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AS Taru

Ph.D. Scholar, Department of Horticulture, MPKV, Rahuri, Maharashtra, India

SA Ranpise

Head, Department of Horticulture, MPKV, Rahuri, Maharashtra, India

PS Pawar

Assistant Professor, Department of Horticulture, MPKV, Rahuri, Maharashtra, India

Effect of different levels of irrigation and fertigation on yield and fruit quality of acid lime (*Citrus aurantifolia* Swingle) cv. Phule Sharbati

AS Taru, SA Ranpise and PS Pawar

Abstract

The Research entitled was carried out at “All India Coordinated Research Project on Fruits”, Department of Horticulture, MPKV., Rahuri, Dist. Ahmednagar (MS) during the year 2015-16 and 2016-17 to find the effect of different 9 treatments i.e. combinations of 3 different levels of irrigation (I₁-100%, I₂-75% & I₃-50% ETr) and 3 levels of fertigation (F₁-90%, F₂-80% & F₃-70% of RDF). The interaction effect of irrigation and fertigation was found significant on qualitative parameters and yield of acid lime cv. Phule Sharbati. Irrigation level I₁-100% ETr through drip along with fertigation level F₁-90% RD through WSF recorded significantly the maximum yield t hectare⁻¹ in *Ambia bahar* (8.25 t, 9.37 t and 8.81 t), *Mrig bahar* (5.84 t, 7.03 t and 6.44 t), *Hast bahar* (5.53 t, 6.97 t and 6.25 t) and annual (19.62 t, 23.36 t and 21.49 t) in the both year of investigation and in pooled results respectively.

Keywords: Acid lime, irrigation, fertigation, quality, yield

Introduction

Acid lime is one of the most beneficial fruit when its come to its natural benefits and curative properties. The citrus growing states in India are Maharashtra, Andhra Pradesh, Punjab, Karnataka, Orissa, Bihar, Assam, Tamil Nadu, Gujarat etc. The area and production of citrus in India during 2016-17 was 1,055.65 thousand ha and 12,746 thousand MT respectively. State wise Andhra Pradesh ranks first in production, Maharashtra ranks third (Annon, 2017) [1]. Water is prime source for all biological activities and now a day's water has precious than gold and oil. Therefore, drip irrigation is one such technology which can help to increase the irrigation potential by optimizing the use of available irrigation water also precise management of irrigation quantity along with the rate and timing of nutrient application are of critical importance to obtain desired results in terms of productivity and nutrient use efficiency. The fertigation allows application of right amounts of plant nutrients uniformly to the wetted root volume zone where most of the active roots are concentrated and this helps enhance nutrient use efficiency (Alva *et al.* 2008) [2].

Material and Methods

The investigation was carried out at All India Coordinated Research Project on Fruits, Department of Horticulture, MPKV, Rahuri (Maharashtra) during 2015-16 and 2016-17 with a view to elicit the “Fertigation Studies in Acid lime (*Citrus aurantifolia* Swingle) cv. Phule Sharbati”. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications and ten treatments, In this investigation nine treatments included combinations of three Irrigation Levels (I) i.e I₁- 100% irrigation of the ETr., I₂- 75% irrigation of the ETr. and I₃- 50% irrigation of the ETr. with three Fertigation Levels (F) i.e. F₁- 90% of RDF, F₂- 80% of RDF and F₃- 70% of RDF through Drip irrigation and T₁₀- Control I₄- Conventional surface irrigation with 100% RDF as per the farmer practice. Irrigation was applied by drip irrigation on an alternate day. The reference crop evapotranspiration was calculated by using the FAO Penman-Monteith method. (Allen *et al.* 1998) [1]. The fertigation was distributed in three parts in a year for management of all three bahars.

