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Research Paper

Effects of pan evaporation-based drip irrigation levels on performance of guava grown in Udaipur and Rewa regions of India

S.S. LAKHAWAT[1], VIKAS SHARMA[2], T.K. SINGH[3], PRAKASH PATIL[4], S. PRIYADEVI[4] and S. GUTAM[4]

[1]Department of Horticulture, Maharana Pratap University of Agriculture and Technology, Udaipur-313001, Rajasthan, India
[2]Department of Soil and Water Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur-313001, Rajasthan, India
[3]Fruit Research Station, Rewa, JNKV, Jabalpur, Madhya Pradesh, India
[4]Project Coordination Cell, ICAR-AICRP on Fruits, ICAR-IIHR, Hessaraghatta, Bengaluru - 560089, Karnataka, India
[*]Corresponding author email: lakhawatss@gmail.com

ABSTRACT

A field experiment was conducted for three years (2019-20, 2020-21 and 2021-22) on 4 years old guava orchard established at 3×2 m spacing with drip irrigation treatments at two locations viz. Udaipur, Rajasthan and Rewa, Madhya Pradesh. Plant growth, yield contributing parameters, fruit yield and water use efficiency was significantly affected by different pan evaporation-based drip irrigation levels (70, 80, 90 & 100% of Epan) over local control. In existing climatic conditions of Udaipur and Rewa regions, the daily irrigation water requirement of high-density planting guava tree was varied from 7.8 to 26.3 and 4.5 to 26.5 liter/plant/day, respectively. Among all the pan evaporation-based drip irrigation levels, the irrigation supplied at 80% and 90% of daily pan evaporation were found as best approach for irrigating high density plantation (HDP) guava orchard through drip irrigation in Udaipur & Rewa regions with maximum fruit yield (37.3 & 30.7 t ha^{-1}), irrigation water use efficiency (0.359 & 0.263t ha^{-1}-cm) along with significant water saving (29.2 & 22.2%), respectively over local control. Results will help farmers, policy makers and irrigation managers to conserve available fresh water resources in water scares regions of Rajasthan and Madhya Pradesh.

Keywords: Crop evapotranspiration (ETc), Drip irrigation, Guava, High density panting (HDP), and Water use efficiency

Guava (*Psidium guajava* L.) belongs to Myrtaceae family, which is a popular fruit crop in Southern Rajasthan and North-Eastern Madhya Pradesh. It is easily available at cheaper cost in local markets and contains high nutritive value so it is also known as “apple of tropics” and “poor man’s fruit” (Kumar *et al.,* 2009). The standard spacing of planting guava is 6 m x 6 m which contain 112 plants/acre but due to their growth style, there is an opportunity to plant more number of plants per unit land area, which is mainly known as high density panting (HDP) of guava orchard. This planting pattern will not only produce high yield but also promote efficient utilization of available cultivatable land (Reddy, 2014). HDP can give high productivity (yield per unit area) by utilizing appropriate pruning techniques and effective nutrition and irrigation water management strategies (Mehta *et al*., 2012). Water is an indispensable natural resource and plays an important role to grow fruit crops in agriculture sector. The available fresh water resources are limited and depleting at very high rate (Sharma *et al*., 2021), which results water scarcity. In different states of India, conventional irrigation methods are widely used to supply irrigation water in orchards but they result in huge wastage of irrigation water by evaporation, leaching and conveyance losses. The overall efficiency of flood irrigation is considerably poor (33%) which indicate that 67% of the total irrigation water is wasted and ineffectual (Singh *et al*., 2019), so effective irrigation water management through modern irrigation techniques is one of the pathways to conserve irrigation water as well as to sustain fruit production with higher water use efficiency.

Drip irrigation (DI) is basically a modern irrigation method by which precious amount of irrigation water can supply directly near to the effective plant root zone in the form of droplets.

