



Research Article

EFFECT OF STAGE WISE APPLICATION OF IRRIGATION WATER ON GROWTH, YIELD AND FRUIT QUALITY IN ACID LIME (*Citrus aurantifolia* Swingle)

PAWAR P.S.^{*1}, MUKUNDA LAKSHMI L.² AND PATIL P.³

¹Jr. Horticulturist, ICAR-AICRP on Fruits, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, 413722, MS, India

²Senior Scientist, ICAR-AICRP on Fruits, Citrus Research Station, Tirupati, 517502, Dr. Y.S.R. Horticultural University, Venkataramannagudem, 534101, India

³Project Coordinator, ICAR-AICRP on Fruits, ICAR-Indian Institute of Horticultural Research, Bengaluru, 560089, Karnataka, India

*Corresponding Author: Email - pawarpopat1968@gmail.com

Received: May 06, 2022; Revised: May 27, 2022; Accepted: May 28, 2022; Published: May 30, 2022

Abstract: This field experiment on effect of stage wise application of irrigation water on growth, yield and fruit quality in acid lime (*Citrus aurantifolia* Swingle) was conducted at Rahuri, Maharashtra (pooled mean 2014-15 to 2018-19) and at Tirupati, Andhra Pradesh (pooled mean 2015-16 to 2019-20) with an objective to study the water requirement at different stages of growth in acid lime. The experiment was conducted in Randomized Block Design (RBD) with five treatments replicated four times. The irrigations were scheduled on percent of pan evaporation replenishment (ER) at various stages of growth and fruit development: Stage-I (Jan-Feb), Stage-II (Mar-April), Stage-III (May-June), Stage-IV (July-Aug), Stage-V (Sept-Oct) and Stage-VI (Nov-Dec). At Rahuri centre, the effect of different levels of irrigation at different stages on growth, yield and fruit quality of acid lime was found to be significant. The maximum plant height (3.13 m), canopy volume (23.66 m³), number of fruits/tree (805.54), fruit weight (47.60 g), fruit yield (38.71 kg/tree and 10.71 t/ha), juice (49.08 %), acidity (6.85 %), ascorbic acid (32.85 mg/100 ml juice) and B:C ratio (1.57) were recorded under the treatment T₄ i.e., application of irrigation water at 80:80:80:80:80 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) and was at par with the treatment T₃ i.e., application of irrigation water at 60:80:60:80:80 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) and recorded plant height (3.11 m), canopy volume (23.63 m³), number of fruits/tree (796.75), fruit weight (47.04 g), fruit yield (37.78 kg/tree and 10.46 t/ha), juice (47.55 %), ascorbic acid (31.79 mg/100 ml juice) and B:C ratio (1.54). Based on the results, for acid lime growing under Western Maharashtra, irrigation at 60:80:60:80:80 ER (%) during January to December is recommended for better growth, yield, fruit quality with efficient water use. At Tirupati centre, the maximum fruit yield (84.38 kg/tree and 23.37 t/ha), TSS (8.54 oB) and B: C ratio (1.47) were recorded under the treatment T₄ i.e., application of irrigation water at 80:80:80:80:80 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec). However, the maximum plant height (3.31 m) was recorded under the treatment T₂ and was at par with the treatments T₃ and T₄. The treatment T₃ i.e., application of irrigation water at 60:80:60:80:80 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) recorded the plant height (3.29 m), fruit yield (71.24 kg/tree and 19.74 t/ha), TSS (8.50 oB) and ascorbic acid (46.05 mg/100 ml juice). Based on the results, for acid lime growing under Andhra Pradesh, irrigation at 60:80:60:80:80 ER (%) during January to December is recommended for better growth, yield, fruit quality with efficient water use.

Keywords: Acid lime, Percent pan evaporation, Drip irrigation schedule

Citation: Pawar P.S., et al., (2022) Effect of Stage Wise Application of Irrigation Water on Growth, Yield and Fruit Quality in Acid Lime (*Citrus aurantifolia* Swingle).

International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 14, Issue 5, pp.- 11371-11375.

Copyright: Copyright©2022 Pawar P.S., et al., This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.

