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Effect of Different Levels of Water Stress on the Growth and Yield of Mango (*Mangifera indica L.*) by Using Drip Irrigation Technology

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Abstract
The present study was undertaken to see the effect of different levels of irrigation treatments on the growth and yield of mango on a sandy-loamy clay soil, by using drip irrigation technique having flow rate of drippers 4 liters per hour (LPH). The data obtained revealed that maximum plant height (443.63 cm), number of flowers (558.60), number of fruits per tree (987.00), fruit length (20.07 cm), and fruit yield (64.28 kg/plant) were recorded in T_5 (twice application of water for 62.5 minutes). However, the maximum plant girth (77.90 cm) and fruit weight (140.18 gm) was found in T_6 (twice application of water for 75 minutes) respectively. The treatment T_1 showed poor results for all the parameters which indicate that too low or high irrigation application per day through drip irrigation system may negatively affect the vigorous growth and yield parameters of mango. Results suggests that the twice application of water comprised of (62.5 minutes) longer duration by using 4 drippers (flow rate 16 LPH) for the mango trees, were found appropriate for best possible growth and yield of mango.
Keywords: Mango, Anwar Ratole, Water Stress, Drip Irrigation, Makhdum Rasheed, Multan.

INTRODUCTION

Mango (*Mangifer indica L.*) belongs to Anacardiaceous family. Mango variety (Anwar Ratole) is familiar for its rich flavor all around the world. These mangoes are widely grown in Pakistan especially in Multan. Its peak harvest season starts from the mid of July and ends in August. It grows well in a soil having pH range between 5.5 and 8.7 and which are free of hardpan, and sticky clay. In the case of mangoes, the waterlogging and excessive rains adversely affect it both in growth and yield (Tahir *et al.,* 2003). It has a unique annual growth cycle. The tree acquires many roots having a deep axle root system. Ample amount of light is imperative for its growth and flowering as its plays a very vital role in pertinent context (Azzouz *et al.,* 2015). A well-drained sandy loam soils capable of holding moisture, supplemented with organic matter is an excellent choice to ensure maximal positive results. Adoption of appropriate technology and good management of mango throughout the production cycle allows the growers to maximize production of marketable fruit (Zude *et al.,* 2015). Growing mangoes via drip irrigation technique have a cutting edge over the traditional techniques and by adopting this methods, farmers can attain a handsome yield for a long-time period (Azevedo *et al.,* 2003). The mango trees require plenty of fertilizers at different stages i.e. nitrogen, phosphorus, and potassium; during the whole growth cycle, from flowering stage till fruit ripening process respectively (Spreer *et al.,* 2002).

The irrigation requirement of mango trees mainly depend on agronomic and climatic factors of the particular zone (Naor *et al.,* 2012). In addition to this, the water requirement during the summer season is more than winter season (Tejero *et al.,* 2010). Therefore, the shortage of water during flowering and fruit development stage in soil may result in flowering and fruit dropping (Pavel *et al.,* 2004). The plants irrigated through the drip irrigation system, minimizes the soil storage and provides optimum water supply to the roots and helps in controlling soil moisture in the rhizosphere which ultimately reduce the plant water stress (Zuazo *et al.,* 2011). Various studies show that mango harvested yield was found more with drip irrigation system as the fruit parameters (length, diameter, number of fruits, and weight of fruit etc), were significantly affected by irrigation quantities (Levin *et al.,* 2017).

Keeping the above facts in view the subject study was focused to evaluate the effect of different levels of irrigation treatments with constant doses of fertilizers on the growth and production parameters of mango by using drip irrigation technique.

MATERIALS AND METHODS

Location

The research work was conducted in a private mango orchard (Dogar Agricultural Farm) located at 8 km distance from Makhdum Rasheed Village– Vehari Road, Multan, Punjab, Pakistan; during the year 2016-17 respectively. The soil of the agricultural farm was sandy-loam clay in texture, with hydraulic conductivity (1.119 x 10^{-4} m/sec), bulk density (1.4 g/cm^3), and porosity (0.44) respectively.