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DI method improves crop yield up to 30% and water saving up to 60% as compared to traditional irrigation methods (Singh *et al*., 2019). Scheduling water application is also a challenging task under drip irrigation, as over irrigation decreases yield, while inadequate irrigation results water stress and reduces plant growth and overall production (Changade *et al.*, 2023). In climate change scenario, the climatological approach of irrigation scheduling is quite comprehensive (Satpute *et al*., 2021) and is based on daily water loss from soil as well as plant canopy. In this approach, daily irrigation water requirement can be estimated by using evapotranspiration data (Saxena *et al.,* 2020). Kumar *et al.,* (2008) have seen maximum canopy volume by applying irrigation water equivalent to 75% of daily pan evaporation over control. Deficit irrigation refers to the application of irrigation water below the actual crop water requirements, either during the full growing period of crop or at some specific growth stages. It seems that in water scare regions, deficit irrigation can play an important role to conserve available irrigation water resources. In the water scarcity regions of Rajasthan and Madhya Pradesh, some farmers are reluctant to use drip irrigation technique due to lack of knowledge on irrigation scheduling for guava crop. In order to overcome this problem, the application of irrigation water by drip irrigation in relation to the quantity of water evaporated from a Class A pan evaporimeter would be a convenient approach to schedule irrigation for guava, as these pan evaporation data are easily available in most farming areas. Hence, this present study was undertaken.

MATERIAL AND METHODS

Experiment details

A field experiment was conducted for three years (2019-20, 2020-21 and 2021-22) at two locations (i) Rajasthan College of Agriculture, MPUAT Udaipur (Latitude 24° 35'31.5" N, Longitude 73°44'18.2" E, Altitude 582.17 m AMSL) and (ii) Fruit Research Station, Rewa, Madhya Pradesh (Latitude 24° 31' 50.6172" N, Longitude 81° 17' 56.7960" E and Altitude 304 m AMSL). In this study, 4 years old high-density plantation (HDP) guava plants established at 3×2 m spacing were undertaken for irrigation treatments from Oct, 2019 onwards. The varieties of guava were selected as Sardar for Udaipur and Allahabad Safeda for Rewa. The experiment was conducted in random block design with five treatments and six replications. The treatments were comprised of

T_1: Irrigation at 70% Epan,

T_2: Irrigation at 80% Epan,

T_3: Irrigation at 90% Epan

T_4: Irrigation at 100% Epan, and

T_5: Local control

In the first four treatments the irrigation water was supplied through drip irrigation as per daily irrigation water requirement of guava plant which was calculated on the basis of daily pan evaporation (Epan) data. While in treatment T_5, irrigation was done as per local calendar schedule through flood irrigation.

Calculation of crop water requirement

The pan evaporation and effective rainfall during the crop period was acquired from the meteorological observatory located at both centers. The crop evapotranspiration (ET_c) was calculated separately from pan evaporation (E_{Pan}), pan coefficient with the help of crop coefficient (K_c) using Eq.1.The pan coefficient (K_p) for calculating crop evapotranspiration by using pan evaporation data was taken as 0.8 (Sharma *et al*., 2021). Further the estimation of daily crop water requirement was done by using Eq. 2, for fixation of irrigation scheduling of guava orchard.

$$ET_C = E_{pan} \times \mathbf{K}_p \times K_C \quad (1)$$

$$V = \sum (Ep \times Kp \times Kc \times Sp \times Sr \times WP + ER) \quad (2)$$

Where,

V = estimated crop water requirement at 100% water use scheduling, liter/day/plant, Epan = Pan Evaporation, mm, Kp = Pan coefficient, Kc = Crop coefficient, Sp = Plant to plant spacing, m, Sr = Row to row spacing, m, WP = Percentage wetted area, 90%, ER = Effective rainfall, mm

In this study, based on USDA S.C.S method the effective rainfall (ER) was calculated on monthly basis by following equation (Sharma *et al*., 2021):

$$ER = P_t \left[\frac{125-0.2\times Pt}{125} \right] \text{ for } Pt < 250 \text{ mm}$$

Where, P_t - total rainfall (mm)

Crop observation

The plant height and girth were measured at the end of each growing year while the data related to number of fruits per tree, fruit weight (g) and yield (t ha^{-1}) were taken at the time of each harvesting. The daily irrigation water requirement, irrigation water saving, and water use efficiency were calculated for analyzing the best irrigation level in HDP guava orchard under drip irrigation. The data were analyzed statically through software.