Academic Editor / Reviewer: M. V. Dabhi, Dr Prashant Shrivastava, Dr B. S. Vyakarnahal

Introduction

Acid lime (*Citrus aurantifolia* Swingle) is mainly grown in semi-arid climate of Maharashtra and adjoining states like Andhra Pradesh, Telangana, Karnataka and Gujarat in central India. The productivity of acid lime is very low due to surface gravity method of irrigation, poor soil-water-air equilibrium and soil application of fertilizers with micro nutrient deficiencies [1]. Irrigation scheduling based on daily pan evaporation is the essential component affecting growth, yield and fruit quality mainly dependent on the constant and adequate supply of soil moisture in feeder root zone right from fruit set to fruit maturity of acid lime [2,3].

Acid lime being a perennial evergreen tree requires soil moisture and all required nutrients for higher orchard efficiency during the fruit growth stages. The inadequate moisture and nutrients in critical stages of the crop hampers the plant growth, yield and fruit quality drastically [4]. Acid lime is one of the most beneficial fruits when it comes to its natural benefits and curative properties. Water is the 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 [5].

Since current day, acid lime orchards are watered through the flow irrigation or drip irrigation method without considering the stage wise water requirement of the plant and not much research has been conducted on stage wise application of irrigation water at different levels of cultivation. The objectives of this investigation were to study the water requirement at different stages of growth and to study the effect of stage wise application of irrigation water on growth, yield and fruit quality in acid lime (*Citrus aurantifolia* Swingle) in Maharashtra and Andhra Pradesh. Acid lime is one of the important citrus fruits grown in India on an area of 317 thousand hectares with total production of 3717 thousand MT and productivity of 11.72 MT/ha [6].

Material and Methods

The present experiment was conducted at ICAR-AICRP on Fruits, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, Maharashtra and at Citrus Research Station, Dr. YSR Horticulture University, Tirupati, Andhra Pradesh. To study the effect of stage wise application of irrigation water on growth, yield and fruit quality in acid lime, field experiments were conducted in a Randomized Block Design (RBD) with five treatments replicated four times at Rahuri and Tirupati.

Treatment details (ER = Evaporation Replenishment)

Treatment	Stage -I (Jan-Feb)	Stage -II(Mar-April)	Stage -III(May-June)	Stage -IV(July-Aug)	Stage -V(Sept-Oct)	Stage -VI(Nov-Dec)
T ₁	30 ER (%)	40 ER (%)	30 ER (%)	40 ER (%)	30 ER (%)	40 ER (%)
T ₂	40 ER (%)	60 ER (%)	40 ER (%)	60 ER (%)	40 ER (%)	60 ER (%)
T ₃	60 ER (%)	80 ER (%)	60 ER (%)	80 ER (%)	60 ER (%)	80 ER (%)
T ₄	80 ER (%)	80 ER (%)	80 ER (%)	80 ER (%)	80 ER (%)	80 ER (%)
T ₅	30 ER (%)	30 ER (%)	30 ER (%)	30 ER (%)	30 ER (%)	30 ER (%)

Table-1 Monthly total rainfall, mean evaporation, temperature and relative humidity

Months	Rahuri centre (2014-2018)				Tirupati centre (2015-2019)			
	Total rainfall (mm)	Evaporation (mm)	Temperature (°C)	Relative humidity (%)	Total rainfall (mm)	Evaporation (mm)	Temperature (°C)	Relative humidity (%)
January	1.20	4.49	28.85	58.60	2.20	4.16	29.81	86.79
February	-	5.67	31.80	55.00	29.40	5.57	32.76	84.38
March	163.00	6.59	33.64	48.80	117.80	6.43	35.92	79.85
April	8.20	8.71	38.01	41.20	127.00	7.20	38.64	76.48
May	21.60	10.80	39.37	43.80	313.70	7.17	39.11	67.80
June	354.80	9.19	37.14	61.60	525.70	6.32	36.54	70.65
July	384.40	5.85	32.56	71.80	436.70	6.13	35.75	71.58
August	284.60	4.92	30.19	75.00	688.60	5.47	34.46	75.85
September	573.90	4.88	30.76	75.20	950.30	4.46	33.11	82.59
October	702.00	5.08	32.26	75.40	818.80	4.55	32.68	84.68
November	73.20	5.55	32.57	62.00	1111.30	4.64	30.19	85.23
December	122.20	5.10	30.72	63.00	485.60	4.07	29.19	87.10

