.49	1.94	7.63	0.69
SEm±	0.11	0.43	1.56	0.78	0.01	0.04	0.13	0.008
CD (P=0.05)	0.31	1.26	4.56	2.28	NS	0.11	0.38	0.02

Table 3. Interaction effect of water regime and fertigation levels on fruit yield of sweet orange

Treatment	Fertigation level			
	75% RDF	100 % RDF	125 % RDF	Mean
Water regime				
0.6 V water through drip	27.70	31.14	31.25	30.03
0.8 V water through drip	35.10	36.80	35.62	35.84
1.0 V water through drip	35.75	40.75	38.00	38.17
1.0 V water through surface	19.75	21.25	24.57	21.86
Mean	29.58	32.48	32.36	31.47
	Water regime	Fertigation		W x F
SEm±	0.71	0.43		0.86
CD (P=0.05)	2.26	1.26		2.51

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