Orchard Size and Drip Irrigation System

The total area of a mango orchard under HEIS (High Efficiency Irrigation System) was comprised of 25.47 acres having 9 zones and each zone had an area of 2.83 acres respectively. The plant and row spacing were kept 6.4m x 6.4m and the canopy diameter and area was adopted as 4.88 m and 18.69 m^2 respectively. The drip line was laid out as per the spacing of mango trees. For each tree, 4 drippers having flow rate 16 LPH were installed at a distance of 0.45 m from the plant. A venturi assembly was used for mixing fertilizer with irrigation water (Fereres *et al.,* 2007). Based on the water requirement of mango trees, the irrigation hours were worked out. Fertigation to an individual tree in each replication was controlled by providing a manual regulating valve fixed to the lateral lines to ensure precise delivery of the required inputs thus enabling full control of experimental setup (Suresh, 2014).

Field Experiment

The present research was carried out on a randomized complete block design (RCBD) having seven different rates of irrigation treatments with three replications. Each replication consists of a three trees. Total sixty three (63) trees of mango cv. (Anwar Ratole) of uniform size and age fifteen were selected for this study. The irrigation water was applied in such a way that (T_1 = 12.5 minutes, T_2 = 25 minutes, T_3 = 37.5 minutes, T_4 = 50 minutes, T_5 = 62.5 minutes, T_6 = 75 minutes, and T_7 = 87.5 minutes) twice application per day respectively. The farmyard manure was applied at the rate of 50 kg/tree/year to all plants on December 9th, 2016. Fertilizers were applied through the drip irrigation system (fertigation). Poly-Feed water soluble drip N-P-$K_{(20\text{-}20\text{-}20)}$ fertilizers as per schedule were dissolved in water and then injected to sub-main through venturi and then to lateral lines respectively. The fertilizers were applied through drip irrigation at weekly intervals. Weeding, hoeing, and other agronomic practices prior to the inception of treatments were applied as proposed by (Zude *et al.,* 2015). Data were analysed using the Analysis of Variance (ANOVA) and the differences between treatment means were compared by the Least Significant Different (LSD) method using SPSS software accordingly (Arshad *et al*., 2014).

RESULTS AND DISCUSSION

The study revealed that the different agronomic parameters of mango i.e. plant height (cm), plant girth (cm), number of flowers per panicle, number of fruits per tree,

average fruit weight (gm), fruit length (cm), and fruit yield per tree (kg); differed very significantly between application of different rates of irrigation water as presented in Table 1. The critical gathered observations and data for the above discussed parameters during the present research work are appended below:

Plant Height

Growth parameters observed during the field experiment like plant height; responded positively to the different irrigation treatments as shown in Table 1. At first harvest, the maximum height of plant (443.63 cm) was recorded with the treatment T_5, followed by T_6 (442.58 cm), and T_4 (422.63 cm) respectively. Whereas, minimum height of mango plant was recorded for the treatment T_1 (387.85 cm), where irrigation was applied twice in a day for 12.5 minutes respectively. The increase in plant height mainly depends on the environmental and agronomic factors; therefore the plants receiving more amount of irrigation water may increase the water in root zone which ultimately boost the movement of macro-element from the soil. Likewise soil condition and texture also play a critical role in enhancing the root length. These results are in agreement with the findings of Brun *et al.* (2015), who found that, the height of the plant mainly in Anjou pears was expressively increased with high pulse irrigation up to some extent; however over-irrigation may reduce the plant growth, encourage disease, and scars on the fruit.