The scientists used 4 plants/treatment at Rahuri and Tirupati centres. Phule Sharbati variety of acid lime was studied at Rahuri centre, while Balaji variety of acid lime was investigated at Tirupati centre. Tree age was 9 years at Rahuri centre and 10 years at Tirupati centre. Fertilizer application of 15 kg FYM + 15 kg neem cake + 600:300:600 g NPK/plant/year was given at Rahuri centre and 80 kg FYM + 8 kg neem cake + 750:600:800 g NPK/plant/year was administered at Tirupati centre.

The irrigation was scheduled on percent of pan evaporation replenishment (ER) in various stages of growth and fruit development. The irrigation quantity was calculated by taking into account pan factor (0.70), canopy factor (0.80) and crop factor (0.75). Stage wise quantity of irrigation water was recorded from January to December at Rahuri and Tirupati centres. Observations on growth, yield, fruit quality and water requirement were recorded at both the centres. The canopy volume (m³) of acid lime tree was calculated based on Castle's [7] formula, while fruit quality analysis was conducted in line with Ranganna's [8] procedure. The data were statistically analyzed using the standard procedure given by Panse and Sukhatme [9]. Monthly total rainfall, mean evaporation, temperature and relative humidity recorded at both the centres are depicted in [Table-1].

Results and Discussion

The daily weather data recorded at the two centres was used for irrigation scheduling based on evaporation.

Rahuri centre (Pooled data 2014-15 to 2018-19)

The pooled data 2014-15 to 2018-19 of growth and yield presented in [Tables-2 and 3] showed that, application of different levels of irrigation at different stages of growth and yield had a significant effect. The treatment T₄ i.e., application of irrigation water at 80:80:80:80:80:80 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) recorded significantly the maximum figures for plant height (3.13 m), canopy volume (23.66 m³), number of fruits/tree (805.54), fruit weight (47.60 g) and yield (38.71 kg/tree and 10.71 t/ha) and was at par with the treatment T₃ i.e., application of irrigation water at 60:80:60:80:60:80 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) and recorded plant height (3.11 m), canopy volume (23.63 m³), number of fruits/tree (796.75), fruit weight (47.04 g) and yield (37.78 kg/tree and 10.46 t/ha).

The minimum plant height (3.03 m), canopy volume (19.83 m³), number of fruits/tree (759.50), fruit weight (41.48 g) and yield (31.15 kg/tree and 8.62 t/ha) were recorded under the treatment T₅ i.e., application of irrigation water at 30:30:30:30:30:30 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec). The maximum growth and yield by application of irrigation water at 80 ER (%) at all the

growth stages might have been due to its beneficial effects on photosynthesis and dry matter production. Balaganvi and Kumathe (2004) [10] and Shirgure *et al.* (2014) [11] reported similar increase in growth and yield by application of irrigation water at 80 ER (%) at all growth stages in acid lime and Nagpur mandarin, respectively.

The fruit quality data presented in [Table-4] were also affected under various treatments, with the maximum figures for juice (49.08 %), acidity (6.85 %) and ascorbic acid (32.85 mg/100 ml juice) were recorded under the treatment T₄ i.e., application of irrigation water at 80:80:80:80:80:80 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) and was at par with the treatment T₃ i.e., application of irrigation water at 60:80:60:80:60:80 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) and recorded juice (47.55 %), acidity (6.53 %) and ascorbic acid (31.79 mg/100 ml juice). The minimum juice (44.67 %), acidity (6.15 %) and ascorbic acid (30.55 mg/100 ml juice) were recorded under the treatment T₅ i.e., application of irrigation water at 30:30:30:30:30:30 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec). There was non-significant difference between the treatments for TSS. The application of irrigation water at 80 ER (%) at all the growth stages enhanced the photosynthetic rate and auxin production, which in turn improved the fruit quality of acid lime.