Results & Discussion

Irrigation at 100% ETr irrigation level through drip and fertigation F₁-90% RD through WSF exhibited yield of acid lime and recorded significantly higher average weight of fruit as well as yield t ha⁻¹ during 2015-16 and 2016-17. Whereas, treatment T₁- irrigation level I₁-100% ETr through drip along with fertigation level F₁-90% RD through WSF recorded significantly

Corresponding Author:**AS Taru**

Ph.D. Scholar, Department of Horticulture, MPKV, Rahuri, Maharashtra, India

highest average weight of fruit in *Ambia bahar* (48.40 g, 50.43 g and 49.42 g), *Mrig bahar* (50.40 g, 52.53 g and 51.47 g), *Hast bahar* (47.95 g, 49.02 g and 48.49 g) and annual (48.79 g, 50.61 g and 49.70 g) with significantly maximum yield t hectare⁻¹ in *Ambia bahar* (8.25 t, 9.37 t and 8.81 t), *Mrig bahar* (5.84 t, 7.03 t and 6.44 t), *Hast bahar* (5.53 t, 6.97 t and 6.25 t) and annual (19.62 t, 23.36 t and 21.49 t) in both the year of investigation and in pooled results respectively as shown in Table 1 & 2. This might be due to uniform application and quantity of nutrients directly in vicinity of the root zone throughout crop growth period increased the nutrient use efficiency which leads to enhance all the yield and quality parameters of crop coupled with increase in physiological processes and efficient translocation of photosynthates towards reproductive growth in terms of yield of acid lime. The uniform application of nutrients at proper time helps to initiation of *Hast bahar* and increased the yield in *Hast bahar*. Similar results were reported by Shirgure *et al.* (2004) [10] in acid lime, Panigrahi and Srivastava (2011) [7] in

Nagpur mandarin, Patel *et al.* (2012) [8] in acid lime, Barua and Hazarika (2014) [4] in Assam lemon and Ramana *et al.* (2014) [9] in sweet orange, Goud *et al.* (2017) [6] in Nagpur mandarin.

Regarding quality parameters as result presented in Table 3a & 3b irrigation level I₁- 100% ETr noted significantly higher juice, TSS, acidity, ascorbic acid, fruit length, fruit diameter and fruit volume whereas, fertigation level F₁-90% RD through WSF recorded significantly maximum TSS only during both the year of investigation and in pooled results. However, interaction effects i.e. T₁- irrigation level I₁-100% ETr through drip along with fertigation level F₁-90% RD through WSF recorded significantly maximum juice 49.75%, 49.02% and 49.38%, TSS 7.89 °Brix, 7.87 °Brix and 7.88 °Brix, acidity 6.92%, 6.94% and 6.93%, ascorbic acid 31.55 mg, 30.95 mg and 31.25 mg, fruit length 4.67 cm, 4.77 cm and 4.72 cm, fruit diameter 3.90 cm, 4.07 cm and 3.98 cm and fruit volume 42.20 ml, 43.07 ml and 42.63 ml during 2015-16, 2016-17 and in pooled results respectively.

Table 1: Average weight of fruits in acid lime as influenced by different levels of irrigation, fertigation and their interaction