RESULT AND DISCUSSION

Pan evaporation (Epan), crop evapotranspiration (ETc) and irrigation water requirement (IWR) of guava

The daily pan evaporation (Epan), crop evapotranspiration (ETc) and irrigation water requirement (IWR) calculated for three years for both the locations were averaged over the years and mean data are presented in Table 1. In Udaipur and Rewa, the maximum pan evaporation was recorded as 11.09 and 10.2 mm/day, respectively during the month of May while it was recorded minimum as 2.3 and 2.1 mm/day, respectively during the month of December. In Udaipur and Rewa, the crop evapotranspiration was recorded maximum as 6.3 and 8.9 mm/day during June and May months, respectively. In Udaipur, the variation in average daily irrigation water requirement was found as 7.8 to 26.3 liter/plant/day during growing whole growing season while in Rewa, the variation in average daily irrigation water requirement was noted as 4.5 to

Table 1: Average daily pan evaporation, crop evapotranspiration and irrigation water requirement (on the basis 100% of E_{pan}) during different months and growing years (3-years pooled data).

Months	Pan evaporation (mm/day)		Crop evapotranspiration (mm/day)		Irrigation water requirement (Liter/plant/day)	
	Udaipur	Rewa	Udaipur	Rewa	Udaipur	Rewa
January	2.5	3.0	1.8	2.4	10.7	9.2
February	3.3	3.1	2.6	2.5	14.8	9.3
March	6.4	6.5	5.1	4.2	26.3	15.7
April	8.8	8.0	5.6	6.1	23.3	11.4
May	11.0	10.2	8.0	8.7	18.2	17.7
June	8.7	9.2	6.3	7.4	25.3	26.5
July	6.7	6.4	5.2	4.1	24.7	14.7
August	3.9	5.3	2.8	3.5	8.2	8.8
September	3.5	4.1	2.7	2.9	11.1	12.2
October	4.5	3.9	2.6	2.8	18.6	10.5
November	3.2	3.0	2.6	2.2	13.1	4.5
December	2.3	2.1	1.5	1.4	7.8	5.2
Total (mm)	1978.3	2008.8	1425.8	1494.2	6265.1	4516.7

26.5 liter/plant/day. The pooled data indicated that in Udaipur, the irrigation water requirement was found minimum as 7.8 liter/plant/day during December and maximum as 26.3 liter/plant/day during March while in Rewa, the irrigation water requirement was found minimum as 4.5 liter/plant/day during November and maximum as 26.5 liter/plant/day during June (Table 1). In case of both the locations, the daily pan evaporation was recorded relatively higher in April and May months as compared to March but due to pruning of high-density guava plant, the correspond wetted fraction was recorded less which result less amount of daily irrigation water (liter/plant/day). Result clearly indicates that, the maximum volume of irrigation water is needed during the flowering and fruit setting stage and comparatively less amount of water needed in initial and maturity stage.

