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Effect of micro-irrigation and fertigation on growth parameter and fruit yield of acid lime

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Abstract
The experiment was laid out in factorial randomized block design comprised of three levels of irrigation *i.e*. 100, 90 and 80 per cent micro-irrigation of Evp and three levels of fertigation i.e. 100, 80 and 60 per cent RDF with nine treatment combinations replicated thrice to study the effect of micro-irrigation and fertigation on plant growth parameters. The plant growth in respect of plant height and plant spread was found maximum in I_1 (100% micro irrigation at Evp) and in F_1 (100% RDF through fertigation) individually which were at par with I_2 (90% micro irrigation at Evp) and F_2 (80% RDF fertigation) except increment in shoot length. The treatment combinations of irrigation and fertigation were non-significant on these parameters. The significantly highest number of fruits in *hasta bahar* were produced in the irrigation level I_3 (676.6); fertigation level F_1 (688.6) and in combination treatment I_3F_1 (734.2) which were at par with I_2 (664.2); F_2 (671.9) and I_3F_2 (719.5) and I_2F_1 (710.5), respectively during pooled results.

Keywords: acid lime, irrigation, fertigation, growth parameters

Introduction
Acid lime popularly known as Kagzi lime (*Citrus aurantifolia* Swingle) belongs to family Rutaceae with chromosome numbers 2n=18, is an indigenous fruit of our country widely distributed in tropical and subtropical zones. Acid lime has various kinds of uses and nutritional as well as medicinal values. Lime is appetizer, stomachic, antiscorbutic, antihelmintic and it checks biliousness. Due to various uses and the increasing consumer awareness, the demand for lime fruits is constantly increasing. To fulfill this demand, large scale plantations are coming up particularly in Vidarbha region of Maharashtra state. Presently, area under acid lime in Maharashtra is 45000 ha (16.3 per cent) with 306 thousand MT (17.4 per cent) production (Fig. 5) with productivity of 6.4 t ha^{-1} (Anonymous, 2015) [2]. Like mandarin and sweet orange, the acid lime is also sensitive to moisture deficit. Water through suitable irrigation method and nutrient management by proper fertilizer application. Nutrition management is also one of the important aspect for improving the productivity and quality of fruit crops. The knowledge of precise nutrient and water requirement is prerequisite for improved fertilizer and water use efficiency for avoiding unnecessary use of excess fertilizer and water. Hence present investigation was carried out to find out the optimum level of micro-irrigation and fertigation for obtaining higher production and quality of acid lime fruits.

Materials and Methods
The experiment was conducted at All India Co-ordinated Research Project on Fruits, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2012-13 and 2013-14 with twelve years old healthy acid lime plants. The initial soil pH was 7.52, organic carbon 5.1 g kg^{-1}, available N 185.5 kg ha^{-1}, available P 13.02 kg ha^{-1} and available K 380.5 kg ha^{-1}. The experiment was laid out in factorial randomized block design (RBD) with four replications and three adjacent trees in a row per replication. The treatments comprised of three levels of micro-irrigation (I_1-100, I_2-90 and I_3-80% Evp) and three levels of fertigation (F_1-100, F_2-80 and F_3-60% RDF) in nine treatment combinations replicated thrice.
For all the above treatments water stress i.e. *Bahar* treatment was imposed to induce the maximum flowering in *Hasta Bahar*. The stress was given by withholding the irrigation for one month from first of September to first of October in both the years.

But, due to rains received in between the stress period, the stress period was further extended till fifteenth of October in both the years of experiment. The spraying of plant growth regulators and micronutrients was done as per the following recommended schedule during both the years of experimentation (2012-13 and 2013-14).

A ring of drip lateral with suitable number of drippers of equal discharge rate (8 lph) was installed around each tree. For treatment I_1- 10 drippers, for treatment I_2- 9 drippers and for treatment I_3- 8 drippers were installed at equal distance in the ring so that, the irrigation regimes of 100, 90 and 80 per cent of evaporation replenishment would have been achieved within single operation. For drip irrigation quantity of water to be applied was calculated by the following formula (FAO, 1998, Palve, 2012) [1, 7].