Treatments	Average weight of fruits (g)											
	<i>Ambia bahar</i>			<i>Mrig bahar</i>			<i>Hast bahar</i>			Annual		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Irrigation Levels (I)												
I ₁	47.08	49.26	48.17	49.08	51.36	50.22	46.64	47.85	47.25	47.47	49.43	48.45
I ₂	43.89	42.89	43.39	45.89	44.32	45.11	43.16	41.26	42.21	44.19	42.83	43.51
I ₃	41.12	41.65	41.39	42.78	43.19	42.99	39.28	38.48	38.88	41.02	41.37	41.20
SE (m) ±	0.58	0.84	0.71	0.68	0.89	0.79	0.68	0.76	0.72	0.60	0.76	0.68
CD at 5%	1.72	2.49	2.11	2.01	2.66	2.34	2.01	2.25	2.13	1.78	2.27	2.02
Fertigation Levels (F)												
F ₁	44.94	45.49	45.22	46.94	47.59	47.27	43.97	43.42	43.70	45.19	45.56	45.38
F ₂	44.46	44.68	44.57	46.23	45.89	46.06	43.16	42.82	42.99	44.53	44.55	44.54
F ₃	42.69	43.63	43.16	44.58	45.39	44.99	41.94	41.35	41.65	42.95	43.52	43.24
SE (m) ±	0.58	0.84	0.71	0.68	0.89	0.79	0.68	0.76	0.72	0.60	0.76	0.68
CD at 5%	1.72	2.50	1.72	2.01	2.66	2.34	2.01	2.25	2.13	1.78	2.27	2.03
Interaction (I x F)												
T ₁ -I ₁ F ₁	48.40	50.43	49.42	50.40	52.53	51.47	47.95	49.02	48.49	48.79	50.61	49.70
T ₂ -I ₁ F ₂	46.97	49.47	48.22	48.97	51.57	50.27	46.55	48.06	47.31	47.37	49.63	48.50
T ₃ -I ₁ F ₃	45.87	47.88	46.88	47.87	49.98	48.93	45.43	46.47	45.95	46.25	48.04	47.15
T ₄ -I ₂ F ₁	44.87	43.90	44.39	46.87	46.00	46.44	44.45	42.49	43.47	45.28	44.10	44.69
T ₅ -I ₂ F ₂	45.30	43.20	44.25	47.30	43.30	45.30	43.90	41.79	42.85	45.37	42.83	44.10
T ₆ -I ₂ F ₃	41.52	41.57	41.55	43.52	43.67	43.60	41.12	39.49	40.31	41.91	41.57	41.74
T ₇ -I ₃ F ₁	41.57	42.15	41.86	43.57	44.25	43.91	39.52	38.74	39.13	41.51	41.97	41.74
T ₈ -I ₃ F ₂	41.10	41.87	41.24	42.43	42.80	42.62	39.33	38.62	38.83	40.86	41.19	41.03
T ₉ -I ₃ F ₃	40.68	41.43	41.06	42.35	42.53	42.44	39.28	38.09	38.69	40.69	40.96	40.83
SE (m) ±	1.01	1.45	1.23	1.17	1.55	1.36	1.17	1.31	1.24	1.04	1.31	1.18
CD at 5%	2.99	4.31	3.65	3.48	4.60	4.04	3.48	3.89	3.69	3.08	3.90	3.49
T ₁₀ -Control	43.30	40.37	41.84	42.97	42.47	42.72	39.58	38.96	39.27	42.18	40.59	41.39

Table 2: Yield of acid lime as influenced by different levels of irrigation, fertigation and their interaction

Treatments	Yield (t ha ⁻¹)											
	<i>Ambia bahar</i>			<i>Mrig bahar</i>			<i>Hast bahar</i>			Annual		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Irrigation Levels (I)												
I ₁	7.88	9.08	8.48	5.44	6.60	6.02	5.13	6.60	5.87	18.45	22.28	20.37
I ₂	6.72	7.33	7.03	4.62	5.05	4.84	4.11	4.73	4.42	15.45	17.11	16.28
I ₃	6.25	6.83	6.54	4.15	4.56	4.36	3.18	3.14	3.16	13.59	14.53	14.06
SE (m) ±	0.12	0.19	0.16	0.10	0.15	0.13	0.08	0.09	0.09	0.23	0.37	0.30
CD at 5%	0.37	0.57	0.47	0.30	0.45	0.38	0.23	0.26	0.26	0.69	1.09	0.89
Fertigation Levels (F)												
F ₁	7.22	8.06	7.64	5.03	5.79	5.41	4.33	5.08	4.71	16.58	18.93	17.76
F ₂	7.12	7.89	7.51	4.81	5.34	5.08	4.15	4.84	4.50	16.07	18.06	17.07
F ₃	6.51	7.29	6.90	4.38	5.09	4.74	3.94	4.55	4.25	14.83	16.93	15.88
SE (m) ±	0.12	0.19	0.16	0.10	0.15	0.13	0.08	0.09	0.09	0.23	0.37	0.30
CD at 5%	0.37	0.57	0.47	0.30	0.45	0.38	0.23	0.26	0.26	0.69	1.09	0.89