Effect of various treatments on growth parameters of guava plant

The data presented in Table 2 indicates the effects of different pan evaporation-based irrigation levels on plant height and girth. The plant height and plant girth were significantly affected by drip irrigation (except treatment T_4) over flood irrigation. Further the various pan evaporation-based irrigation levels were also significantly affecting the growth parameters of guava plant under drip irrigation. Among all treatments, the plant height and plant girth at Udaipur location was recorded maximum as 4.21 m and 35.23 cm respectively under treatment T_3 (Irrigation at 90% Epan) and minimum as 3.50 m and 27.50 cm, respectively under treatment T_1 (Irrigation at 70% Epan) while at Rewa location, the plant height and plant girth was recorded maximum as 3.98 m and 25.03 cm under treatment T_3 (Irrigation at 90% Epan) and minimum as 3.55 m and 18.02 cm, respectively under treatment T_5 (Irrigation as per local control) which is clearly indicates that, the severe water stress (irrigation at 70% of Epan) reduces significant growth of guava plant under drip irrigation in climatic condition of Udaipur and Rewa respectively. The similar finding for guava was reported by Mehta *et al.,* (2012). The plant growth was significantly superior in drip irrigation as compared to flood irrigation. It was probably due to that, in drip irrigation treatments the precise amount of irrigation water was applied slowly which results more availability of moisture content in effective root zone of guava plant, more infiltration time and minimum irrigation water losses which occurs through surface evaporation, deep percolation and seepage.

Effect of various treatments on yield and yield contributing parameters of guava plant

The number of fruits per tree, fruit weight (g) and fruit yield/hectare were significantly affected by different pan evaporation-based drip irrigation level over flood irrigation (where irrigation was as per calendar schedule) at both the locations (Table 2). Among all treatments in Udaipur, the number of fruits per tree, average fruit weight (g) and fruit yield per hectare were recorded maximum as 90.17, 243.35 gm and 37.30 t ha^{-1}, respectively under treatment T_2 (Irrigation at 80% Epan) followed by treatment T_3 and minimum as 56.89, 195.83 g and 18.69t ha^{-1}, respectively under treatment T_1 (Irrigation at 70% Epan) whereas in Rewa, the number of fruits per tree, average fruit weight (g) and fruit yield per hectare were recorded maximum as 90.00, 205.00 gm and 30.74 t ha^{-1}, respectively under treatment T_3 (Irrigation at 90% Epan) followed by treatment T_4 and minimum as 65.00, 175.00 g and 18.95 t ha^{-1}, respectively under treatment T_5 (local control). Results indicates the significant reduction in yield contributing parameters and fruit yield of guava under drip irrigation by supplying irrigation water at high deficit irrigation level (30% water deficit from full irrigation) in both the selected study areas. In case of the same level of drip irrigation, the difference in fruit yield at both the stations might be due to variety of plant to a certain extent. Furthermore, the performance of guava plant was found better in drip irrigation plot as compared to

Table 2: Yield and yield contributing parameters of guava plant under different treatments (3-years pooled data)

Treatment	Plant height (m)		Plant girth (cm)		Number of fruits per tree		Average fruit weight (g)		Fruit yield (t ha^{-1})	
	Udaipur	Rewa	Udaipur	Rewa	Udaipur	Rewa	Udaipur	Rewa	Udaipur	Rewa
70% E_p	3.5	3.9	27.5	22.3	56.8	70.0	195.8	180.0	18.6	20.9
80% E_p	4.0	3.5	30.1	21.0	90.1	68.0	245.3	176.0	37.3	20.9
90% E_p	4.2	3.9	35.2	25.0	81.8	90.0	233.4	205.0	32.1	30.7
100% E_p	3.6	3.5	31.9	21.2	75.0	72.0	224.1	195.0	28.3	23.3
Local control	3.6	3.5	30.9	18.0	71.7	65.0	205.9	175.0	24.8	18.9
CD at 5 %	0.2	0.4	1.8	0.9	1.61	1.6	12.7	3.8	3.4	1.1
CV (%)	8.3	9.3	9.0	13.0	4.55	4.5	8.6	9.0	18.0	8.3

Table 3: Irrigation water requirement and irrigation water saving under different treatments (3-years pooled data)

