Studies on irrigation and nutrient interactions in sweet orange (*Citrus Sinensis* Osbeck)

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ABSTRACT

Sweet orange (*Citrus sinensis* Osbeck) is one of the most important commercially cultivated fruit crop in India. It stands on second position amongst citrus group after mandarin. Irrigation and fertigation are vital importance of sweet orange orchard and considered to be the most critical cultural operations. The soil acts as the reservoir of water and applied nutrients, the interaction between irrigation and fertigation leads to the ultimate quality and production of fruits. The increasing cost of fertilizers and scarcity of irrigation water forced the farmers for optimum use of irrigation and nutrients. The experiment was conducted with object to find out irrigation and nutrient interaction in sweet orange to optimize the use of both the factors. The experiment was conducted in medium to deep soil. The irrigation level I_3,drip irrigation at 90% ER (effective rainfall) and fertigation level F_3 80% RDF (recommended dose of fertilizer) recorded significantly maximum plant height, plant spread, canopy volume, number of fruits, weight of fruit, fruit yield kg/plant and t/ha followed by F_2 , fertigation with 70% RDF. The interaction effect of irrigation and fertigation on growth was also significant and the maximum plant height, E-W spread, N-S spread, canopy volume, highest number of fruits, weight of fruit and yield kg/plant and t/ha was recorded in T_9 i.e. I_3F_3 drip irrigation at 90% ER and fertigation with 80% of RDF followed by I_3F_2 drip irrigation at 90% ER and fertigation with 70% of RDF.

Key words: Sweet orange, Fertigation, Irrigation, Interactions.

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1. Introduction

The citrus is world leading tree-fruit crop. The sweet orange is one of the most important tree-fruit crop amongst the citrus group. The sweet orange (Citrus sinensis) is highly polyembryonic species of Chinese origin. The species is of great economic importance for its excellent fruit quality and for its rootstalk value to limited extent. It is grown in the states Aandhra Pradesh, Telangana, Maharashtra, Karnataka and North eastern states of the India. It is also cultivated larger extent China, USA, Israel, Egypt and Spain.

Annual nutrient determination includes the needs of both new developing organs (reproductive and vegetative) and old permanent organs growth consumption. This demand does not include annual old leaves requirements because these leaves, at the beginning of a new fertilization program, translocate mobile nutrients to different new organs, before its abscission. The total amount taken up by a citrus tree along one-year vegetative cycle by means of sequential destructive harvests of trees of different ages (2-, 6- and 12-years-old) along the cycle (Martínez-Alcántara et al. 2011). The difference between new and old organs nutrient demand and that covered by old leaves reserves represents net annual needs for citrus tree.

Citrus is predominantly grown in tropical and subtropical areas in India. Flood irrigation in tree basin is widely used in citrus orchards, in India. But it has several drawbacks in terms of losses through conveyance, percolation, evaporation, and distribution, without affecting growth, yield, and fruit quality (Shirgure, 2013). In light of growing scarcity of water and poor water use efficiency under basin irrigation, micro-irrigation has gained wide application in citrus orchards. The lack of uniformity in moisture distribution within the trees' rhizosphere due to variation in sub-soil properties can adversely affect the development of desired fruit size (Shirgure et al., 2004). Method of irrigation which is capable of replenishing the plant's evapotranspiration demand, as well as keep the soil moisture within the desired limit during different developmental stages, would ensure a production sustainability of citrus orchards with prolonged orchard's productive life.

Many efforts have been made in the past to devise ways and means to enhance fruit yield with combined use of irrigation and fertilizer being far superior to conventional broadcast method of fertilization (Zhang et al., 1996). In many citrus growing areas, low water use efficiency (WUE) and fertilizer use efficiency (FUE) are amongst the major production related constraints (Srivastava and Singh, 2003). The components responsible for the fruit yield and quality are use efficiency of applied fertilizers, application time, method of application, and rate of application. In the present investigation drip irrigation and fertigation methods are used to provide water and fertilizers to study the use efficiency of water and nutrients by sweet orange over the recommended dose of fertilizer and irrigation.

Materials and Methods

A field trial was conducted in the year 2014-15 at the sub centre of All India Co-ordinated Research Project on Fruits, Shrirampur, located in the Ahmednagar district of Maharashtra state. The pattern of rainfall is erratic and comes under semiarid climate with irrigation facility. The experiment was conducted on sweet orange cv. Nucellar planted at distance 6X6 m. The soil of experimental site was medium to deep black. The recommended dose of fertilizer (RDF) for sweet orange in the region is 800: 300: 600 g Nitrogen: Phosphorus: Potash + 20 kg FYM + 15 kg neem cake/plant/year. All standard package of practices were followed during the experiment *viz.*, weeding, pest and disease management etc. Irrigation levels were calculated on the basis of tree requirement, evaporation and transpiration rate with the help of pan evaporimeter Table 3. The fertigation levels decided by calculation on basis of recommended dose of fertilizers. The sources of fertilizers used are of water soluble grade where as the bore well used as source of irrigation for orchard.