Interaction (I x F)												
T ₁ -I ₁ F ₁	8.25	9.37	8.81	5.84	7.03	6.44	5.53	6.97	6.25	19.62	23.36	21.49
T ₂ -I ₁ F ₂	7.99	9.19	8.59	5.46	6.56	6.01	5.07	6.57	5.82	18.53	22.32	20.43
T ₃ -I ₁ F ₃	7.39	8.69	8.04	5.03	6.20	5.62	4.79	6.27	5.53	17.21	21.16	19.19
T ₄ -I ₂ F ₁	7.11	7.82	7.47	4.89	5.43	5.16	4.23	5.03	4.63	16.23	18.28	17.26
T ₅ -I ₂ F ₂	6.92	7.54	7.23	4.78	4.90	4.84	4.24	4.78	4.51	15.93	17.23	16.58
T ₆ -I ₂ F ₃	6.12	6.62	6.37	4.19	4.83	4.51	3.86	4.37	4.12	14.17	15.82	15.00
T ₇ -I ₃ F ₁	6.29	7.00	6.65	4.37	4.90	4.64	3.24	3.25	3.25	13.89	15.15	14.52
T ₈ -I ₃ F ₂	6.45	6.93	6.69	4.18	4.55	4.37	3.23	3.16	3.19	13.76	14.63	14.20
T ₉ -I ₃ F ₃	6.01	6.56	6.29	3.92	4.22	4.07	3.17	3.02	3.10	13.10	13.80	13.45
SE (m) +	0.31	0.33	0.32	0.28	0.27	0.27	0.27	0.25	0.26	0.83	0.96	0.89
CD at 5%	0.94	0.99	0.96	0.83	0.79	0.81	0.80	0.75	0.78	2.49	2.89	2.69
T ₁₀ -Control	6.94	7.45	7.20	4.56	4.75	4.66	3.73	4.04	3.89	15.23	16.25	15.74

Table 3a: Different qualitative parameters of acid lime as influenced by different levels of irrigation, fertigation and their interaction

Treatments	Juice (%)			TSS (° Brix)			Acidity (%)			Ascorbic acid (mg 100 ml ⁻¹ of juice)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Irrigation Levels (I)												
I ₁	49.01	48.82	48.91	7.85	7.85	7.85	6.89	6.90	6.90	31.29	30.70	30.99
I ₂	46.24	46.17	46.20	7.29	7.38	7.33	6.55	6.43	6.49	29.80	29.60	29.70
I ₃	44.31	44.36	44.33	7.11	7.23	7.17	6.47	6.44	6.46	28.39	28.57	28.48
SE (m) ±	0.41	0.43	0.42	0.05	0.04	0.04	0.04	0.03	0.04	0.22	0.22	0.22
CD at 5%	0.121	0.129	0.125	0.15	0.11	0.13	0.13	0.10	0.12	0.65	0.67	0.66
Fertigation Levels (F)												
F ₁	46.93	46.84	46.88	7.50	7.58	7.54	6.72	6.63	6.68	30.00	29.83	29.91
F ₂	46.82	46.23	46.52	7.45	7.46	7.46	6.66	6.56	6.61	29.92	29.64	29.78
F ₃	45.81	46.27	46.04	7.31	7.41	7.36	6.52	6.58	6.55	29.56	29.40	29.48
SE (m) +	0.41	0.43	0.42	0.05	0.04	0.04	0.04	0.03	0.04	0.22	0.22	0.22
CD at 5%	NS	NS	NS	0.15	0.11	0.13	NS	NS	NS	NS	NS	NS
Interaction (I x F)												
T ₁ -I ₁ F ₁	49.75	49.02	49.38	7.89	7.87	7.88	6.92	6.94	6.93	31.55	30.95	31.25
T ₂ -I ₁ F ₂	48.74	48.75	48.74	7.86	7.84	7.85	6.91	6.86	6.89	31.35	30.63	30.99
T ₃ -I ₁ F ₃	48.54	48.67	48.60	7.81	7.83	7.82	6.83	6.81	6.82	30.96	30.52	30.74
T ₄ -I ₂ F ₁	46.52	46.81	46.66	7.46	7.52	7.49	6.73	6.59	6.66	29.59	29.75	29.67
T ₅ -I ₂ F ₂	47.02	46.36	46.69	7.32	7.35	7.34	6.51	6.34	6.43	30.00	29.60	29.80
T ₆ -I ₂ F ₃	45.18	45.35	45.26	7.09	7.27	7.18	6.42	6.35	6.39	29.82	29.44	29.63
T ₇ -I ₃ F ₁	44.53	44.70	44.61	7.14	7.35	7.24	6.52	6.36	6.44	28.86	28.79	28.82
T ₈ -I ₃ F ₂	44.70	44.79	44.74	7.17	7.20	7.19	6.57	6.47	6.52	28.42	28.68	28.55
T ₉ -I ₃ F ₃	43.69	43.59	43.64	7.02	7.13	7.08	6.30	6.28	6.29	27.90	28.23	28.06
SE (m) +	0.70	0.73	0.71	0.09	0.07	0.08	0.08	0.06	0.07	0.38	0.39	0.38
CD at 5%	2.09	2.03	2.06	0.27	0.21	0.24	0.22	0.17	0.20	1.13	1.15	1.14
T ₁₀ -Control	46.11	46.96	46.53	7.63	7.45	7.54	6.72	6.70	6.71	29.85	29.11	29.48