Water requirement (Q) = A x Epan x Kp x Kc

Where,

Q is the water requirement of plant (liters $day^{-1}plant^{-1}$), A is area of each plant (6 m x 6 m), Epan is pan evaporation (mm day^{-1}) Kp is pan coefficient i.e. 0.8 (Deshmukh and Wadatkar, 2011), Kc is crop coefficient i.e. 0.7 for citrus crop (Allen *et al.*, 1998) [1].

The quantity of water in litres per day per plant was computed by the formula which was applied to irrigate the plant as per the treatment. The irrigation water was applied at alternate day considering the total evaporation during the interval gap. During the rainy days, the watering was done taking into account the amount of rainfall (mm) received. But, during the heavy rainfall and continuous rainy days, the irrigation was withhold for 72 hours so as to bring down the excess water in the soil to the field capacity level. Further, again the irrigation water was applied by considering the evaporation rate.

Table 1: Split doses of fertilizer applied with micro irrigation

Quantity of fertilizer through fertigation at each stage									
Split	**F_1 (100%)**			**F_2 (80%)**			**F_3 (60%)**		
	N (g)	**P (g)**	**K (g)**	**N (g)**	**P (g)**	**K (g)**	**N (g)**	**P (g)**	**K (g)**
1st October	150	75	60	120	60	48	90	45	36
2nd November	150	75	60	120	60	48	90	45	36
3rd December	120	60	60	96	48	48	72	36	36
4th January	120	60	60	96	48	48	72	36	36
5th February	60	30	60	48	24	48	36	18	36
Total (g)	600	300	300	480	240	240	360	180	180

The height of observational plant was measured from ground level to the growing tip with the help of marked bamboo. The plant height was measured twice, first before the start of experiment as initial and final i.e. at the end of experiment and it was recorded as plant height in meter. The plant spread was measured twice, first before the start of experiment as initial and after harvesting i.e. at the end of experiment. The plant spread was measured with the help of meter tape along East-West and North-South directions and recorded as mean plant spread in meter. An increment in plant spread over the previous year was computed by subtracting the previous year's plant spread from the current year plant spread. The fruits harvested from an observational plant were counted at each harvest. The total number of fruits of all pickings were counted together and recorded in numbers as of fruits per plant.

The recommended dose of fertilizer (RDF) 600 g N, 300 g P_2O_5 and 300 g K_2O per tree per year was applied with water soluble fertilizers and for fulfilling the nutrients requirement the fertilizers viz. urea (46% N), 19:19:19, phosphoric acid (27% P), sulphate of potash(50% K) were used to quantify the dose of N, P and K in the splits.

For all the above treatments water stress i.e. *Bahar* treatment was imposed to induce the maximum flowering in *Hasta Bahar*. The stress was given by withholding the irrigation for one month from first of September to first of October in both the years. But, due to rains received in between the stress period, the stress period was further extended till fifteenth of October in both the years of experiment. The spraying of plant growth regulators and micronutrients was done as per the following recommended schedule during both the years of experimentation (2012-13 and 2013-14).

Results and Discussion

The result revealed that, the plant height showed non-significant response to irrigation levels during the year 2012-13. However, in the year 2013-14, the significant effect of irrigation levels on plant height of acid lime was observed (Table 2). The irrigation level I_2 (90% irrigation of Evp) had recorded the maximum plant height (3.86 m) and it was closely followed by and at par with the treatment I_1 (100% irrigation of Evp) (3.85 m). The various fertigation levels noted the significant response on the plant height during both the years of experimentation. The fertigation level F_1 (100% RDF fertigation) produced the maximum plant height (3.71 and 3.92 m in 2012-13 and 2013-14, respectively) followed by the fertigation treatment F_2 (80% RDF fertigation) (3.68 and 3.87 m in 2012-13 and 2013-14, respectively) which was at par with each other.

The data pertaining to the plant height showed non-significant response to an interaction of irrigation and fertigation levels during both the years of experiment. Shirgure *et al.* (2003) [12] observed a significant response of irrigation and fertigation on acid lime plant height and the response was more in 30 per cent depletion of available water with 500:140:70 g NPK g $tree^{-1}$ through fertigation.