A. Irrigation levels		**B. Fertigation levels**	
Treatment	**ER (%)**	**Fertilizer levels**	**Percent RDF**
I_1	70	F_1	60
I_2	80	F_2	70
I_3	90	F_3	80

RDF: 800: 300: 600 g NPK + 20 kg FYM + 15 kg neem cake/plant/year

Treatment combinations (3 x 3): 9

$I_1 F_1$	$I_1 F_2$	$I_1 F_3$
$I_2 F_1$	$I_2 F_2$	$I_2 F_3$
$I_3 F_1$	$I_3 F_2$	$I_3 F_3$

Plant height, E-W spread, N-S spread, canopy volume, number of fruits, weight of fruit and yield kg/plant and t/ha were recorded by following slandered procedures.

Results and Discussion

The data presented in Table.1 revealed that, the interaction effect of irrigation and fertigation and individual effect of irrigation and fertigation on growth of sweet orange was found significant. The irrigation level I_3 , drip irrigation at 90 % ER recorded significantly maximum plant height (4.56 m), E-W spread (4.38 m), N-S spread (4.41 m) and canopy volume (39.23 m^3). The growth is due to the expansion and multiplication of cell where the optimum levels of water play vital role. The maximum growth was observed with 90% ER, it might be due to the optimum availability of water for vegetative growth, results are in accordance with Panighahi et al., (2017) and Navarro J. M. et.al. (2010). Similarly within fertigation level F_3, fertigation with 80 % RDF recorded significantly maximum plant height (4.52 m),E-W spread (4.51m), N-S spread (4.49 m) and canopy volume (40.42 m^3) followed by F_2 , fertigation with 70 % RDF. The interaction effect of irrigation and fertigation on growth was also significant Fig.1. and the maximum plant height (4.69m), E-W spread (4.78m), N-S spread (4.80m) and canopy volume (47.16 m^3) was recorded in T_9 i.e. I_3F_3drip irrigation at 90% ER and fertigation with 80% of RDF followed by I_3F_2 drip irrigation at 90% ER and fertigation with 70% of RDF.

The yield data depicted in Table.2 showed that, the interaction effect of irrigation and fertigation and the individual effect of irrigation and fertigation on yield was also significant. The treatment I_3, irrigation at 90% ER and F_3, fertigation with 80% RDF recorded significantly highest number of fruits (272.04 and 265.31 fruits / plant), weight of fruit (219.12 g and 215.05 g), fruit yield (59.76 kg/plant and 57.31 kg/plant) and (15.44 t/ha and 14.39 t/ha) respectively more irrigation causes delayed ripening with inferior quality where as the application of nutrients through broadcasting and other methods leads to more losses of applied fertilizers by leaching or chemical bindings. The fertigation provides required amount of fertilizers at specific stage of development which might be reason for higher yield at 80% RDF similar results were recorded by Navarro J. M. et.al. (2010). The interaction effect of irrigation and fertigation Fig.2. I_3 F_3 , drip irrigation at 90 % ER and fertigation with 80 % of RDF recorded highest number of fruits (286.55 fruits / plant) , weight of fruit (235.75 g) and yield (67.55 kg/plant and 16.30 t/ha) followed by I_3 F_2 , drip irrigation at 90 % ER and fertigation with 70 % of RDF interactive effect of 90%ER irrigation and 80% RDF gives higher growth and more production of sweet orange concluded that the combination was proved better over recommended practices, results are in continuation with Shirgure P.S., Srivastava A.K.(2013).

Table 1. Effect of irrigation and nutrient interactions on growth in sweet orange (2014-15).

Sr. No.	Treatment	Plant height (m)	E-W Spread (m)	N-S Spread (m)	Canopy volume (m^3)	Scion : stock ratio
	I_1	4.25	4.02	3.99	30.53	0.93
	I_2	4.33	4.10	4.09	32.02	0.93
	I_3	**4.56**	**4.38**	**4.41**	**39.23**	0.93
	S.E.±	0.14	0.08	0.12	1.30	0.005
	C.D.at 5 %	0.42	0.25	0.37	3.91	**NS**
	F_1	4.22	3.82	3.85	27.26	0.93
	F_2	4.40	4.17	4.15	34.10	0.93
	F_3	**4.52**	**4.51**	**4.49**	**40.42**	0.94
	S.E.±	0.14	0.08	0.12	1.30	0.005
	C.D.at 5 %	0.42	0.25	0.37	3.91	**NS**
T_1	I_1 F_1	4.10	3.76	3.80	25.75	0.94
T_2	I_1 F_2	4.22	3.86	3.83	27.74	0.93
T_3	I_1 F_3	4.43	4.46	4.36	38.10	0.94
T_4	I_2 F_1	4.17	3.80	3.81	26.38	0.93
T_5	I_2 F_2	4.38	4.20	4.14	33.68	0.93
T_6	I_2 F_3	4.45	4.30	4.33	36.01	0.95
T_7	I_3 F_1	4.39	3.90	3.94	29.66	0.94
T_8	I_3 F_2	4.60	4.47	4.49	40.88	0.93
T_9	I_3 F_3	**4.69**	**4.78**	**4.80**	**47.16**	0.94
	S.E.±	0.24	0.14	0.21	2.26	0.008
	C.D.at 5 %	0.73	0.44	0.65	6.77	**NS**