Table 3b: Different qualitative parameters of acid lime as influenced by different levels of irrigation, fertigation and their interaction

Treatments	Fruit length (cm)			Fruit Diameter (cm)			Fruit volume (ml)			Rind thickness (mm)		
	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled	2015-16	2016-17	Pooled
Irrigation Levels (I)												
I ₁	4.39	4.56	4.47	3.84	3.98	3.91	41.89	42.57	42.23	1.88	1.70	1.79
I ₂	3.80	3.92	3.86	3.38	3.48	3.43	37.93	38.79	38.36	1.90	1.72	1.81
I ₃	3.67	3.79	3.73	3.26	3.33	3.29	37.78	38.42	38.10	1.92	1.81	1.87
SE (m) ±	0.05	0.06	0.05	0.04	0.05	0.04	0.67	0.67	0.67	0.02	0.02	0.02
CD at 5%	0.15	0.17	0.16	0.11	0.14	0.12	2.00	1.98	1.99	NS	NS	NS
Fertigation Levels (F)												
F ₁	4.09	4.23	4.16	3.49	3.64	3.56	38.89	40.19	39.54	1.88	1.71	1.80
F ₂	3.89	4.06	3.97	3.53	3.61	3.57	39.87	39.66	39.76	1.91	1.76	1.84
F ₃	3.88	3.98	3.93	3.46	3.53	3.49	38.84	39.93	39.38	1.92	1.76	1.84
SE (m) +	0.06	0.07	0.06	0.04	0.05	0.04	0.65	0.65	0.65	0.02	0.02	0.02
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (I x F)												
T ₁ -I ₁ F ₁	4.67	4.77	4.72	3.90	4.07	3.98	42.20	43.07	42.63	1.87	1.64	1.76
T ₂ -I ₁ F ₂	4.27	4.57	4.42	3.87	3.93	3.90	41.97	42.30	42.13	1.92	1.72	1.82
T ₃ -I ₁ F ₃	4.23	4.33	4.28	3.77	3.93	3.85	41.50	42.23	41.81	1.87	1.73	1.80
T ₄ -I ₂ F ₁	3.87	4.03	3.95	3.30	3.50	3.40	37.10	38.97	38.03	1.90	1.72	1.81
T ₅ -I ₂ F ₂	3.77	3.87	3.82	3.43	3.57	3.50	38.93	39.50	39.21	1.88	1.73	1.81
T ₆ -I ₂ F ₃	3.77	3.87	3.82	3.40	3.37	3.38	37.77	37.90	37.83	1.92	1.71	1.82
T ₇ -I ₃ F ₁	3.73	3.90	3.82	3.27	3.37	3.32	37.37	38.53	37.95	1.87	1.78	1.83
T ₈ -I ₃ F ₂	3.63	3.73	3.68	3.30	3.33	3.31	38.70	37.17	37.93	1.93	1.82	1.88

T ₉ -I ₃ F ₃	3.63	3.71	3.67	3.20	3.30	3.25	37.27	36.57	35.42	1.97	1.83	1.90
SE (m) +	0.16	0.15	0.16	0.06	0.08	0.07	01.17	01.16	01.16	0.03	0.04	0.03
CD at 5%	0.48	0.47	0.48	0.18	0.25	0.21	3.26	3.44	3.31	NS	NS	NS
T ₁₀ -Control	3.73	3.93	3.83	3.33	3.30	3.31	40.13	39.87	40.00	1.86	1.73	1.92

Conclusions

Considering two years study of irrigation and fertigation level, it is seen that the irrigation level I₁ (100% ETr) and fertigation level F₁ (90% of RDF through water soluble fertilizer) was found better in maximizing the yield and improve the quality of fruits in acid lime cv. Phule Sharbati.

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