Treatment	Total irrigation water applied (mm)		Irrigation water saving over control (%)		Crop water requirement* (mm)		Irrigation water use efficiency (t ha^{-1}-cm)	
	Udaipur	Rewa	Udaipur	Rewa	Udaipur	Rewa	Udaipur	Rewa
70% E_p	908.4	925	38.1	39.5	1698.8	2002.0	0.205	0.230
80% E_p	1038.2	1057	29.2	30.9	1828.5	2134.0	0.359	0.201
90% E_p	1168.0	1189	20.4	22.2	1958.3	2266.0	0.275	0.263
100% E_p	1297.8	1322	11.5	13.6	2088.1	2399.0	0.218	0.180
Local control	1464.5	1530			2254.8	2333.0	0.169	0.123

*Crop water requirement = IWR+ ER

flood irrigation but further selection of appropriate pan evaporation-based irrigation level under drip irrigation plays an important role for optimizing the fruit yield. In HDP guava orchard, water act as a main input in photosynthesis process of the plant, as compared to flood irrigation the adoption of drip irrigation technique gives significant water saving but further the severe reduction in irrigation water level under drip irrigation can reduce photosynthesis rate and fruit yield. Sharma *et al*. (2021) has already reported 43% higher yield under drip irrigation method over flood irrigation for okra crop.

Irrigation water requirement and water saving under various treatments

As per pooled data, the total ER for Udaipur and Rewa was recorded as 790.3 and 1017 mm/year, respectively which was considered for calculating total crop water requirement of HDP guava. The pooled data presented in Table 3 shows that, the total amount of irrigation water supplied was maximum as 1464.5 and 1530 mm for Udaipur and Rewa, respectively for control plot and minimum as 908.4 and 925 mm for Udaipur and Rewa, respectively for treatment T_1 (70% of Epan). In Udaipur, the irrigation water saving over control under drip irrigation was found maximum as 38.1 % under T_1 followed by T_2 (29.2%) and T_3 (20.4%) over control while for Rewa, it was found maximum as 39.5% under T_1 followed by T_2 (30.9%) and T_3 (22.2%). It is due to the fact that, under drip irrigation precise application of irrigation water (on the basis of daily crop need) was supplied which result less wastage of irrigation water. The maximum crop yield and water use efficiency were found as 37.3 t ha^{-1} and 0.359 t ha^{-1}-cm respectively under treatment T_2 (irrigation at 80% Epan) for Udaipur Rajasthan. The maximum crop yield and water use efficiency were found as 30.7 t ha^{-1} and 0.263 t ha^{-1}-cm respectively under treatment T_3 (irrigation at 90% Epan) for Rewa. It was because of optimum moisture content in plant root zone as well as less water losses due to infiltration and seepage. The irrigation water use efficiency was minimum as 0.169 and 0.123t ha^{-1}-cm under control for Udaipur and Rewa, respectively. It is because of wastage of irrigation water which occurred due to evaporation losses, seepage and infiltration (on visual basis). It was found that, a pan evaporation-based approach in severe level of water deficit (70% of Epan or water stress i.e 30 as compared to full irrigation level) could save maximum amount of irrigation water but it will result less growth, yield and water use efficiency over local control.

Scheduling irrigation for getting high fruit yield and water use efficiency for guava orchard is a challenging task in climate change scenario (Sharma *et al*., 2021). Now a days, in India the most of the growers are using water balance method (on the basis of soil moisture depletion) for scheduling the irrigation for drip irrigated crops (Sharma *et al.,* 2021) but this approach gives a general idea of irrigation scheduling. Hence, the selected pan evaporation-based irrigation scheduling is quite comprehensive for drip irrigated guava orchard grown under existing climatic conditions of both the selected area. The results are in line with Satpute *et al*., (2021) who have suggested the feasibility of climatological approaches of irrigation scheduling for different crops. The pan evaporation-based irrigation levels comprise the daily water loss from soil as well as plant canopy under given climatic conditions. The FAO-

56 Penman-Monteith equation is weighed for accurate estimation of daily water loss from soil as well as plant canopy (Saxena *et al*., 2020). The results obtained from previous studies shows that, there is no bound method to estimate daily water loss from soil as well as plant canopy. Some methods require more weather data but accepted as accurate, other require less data but considered as approximate (Meshram *et al*., 2010). The calculation of daily crop water demand for drip irrigated guava plant under limited availability of climatic parameters has led to standardize the pan evaporation-based irrigation levels in both study areas. Overall, the outcome of this study i.e selection of optimum pan evaporation-based irrigation levels for drip irrigated guava orchard will give valuable input to raise agricultural water management strategies for batter fruit production and more irrigation water use efficiency.