Table 2. Effect of irrigation and nutrient interactions on yield of sweet orange (2014-15).

Sr. No.	Treatment	Number of fruits/plant	Av. wt. of fruit (g)	Fruit yield (kg/plant)	Fruit yield (t/ha)
	I_1	232.35	195.62	45.48	12.36
	I_2	258.74	200.93	52.03	13.69
	I_3	**272.04**	**219.12**	**59.76**	**15.44**
	S.E.±	11.95	5.36	2.00	0.66
	C.D.at 5 %	35.83	16.07	6.01	1.99
	F_1	242.19	197.00	47.77	13.54
	F_2	255.63	203.62	52.18	13.55
	F_3	**265.31**	**215.05**	**57.31**	**14.39**
	S.E.±	11.95	5.36	2.00	0.66
	C.D.at 5 %	35.83	16.07	6.01	1.99
T_1	I_1 F_1	220.33	192.21	42.35	11.73
T_2	I_1 F_2	235.48	194.47	45.79	12.68
T_3	I_1 F_3	241.25	200.19	48.29	12.68
T_4	I_2 F_1	248.82	195.68	48.69	13.37
T_5	I_2 F_2	259.26	197.91	51.31	13.48
T_6	I_2 F_3	268.14	209.22	56.10	14.21
T_7	I_3 F_1	257.42	203.13	52.29	15.54
T_8	I_3 F_2	272.16	218.49	59.46	14.48
T_9	I_3 F_3	**286.55**	**235.75**	**67.55**	**16.30**
	S.E.±	20.70	9.28	3.47	1.15
	C.D.at 5 %	62.07	27.83	10.42	3.45

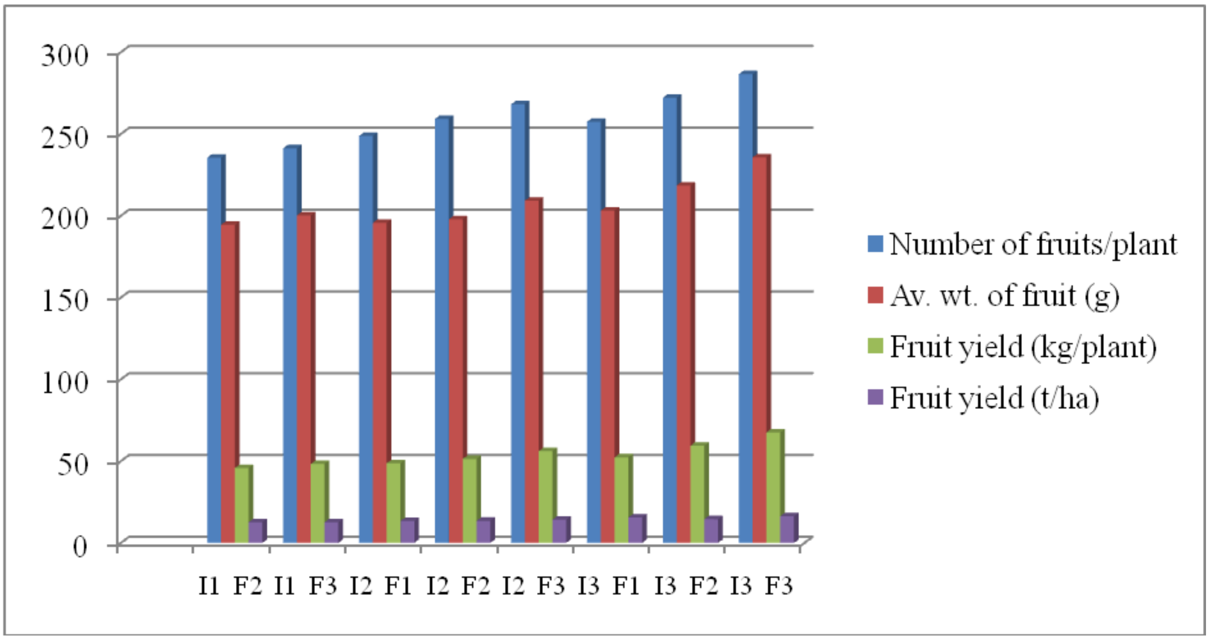

Fig.1. Effect of irrigation and nutrient interactions on growth in sweet orange.