This is in conformity with the findings of Shirgure *et al.* (2004 a) [12] in acid lime and Shirgure and Srivastava (2013) [13] in Nagpur mandarin.

The reduction in the irrigation level from 80 ER (%) to 30 ER (%) during different stages of fruit growth reduced the fruit yield from 10.71 t/ha to 8.62 t/ha. The treatment T₅ i.e., application of irrigation water at 30:30:30:30:30:30 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) recorded the highest WUE (0.68 t/ha cm) [Table-5] and obtained normal yield (8.62 t/ha) by application of less total quantity of irrigation water (4503.60 litres/plant/year) than all other treatments [Table-5] which presents data on the stage wise water requirement in acid lime. The total quantity of irrigation water applied from T₁ to T₅ was in the range of 4503.60 litres/plant/year to 12009.60 litres/plant/year under the drip irrigation method from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec).

The total quantity of irrigation water applied for the treatment T₃ was 10447.20 litres/plant/year and that of treatment T₄ was 12009.60 litres/plant/year. It means that the treatment T₃ saved 1562.40 litres of water per year than the treatment T₄. So, on the basis of water saved and water requirement the treatment T₃ was recommended in acid lime. The quantity of water use was more during the summer months due to low relative humidity and higher temperature and transpiration. Similar studies on water use in citrus crop has been reported by Mageed *et al.* (1988) [14] in Kinnow mandarin, Shirgure *et al.* (2003) [15] in acid lime and Kumar *et al.* (2013) [16] in Sathgudi sweet orange.

Table-2 Effect of stage wise application of irrigation water on growth in acid lime (Pooled mean: 2014-15 to 2018-19 at the Rahuri center and 2015-16 to 2019-20 at the Tirupati center)

Treatment	Plant height (m)		Canopy volume (m ³)	
	Rahuri	Tirupati	Rahuri	Tirupati
T ₁	3.04	3.04	21.23	28.18
T ₂	3.04	3.31	20.83	32.81
T ₃	3.11	3.29	23.63	30.70
T ₄	3.13	3.28	23.66	29.97
T ₅	3.03	3.04	19.83	25.25
S. E.(m) ±	0.02	0.07	0.60	1.92
C. D. at 5 %	0.06	0.22	1.81	NS
C. V. (%)	1.37	5.11	6.19	14.59

Table-3 Effect of stage wise application of irrigation water on yield in acid lime (Pooled mean: 2014-15 to 2018-19 at the Rahuri center and 2015-16 to 2019-20 at the Tirupati center)

Treatment	Number of fruits /tree		Fruit weight (g)		Fruit yield (kg/tree)		Fruit yield (t/ha)	
	Rahuri	Tirupati	Rahuri	Tirupati	Rahuri	Tirupati	Rahuri	Tirupati
T ₁	772.99	1423.8	43.59	46.02	33.63	65.54	9.31	18.16
T ₂	782.66	1470.35	45.29	46.82	35.37	69.49	9.79	19.25
T ₃	796.75	1518.45	47.04	47.24	37.78	71.24	10.46	19.74
T ₄	805.54	1750.10	47.60	47.91	38.71	84.38	10.71	23.37
T ₅	759.50	1312	41.48	47.12	31.15	61.08	8.62	16.92
S. E.(m) ±	3.55	95.15	0.51	0.88	1.03	4.12	0.28	1.14
C. D. at 5 %	10.64	NS	1.54	NS	3.09	12.46	0.85	3.45
C. V. (%)	1.01	14.23	2.57	4.17	6.53	13.10	6.54	13.09

Table-4 Effect of stage wise application of irrigation water on fruit quality in acid lime (Pooled mean: 2014-15 to 2018-19 at the Rahuri center and 2015-16 to 2019-20 at the Tirupati center)