The data revealed that, an incremental plant height (Table 2) had shown the significant response to irrigation and fertigation levels during both the years of experimentation (2012-13 and 2013-14). The irrigation level I_1 (100% irrigation of Evp) produced significantly the maximum increment in plant height (0.19 m) over rest of the irrigation levels in 2012-13. During 2013-14, an increment in plant height (0.20 m) was significantly maximum due to the irrigation treatment I_1 (100% irrigation of Evp) however it was (0.19 m) statistically at par with the irrigation level I_2 (90% irrigation of Evp). Among the fertigation levels, the fertigation treatment F_1 (100% RDF fertigation) gave the maximum increment in plant height (0.19 and 0.21 m in 2012-13 and 2013-14, respectively) and it was found to be at par with its lower level F_2 (80% RDF fertigation) (0.17 and 0.19m, respectively during the years 2012-13 and 2013-14).

The result further revealed that, an incremental plant height had shown non-significant response to an interaction of

irrigation and fertigation levels during both the years of the experiment (2012-13 and 2013-14) and an increment was ranging from 0.22 and 0.24 m (I_1F_1) to 0.11 and 0.11 m (I_3F_3), respectively. Panigrahi and Srivastava (2011) [8] observed increase in plant height with increasing levels of irrigation and fertigation. Similar findings were also recorded by Ramniwas *et al.* (2012) [9] and Kumar *et al.* (2013) [6].

Irrigation level of I_1 (100% irrigation of Evp) produced significantly the maximum plant spread (4.31 and 4.52 m, respectively) for both the years of experimentation (Table 2) and it was observed to be at par with the irrigation level I_2 of 90% irrigation of Evp (4.28 and 4.49 m, respectively) during the years 2012-13 and 2013-14. Amongst the fertigation levels, the fertigation level F_1 (100% RDF) recorded significantly maximum plant spread i.e. 4.32 and 4.55 m, respectively for the first and second year of experiment however, which was at par with the fertigation level F_2 i.e. 4.30 and 4.50 m, respectively). The results further indicated that, the plant spread had not shown significant response to an interaction of irrigation and fertigation levels and the values recorded for plant spread were ranging from 4.37 (I_1F_1 and I_2F_1) to 4.04 m (I_3F_3) in 2012-13 and 4.62 (I_1F_1) to 4.20 m (I_3F_3) during the year 2013-14.

Table 2: Effect of micro-irrigation and fertigation on height and plant spread of acid lime plant

Treatment	Plant height (m)		Incremental height (m)		Plant spread (m)		Incremental spread (m)	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Irrigation								
I_1 : 100% Evp	3.65	3.85	0.19	0.20	4.31	4.52	0.20	0.21
I_2 : 90% Evp	3.68	3.86	0.16	0.19	4.28	4.49	0.18	0.21
I_3 : 80% Evp	3.55	3.71	0.13	0.15	4.17	4.34	0.11	0.16
F test	NS	Sig	Sig	Sig	Sig	Sig	Sig	NS
SE (m) ±	0.047	0.040	0.009	0.010	0.036	0.034	0.029	0.009
CD @ 5%	---	0.135	0.028	0.030	0.108	0.103	0.088	---
Fertigation								
F_1 : 100% RDF	3.71	3.92	0.19	0.21	4.32	4.55	0.19	0.22
F_2 : 80% RDF	3.68	3.87	0.17	0.19	4.30	4.50	0.18	0.20
F_3 : 60% RDF	3.49	3.63	0.13	0.13	4.13	4.30	0.12	0.16
F test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE (m) ±	0.047	0.0449	0.009	0.010	0.036	0.034	0.017	0.009
CD @ 5%	0.140	0.134	0.028	0.030	0.108	0.103	0.051	0.028
Irrigation X Fertigation								
I_1F_1	3.76	4.00	0.22	0.24	4.37	4.62	0.24	0.25
I_1F_2	3.81	4.00	0.20	0.19	4.33	4.54	0.22	0.21
I_1F_3	3.40	3.55	0.14	0.15	4.22	4.40	0.15	0.18
I_2F_1	3.68	3.90	0.21	0.22	4.37	4.61	0.20	0.24
I_2F_2	3.77	3.96	0.16	0.19	4.33	4.57	0.19	0.24
I_2F_3	3.58	3.72	0.12	0.14	4.14	4.30	0.13	0.16
I_3F_1	3.69	3.87	0.14	0.18	4.24	4.41	0.13	0.17
I_3F_2	3.47	3.65	0.13	0.18	4.25	4.40	0.12	0.16
I_3F_3	3.50	3.61	0.11	0.11	4.04	4.20	0.09	0.16
F test	NS	NS	NS	NS	NS	NS	NS	NS
SE (m) ±	0.081	0.077	0.016	0.017	0.063	0.059	0.030	0.016
CD @ 5%	---	---	---	---	---	---	---	---