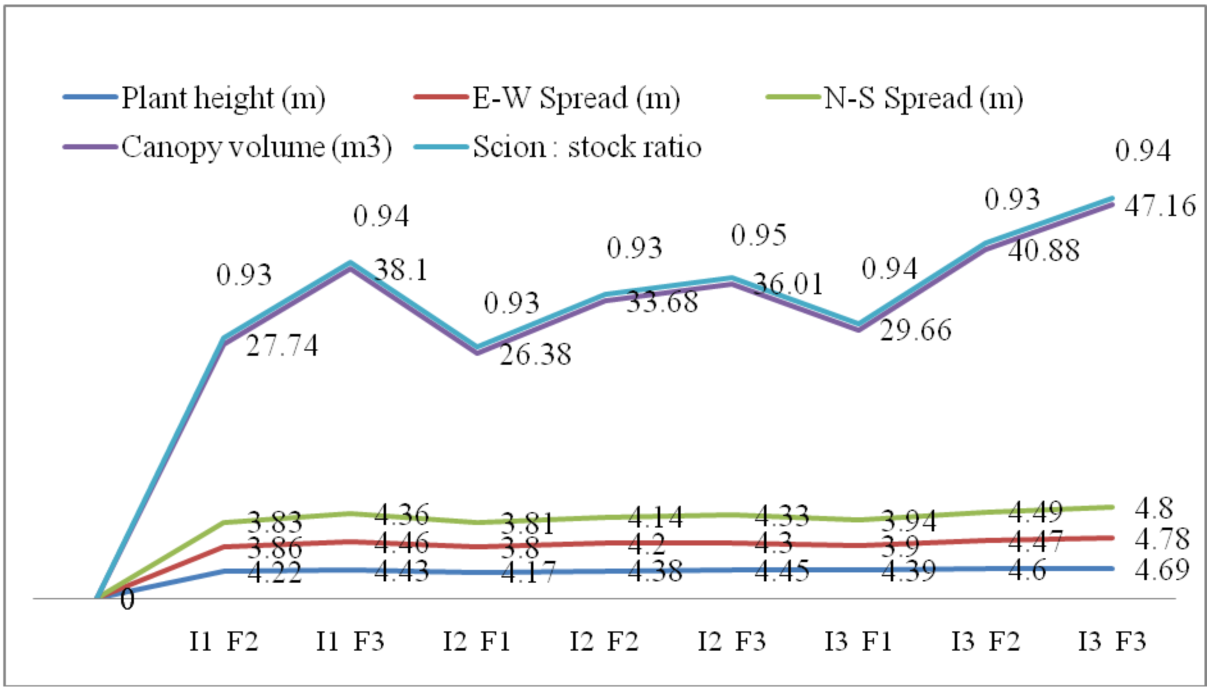

Fig.2. Effect of irrigation and nutrient interactions on yield of sweet orange.

Table 3. Water requirement of sweet orange at different irrigation level (cm/plant/month) (2014-15).

Month	70 % (ER)			80 % (ER)			90 % (ER)		
	Total water applied (cm)	Effective Rainfall (cm)	Irrigation water requirement (cm)	Total water applied (cm)	Effective Rainfall (cm)	Irrigation water requirement (cm)	Total water applied (cm)	Effective Rainfall (cm)	Irrigation water requirement (cm)
January	0.87	-	0.87	0.99	-	0.99	1.12	-	1.12
February	2.28	-	2.28	2.61	-	2.61	2.93	-	2.93
March	2.55	3.36	5.91	2.92	3.36	6.28	3.29	3.36	6.65
April	3.45	-	3.45	3.95	-	3.95	4.43	-	4.43
May	3.89	0.36	4.25	4.44	0.36	4.80	5.00	0.36	5.36
June	4.14	4.38	8.52	4.73	4.38	9.11	5.33	4.38	9.71
July	1.47	6.02	7.49	1.68	6.02	7.70	1.89	6.02	7.91
August	0.91	16.17	17.08	1.03	16.17	17.20	1.17	16.17	17.34
September	1.24	5.10	6.34	1.42	5.10	6.52	1.60	5.10	6.70
October	2.10	2.18	4.28	2.39	2.18	4.57	2.69	2.18	4.47
November	1.70	9.46	11.16	1.94	9.46	11.40	2.18	9.46	11.64
Total	**24.60**	**47.03**	**71.63**	**28.10**	**47.03**	**75.13**	**31.63**	**47.03**	**78.66**

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