Treatment	Juice (%)		TSS (°B)		Acidity (%)		Ascorbic acid (mg/100 ml juice)	
	Rahuri	Tirupati	Rahuri	Tirupati	Rahuri	Tirupati	Rahuri	Tirupati
T ₁	46.09	49.43	7.11	8.37	6.49	7.40	30.75	50.05
T ₂	47.16	47.35	7.08	8.52	6.56	7.03	30.27	53.35
T ₃	47.55	47.68	7.07	8.50	6.53	7.32	31.79	46.05
T ₄	49.08	50.49	7.46	8.54	6.85	7.33	32.85	45.85
T ₅	44.67	47.68	7.07	8.14	6.15	6.99	30.55	47.60
S. E.(m) ±	0.55	0.87	0.15	0.05	0.06	0.14	0.51	0.20
C. D. at 5 %	1.67	NS	NS	0.15	0.19	NS	1.53	0.61
C. V. (%)	2.66	4.02	4.93	1.28	2.21	4.35	3.68	0.81

Table-5 Stage wise mean water requirement of acid lime through drip irrigation system (liters/plant/stage) at the Rahuri centre (2014-15 to 2018-19)

Treatment	Stage-I (Jan-Feb)	Stage-II (Mar-April)	Stage-III (May-June)	Stage-IV (July-Aug)	Stage-V (Sept-Oct)	Stage-VI (Nov-Dec)	Total (litres/pl-ant/year)	WUE (t/ha cm)
T ₁	669.60	1414.80	1105.20	702.00	568.80	763.20	5223.60	0.64
T ₂	892.80	2124.00	1472.40	1051.20	759.60	1144.80	7444.80	0.47
T ₃	1339.20	2833.20	2210.40	1400.40	1137.60	1526.40	10447.20	0.36
T ₄	1785.60	2833.20	2948.40	1400.40	1515.60	1526.40	12009.60	0.32
T ₅	669.60	1062.00	1105.20	525.60	568.80	572.40	4503.60	0.68

Table-6 Stage wise mean water requirement of acid lime through drip irrigation system (liters/plant/stage) at the Tirupati centre (2015-16 to 2019-20)

Treatment	Stage-I (Jan-Feb)	Stage-II (Mar-April)	Stage-III (May-June)	Stage-IV (July-Aug)	Stage-V (Sept-Oct)	Stage-VI (Nov-Dec)	Total (litres/pl-ant/year)	WUE (t/ha cm)
T ₁	347	800	549	495	147	171	2509	2.61
T ₂	462	1200	732	742	196	257	3589	1.93
T ₃	694	1600	1098	989	294	342	5018	1.42
T ₄	925	1600	1464	989	392	342	5713	1.47
T ₅	347	600	549	371	147	128	2142	2.84

Economics

The economics of stage wise application of irrigation water on benefit:cost ratio is shown in [Table-7]. The treatments T₄ and T₃ were found superior over other treatments in terms of growth, yield and fruit quality and recorded the higher benefit:cost ratio (1.57) and (1.54), respectively. Shigurre *et al.* (2002) [17] in acid lime reported the similar results in their study.

Recommendation

For acid lime growing under Western Maharashtra, irrigation at 60:80:60:80:60:80 ER (%) during January to December is recommended for better growth, yield, fruit quality with efficient water use.

Likely beneficiaries of the technology: Growers of acid lime in Maharashtra and adjoining States.

Tirupati centre (Pooled data 2015-16 to 2019-20)

The pooled data 2015-16 to 2019-20 of growth and yield presented in [Table-2] and [Table-3] revealed that, the treatment T₂ *i.e.*, application of irrigation water at 40:60:40:60:40:60 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) recorded

the maximum plant height (3.31 m) and was at par with the treatments T₃ and T₄. The treatment T₄ *i.e.*, application of irrigation water at 80:80:80:80:80:80 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) recorded the maximum yield (84.38 kg/tree and 23.37 t/ha). The treatment T₃ *i.e.*, application of irrigation water at 60:80:60:80:60:80 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) appeared to be the second best treatment for yield (71.24 kg/tree and 19.74 t/ha). Similar fruit yield results were observed in experiments on verna lemon by Sanehez *et al.* (1989) [18], Nagpur mandarin by Shigurre *et al.* (2001b) [19] and in acid lime by Shigurre *et al.* (2004b) [20]. There was non-significant difference between the treatments for canopy volume, number of fruits/tree and fruit weight. The fruit quality data presented in [Table-4] showed that, the treatment T₄ *i.e.*, application of irrigation water at 80:80:80:80:80:80 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) recorded the maximum TSS (8.54 °B) and the treatment T₂ *i.e.*, application of irrigation water at 40:60:40:60:40:60 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) recorded the maximum ascorbic acid (53.35 mg/100 ml juice). Similar data were recorded in earlier studies on irrigation scheduling in Nagpur mandarin by Shigurre *et al.* (2001a) [21] under the central Indian climatic conditions.