CONCLUSION

The present study was undertaken to assess the optimum pan evaporation-based irrigation level for irrigating the HDP guava in given climatic conditions of selected study areas. It can conclude that, for both the selected areas, the adoption of the pan evaporation based approach of irrigation scheduling for irrigating HDP guava orchard under drip irrigation will surely enhance the plant height by 12 to 14%, plant girth by 13 to 37%, number of fruits per tree by 25 to 38%, average weight of fruit by 17 to 18%, fruit yield/hectare by 50 to 62% and simultaneously gives significant irrigation water saving (up to 38.1 and 39.5 %) over conventional method of irrigation (local control). In both regions, the severe water deficit (where irrigation amount will be 30% less from full irrigation water requirement) could save more amount of irrigation water but results less plant growth, yield and water use efficiency as compared to other drip irrigation levels for drip irrigated HDP guava orchard.

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REFERENCES

Changade, N.M., Sharma, V. and Kumar, R. (2023). Performance of okra (*Abelmoschus esculentus)* to different irrigation levels and Mulches under drip irrigation system. *Indian J. Agric. Sci*., 93 (3): 318–320.

Kumar, D., Pandey, V. and Vishal, N. (2008). Effect of drip irrigation regimes on growth, yield and quality of mango hybrid Arka Anmol. *Indian J. Hort., 65(4):* 409-412.

Kumar, D., Pandey, K. and Anjaneyulu, V. (2009). Optimization of major nutrients for guava yield and quality under east coastal conditions. *Indian J. Hort.,* 66(1):18-21.

Mehta, S., Singh. S.K., Das, B., Jana, B.R. and Mali, S. (2012). Effect of Pruning on guava CV. sardar under ultra high-density orcharding system. *Int. J. Plant Res.,* 25(2):192-195.

Meshram, D.T., Gorantiwar, S.D., Mittal, H.K. and Purohit, R.C. (2010). Comparison of reference evapotranspiration methods in western part of Maharashtra state. *J. Agrometeorol.,* 12 (1): 44-46. https://doi.org/10.54386/jam.v12i1.1266

Reddy, B.M.C. (2014). High density planting in horticultural crops. First Indian Horticulture Congress, New Delhi., 6-9:36.

Satpute, S., Singh, M.C. and Garg, S. (2021). Assessment of irrigation water requirements for different crops in central Punjab, India. *J. Agrometeorol.,* 23 (4): 481-484. https://doi.org/10.54386/jam.v23i4.183

Saxena, R., Tiwari, A., Mathur, P. and Chakravarty, N.V.K. (2020). An investigation of reference evapotranspiration trends for crop water requirement estimation in Rajasthan. *J. Agrometeorol*., 22 (4): 449-456. https://doi.org/10.54386/jam.v22i4.447

Sharma, V, Singh, P.K., Bhakar, S.R., Yadav K.K, Lakhawat, S.S. and Singh, Manjeet. (2021). Pan evaporation and sensor-based approaches of irrigation scheduling for crop water requirement, growth and yield of okra. *J. Agrometeorol*., 23 (4): 389-395. https://doi.org/10.54386/jam.v23i4.142

Singh, P.K., Srivastava, P.C., Sangavi, R., Gunjan, P. and Sharma, V. (2019). Rice water management under drip irrigation: an effective option for high water productivity and efficient zinc applicability. *Pantnagar J. Res*., 17(1): 21-26.