The significantly maximum increase in plant spread (0.19 and 0.22 m, respectively for first and second year) was noticed with the fertigation level F_1 (100% RDF fertigation) and it was appeared to be at par with the fertigation level F_2 (80% RDF fertigation) by recording the plant spread 0.18 and 0.20 m, respectively during the years 2012-13 and 2013-14. The result in respect of an interaction for incremental plant spread due to the irrigation and fertigation levels was noted to be non-significant by recording the values ranging from 0.24 (I_1F_1) to 0.09 m (I_3F_3) and 0.25 (I_1F_1) to 0.16 m (I_2F_3, I_3F_2 and I_3F_3), respectively during both the years of experiment. The sufficient moisture coupled with macro nutrients resulted in more uptake of nutrients and water in plant might have helped in enhanced growth of plant due to more photosynthesis avoiding the excess of water in root zones. These observations are in accordance with those of Chauhan *et al.* (2006) [3] who reported that, the maximum plant spread was noticed with the application of 66 per cent of fertigation as compared with 100, 50 and 33 per cent of N, P and K through fertigation. Similar results also reported by Panigrahi and Srivastava (2011) [8], Shirgure *et al.* (2001) [11] in Nagpur mandarin and Shirgure *et al*. (2003) [12] in acid lime.

Data emerged in respect of number of fruits in *Hasta bahar* is presented in Table 3. The result clearly indicated that, the fruits in *Hasta bahar* were significantly influenced due to the irrigation and fertigation levels separately and in combination during both the years of experimentation and in pooled result too. As evident from the pooled data, significantly the maximum fruits (676.6) were produced under the irrigation level I_3 which were followed by the irrigation level I_2 (664.2) and found to be at par with each other. The significantly higher fruits (625.4, 751.4 and 688.6, respectively) were harvested during the years 2012-13, 2013-14 and in pooled result from the fertigation level F_1 which was followed by the fertigation level F_2 (615.8, 728.0 and 671.9, respectively) and which were at par with each other.

Significantly higher fruits (682.3) were produced in the year 2012-13 due to an interaction of irrigation and fertigation levels I_3F_1, which were followed by an interaction of the irrigation and fertigation levels I_3F_2 (669.0) and I_2F_1 (636.7) which were found to be at par with each other. During the *Hasta bahar* the water requirement for the growth and metabolic activity was less due to the low total evaporation during the October to February, which might have favoured

the higher number of fruits due to less evapotranspiration demand thus, lower levels of irrigation have produce more number of fruits. Further, the higher level of irrigation produces more vegetative growth as compared to reproductive growth and vice a versa. Shirgure *et al.* (1999) [10] reported higher number of fruits at 80 per cent N in acid lime. This is in conformity with the results reported by Srinivas *et al.* (2010) [14], Panigrahi and Srivastava (2011a) [8] who reported significantly higher fruits per plant at 75 per cent irrigation and fertigation individually and in combination. Similar results were also observed by Kumar *et al.* (2013) [6] and Shirgure *et al.* (2014) [13]. Results of the experiment also demonstrated that micro-irrigation and fertigation are remunerative technologies for acid lime cultivation. This conclusion is based on two years study; hence, suggestive more research is required for confirmation.