Table-7 Economics on effect of stage wise application of irrigation water in acid lime at the Rahuri centre [Produce sold @ Rs. 25,000/tonne]

Treatment	Total Expenditure (Rs/ha)	Yield (t/ha) Pooled mean	Gross monetary return (Rs/ha)	Net Profit (Rs/ha)	B :C ratio
T ₁	1,64,572=00	9.31	2,32,750=00	68,178=00	1.41
T ₂	1,66,634=00	9.79	2,44,750=00	78,116=00	1.47
T ₃	1,69,509=00	10.46	2,61,500=00	91,991=00	1.54
T ₄	1,70,594=00	10.71	2,67,750=00	97,156=00	1.57
T ₅	1,61,678=00	8.62	2,15,500=00	53,822=00	1.33

Table-8 Economics on effect of stage wise application of irrigation water in acid lime at the Tirupati centre [Produce sold @ Rs. 14,000 to 15,000/tonne]

Treatment	Total Expenditure (Rs/ha)	Yield (t/ha) Pooled mean	Gross monetary return (Rs/ha)	Net Profit (Rs/ha)	B:C ratio
T ₁	2,11,500=00	18.16	2,72,400=00	60,900=00	1.29
T ₂	2,12,000=00	19.25	2,88,750=00	76,750=00	1.36
T ₃	2,13,600=00	19.74	2,96,100=00	82,500=00	1.39
T ₄	2,30,400=00	23.37	3,38,865=00	1,08,465=00	1.47
T ₅	2,08,390=00	16.92	2,53,800=00	45,410=00	1.22

There was non-significant difference between the treatments for juice and acidity. The total irrigation water requirement under T₃ (5018 litres/plant/year) was less as compared to that under T₄ (5713 litres/plant/year) [Table-6]. The treatment T₃ saved 695 litres of water per year than the treatment T₄. So, on the basis of water saved and water requirement the treatment T₃ was recommended in acid lime. The reduction in irrigation from 80 ER (%) to 30 ER (%) during any stage resulted in reduction in yield from 23.37 t/ha to 16.92 t/ha.

The treatment T₅ i.e., application of irrigation water at 30:30:30:30:30 ER (%) from Stage-I (Jan-Feb) to Stage-VI (Nov-Dec) recorded the highest WUE (2.84 t/ha cm) [Table-6] and obtained normal yield (16.92 t/ha) by application of less total quantity of irrigation water (2142 litres/plant/year) than all other treatments [Table-6] which presents data on the stage wise water requirement in acid lime.

Economics

The economics of stage wise application of irrigation water on benefit:cost ratio is presented in [Table-8]. The treatments T₄ and T₃ were found superior over other treatments in terms of yield and recorded the higher benefit:cost ratio (1.47) and (1.39), respectively. Barua and Hazarika (2014) [22] reported the similar results in their study on Assam lemon.

Recommendation

For acid lime growing under Andhra Pradesh, irrigation at 60:80:60:80:60:80 ER (%) during January to December is recommended for better growth, yield, fruit quality with efficient water use. Likely beneficiaries of the technology: Growers of acid lime in Andhra Pradesh and its adjoining States.

Conclusion

Considering five-year study of stage wise application of irrigation water, it was recommended that, irrigation at 60:80:60:80:60:80 ER (%) from January to December (T₃) through the drip method is recommended for better growth, yield, fruit quality with efficient water use in both Western Maharashtra and Andhra Pradesh states.

Application of research

To study the effect of stage wise application of irrigation water on growth, yield and fruit quality in acid lime cv. Phule Sharbati and Balaji.

Research Category: Horticulture

Acknowledgement / Funding: Authors are thankful to ICAR-AICRP on Fruits, Department of Horticulture, Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, 413722, MS, India. Authors are also thankful to ICAR-AICRP on Fruits, Citrus Research Station, Tirupati, 517502, Dr.Y.S.R. Horticultural University, Venkataramannagudem, 534101, Andhra Pradesh, India and ICAR-AICRP on Fruits, ICAR-Indian Institute of Horticultural Research, Bengaluru, 560089, Karnataka, India

****Principal Investigator or Chairperson of research: Prof P.S. Pawar and Dr L. Mukunda Lakshmi.**

University: Mahatma Phule Krishi Vidyapeeth, Rahuri, 413722, MS, India

Research project name or number: ICAR-AICRP on Fruits

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: ICAR-AICRP on Fruits, Department of Horticulture, MPKV, Rahuri and Citrus Research Station, Tirupati, 517502, Andhra Pradesh.

Cultivar / Variety / Breed name: Acid lime (*Citrus aurantifolia* Swingle) cv. Phule Sharbati and Balaji

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Ethical Committee Approval Number: Nil

References

- [1] Imas P. (1999) *Recent trends in nutrition management in horticulture crops*, 11-12.
- [2] Smajstrala A.G. (1993) *Hort. Sci.*, 28(4), 295-298.
- [3] Shigurre P.S. (2012) *Scientific J. of Review*, 1(5), 156-169.
- [4] Davies F.S. and Albrigo L.G. (1994) *Citrus*. CAB International, Wallingford, 254.
- [5] Taru A.S., Ranpise S.A. and Pawar P.S. (2020) *J. of Pharma. and Phytochem.*, 9(4), 1597-1600.
- [6] Anonymous (2020) *National Horticulture Database*.
- [7] Growth C.W. (1983) *Proc. Florida State Hort. Soc.*, 96, 23-25.
- [8] Ranganna S. (1988) *Tata McGraw-Hill Pub. Comp. Ltd. New Delhi.*, 881-882.
- [9] Panse V.G. and Sukhatme P.V. (1995) *Statistical methods for Agril. workers*. ICAR, New Delhi.
- [10] Balaganvi S. and Kumathe S.S. (2004) *Karnataka J. of Agril. Sci.*, 17(3), 626-628.
- [11] Shigurre P.S., Srivastava A.K. and Huchche A.D. (2014) *Indian J. of Agril. Sci.*, 84(3), 317-322.
- [12] Shigurre P.S., Srivastava A.K. and Singh S. (2004 a) *Indian J. of Soil Cons.*, 32(2), 148-151.
- [13] Shigurre P.S. and Srivastava A.K. (2013) *Agril. Advances.*, 2(8), 224-236.

- [14] Mageed K.J.A., Sharma B.B. and Sinha A.K. (1988) *Indian J. of Agril. Sci.*, 58(6), 284-286.
- [15] Shrigure P.S., Srivastava A.K. and Singh S. (2003) *Indian J. of Agril. Sci.*, 73(7), 363-367.
- [16] Kumar H., Yadav P. K., Singh A. K. and Sharma S.K. (2013) *The Asian J. of Hort.*, 8, 709-713.
- [17] Shrigure P.S., Srivastava A. K. and Singh S. (2002) *J. of Soil Water Cons.*, 46(1), 56-60.
- [18] Sanehez M.J., Torrecillas A., Leon A. and Del Amor F. (1989) *Pl. Soil*, 120(2), 299-302.
- [19] Shrigure P.S., Srivastava A.K. and Singh S. (2001b) *Indian J. of Agril. Sci.*, 71(8), 547-550.
- [20] Shrigure P.S., Srivastava A.K. and Singh S. (2004b) *Indian J. of Soil Cons.*, 32(1), 32-35.
- [21] Shrigure P.S., Srivastava A.K. and Singh S. (2001a) *Indian J. of Agril. Sci.*, 71(4), 264-266.
- [22] Barua P. and Hazarika R. (2014) *Indian J. of Hort.*, 71(2), 190-196.