Table 3: Effect of micro-irrigation and fertigation on no. of fruits and fruit yield per plant of *Hasta bahar* in acid lime

Treatment	Fruits plant^{-1}		
	2012-13	2013-14	Pooled
Irrigation			
I_1 : 100% Evp	542.6	651.3	596.9
I_2 : 90% Evp	603.3	725.1	664.2
I_3 : 80% Evp	624.2	729.2	676.7
F test	Sig	Sig	Sig
SE (m) ±	10.22	11.57	7.45
CD @ 5%	30.64	34.68	21.85
F_1 : 100% RDF	625.7	751.4	688.6
F_2 : 80% RDF	615.8	728.0	671.9
F_3 : 60% RDF	528.7	626.2	577.4
F test	Sig	Sig	Sig
SE (m) ±	10.22	11.57	7.45
CD @ 5%	30.64	34.68	21.85
I_1F_1	558.0	684.0	621.0
I_1F_2	549.7	648.3	599.0
I_1F_3	520.0	621.7	570.8
I_2F_1	636.7	784.3	710.5
I_2F_2	628.7	765.7	697.2
I_2F_3	544.7	625.3	585.0
I_3F_1	682.3	786.0	734.2
I_3F_2	669.0	770.0	719.5
I_3F_3	521.3	631.7	576.5
F test	Sig	Sig	Sig
SE (m) ±	17.7	20.04	12.9
CD @ 5%	53.06	60.07	37.84

References

1. Allen RG, Pereira LS, Dirk R, Martin S. FAO guidelines for computing crop water requirement, irrigation and drainage paper 56, FAO, UN, Rome, 1998.
2. Anonymous. 2015. Indian Horticulture Database, 2015. NHB. Gurgaon., at http://nhb.gov.in
3. Chauhan PS, Sharma LK. Rana SS. Study on effect of NPK fertigation levels on growth, fruiting, fruit quality and leaf nutrient status of Red fuji and Scarlet gala apple cultivars in high density plantation, In Temperate Horticulture: Current Scenario. Kishore, D. K, S. K. Sharma and K. K. Pramanik, (eds.) New India publishing agency, New Delhi. 2006, 237-244.
4. Deshmukh MM, Wadatkar SB. Determination of pan coefficient for Akola. PKV Res. J. 2011; 35(1):40-49.
5. FAO. Guidelines for Computing Crop Water Requirement, Irrigation and Drainage, Rome, UN, Paper 1998, 56.
6. Kumar HP, Yadav Y, Singh AK, Sharma SK. Evaluation of water regime and fertigation on growth, yield and economics of sweet orange (*Citrus sinensis* Osbeck) cv. mosambi. Asian J Hort. 2013; 8(2):709-713.
7. Palve DB. Response of garlic to different irrigation systems. M. Tech. (IDE) Thesis (unpub): 34, Dept. IDE., Dr PDKV. Akola, 2012.
8. Panigrahi P, Srivastava AK. Integrated use of water and nutrients through drip irrigation in Nagpur Mandarin. J Agri. Eng. 2011; 48(3):44-51.
9. Ramniwas RA, Kaushik DK, Sarolia Pareek S, Singh V. Effect of irrigation and fertigation scheduling on growth and yield of guava (*Psidium guajava* L.) under meadow orcharding. African J Agricultural Research. 2012; 7(47):6350-6356,
10. Shirgure PS, Lallan Ram, Singh, S, Marathe RA., Yadav RP. Effect of nitrogen fertigation on vegetative growth and leaf nutrient content of acid lime (*Citrus aurantifolia* Swingle) in Central India. Indian J Soil Cons. 1999; 27(1):45-49.
11. Shirgure PS, Srivastava AK, Singh S. Effect of pan evaporation based irrigation scheduling on yield and quality of drip irrigated Nagpur mandarin (*Citrus reticulate*). Indian J Agric. Sci. 2001; 71(4):264–266.
12. Shirgure PS, Srivastava AK, Singh S. Irrigation scheduling and fertigation in acid lime (*Citrus aurantifolia*). Indian J Agric. Sci. 2003; 73(7):63-367.
13. Shirgure PS, Srivastava AK, Huchche AD. Water requirements in growth stages and effects of deficit irrigation on fruit productivity of drip irrigated Nagpur mandarin (*Citrus reticulata*). Indian J Agric. Sci. 2014; 84(3):317-322.
14. Srinivas K, Sulladmath VV. Palaniappan R, Venugopalan R. Plant water relations, yield and nutrient content of passion fruit in relation to evaporation replenishment and fertigation. Indian J Hort. 2010; 67(3):289-292.