Plant Girth

Different irrigation levels varied significantly in respect of plant girth as shown in Table 1. The lowest plant girth was observed for treatment T_1 (59.18 cm), and maximum plant girth was recorded for T_6 with (77.90 cm) followed by T_5 (73.98 cm) and T_4 (72.50 cm) respectively. The present results are supported by the findings of Mostert *et al.* (2007), who concluded that high pulse irrigation levels could significantly alter vegetative growth of leaves, and plant girth of mango trees.

Number of Flowers per Panicle

The number of flowers per panicle was significantly affected by different levels of irrigation treatments as shown in Table 1. At first harvest, the maximum number of flowers were recorded for treatment T_5 with (558.60 flowers), followed by T_4 with (466.89 flowers) and T_6 with (362.25 flowers) respectively. While the overall minimum number of flowers per panicle, once again recorded for treatment T_1 with (238.79 flowers). As plants receives optimum amount of water it directly improves cell permeability which enhances photosynthetic process and results in more number of leaves and flowers. Similar results were obtained by Larson *et al.* (2008) for peach, who concluded that the number of flowers per panicle was highly influenced by different levels of irrigation through drip irrigation.

Table 1. The effect of different rates of irrigation treatment on the plant growth and fruit yield parameters of mango trees.

Treatment	Plant Height	Plant Girth	Number of flowers	Number of fruits per tree	Fruit Length	Average Fruit Weight	Fruit yield
	cm	cm			cm	gm	kg / plant
T_1	387.85 d	59.18 c	238.79 e	693.50 d	17.27 c	95.87 d	33.56 d
T_2	417.54 bc	65.83 bc	274.00 d	745.00 cd	19.10 ab	105.05 c	40.90 cd
T_3	399.35 cd	66.70 b	292.74 cd	729.50 c	18.32 ab	108.78 bc	55.24 b
T_4	422.63 b	72.50 ab	466.89 ab	924.00 a	19.04 ab	123.80 ab	60.59 a
T_5	443.63 a	73.98 ab	558.60 a	987.00 a	20.07 a	127.37 ab	64.28 a
T_6	442.58 a	77.90 a	362.25 bc	889.60 b	19.71 a	140.18 a	50.43 b
T_7	404.25 bc	67.20 b	342.30 c	777.00 bc	18.80 ab	114.87 b	44.37 c

Means followed by different letter shows significant result at 5% level of significance

Number of Fruits per Tree

The number of fruits per tree varied significantly for all the treatments as shown in Table 1. At first harvest the highest numbers of fruits were observed for treatment T_5 (987.00 fruits) followed by T_4 (924.00 fruits) and T_6 (889.60 fruits) respectively. The lowest number of fruits per plant was recorded for treatment T_1 (693.50 fruits) per plant. This effect can be positively correlated to the fact that optimum amount of water plays a vital role in metabolism and nutrient uptake. Proper amount of water application boosts up the vigorous growth of mango which eventually increases the number of fruits per tree, which conforms the findings of Arshad *et al.* (2017) for bell pepper when water was applied to the plants through pulse irrigation at high rate.

Fruit Length

Statistically significant results were observed for the fruit length per plant as shown in Table 1. In general the length of mango fruit were found usually more in those plants which received high pulses per irrigation as compared to those that received less number of pulses per irrigation. The maximum fruit length (20.07 cm) was recorded for treatment T_5, followed by T_6 (19.71 cm) and T_4 (19.04 cm) respectively. Once again the overall minimum fruit length (17.27 cm) was observed for treatment T_1. As mango requires an ample amount of water during summer season, therefore increasing the amount of irrigation water to a certain level T_5, the fruit length may exhibit increase. Similar results were reported by El-Kosary *et al.* (2011) for mango, who concluded that plants that do not get the required amount of water produce undersized and deformed fruits.

Average Fruit Weight

Statistically variable results were observed for the weight of fruits per tree (Table 1), which shows that the increase in irrigation water will result in high fruit weight. The overall maximum fruit weight (140.18 gm) was recorded for treatment T_6 followed by T_5 (127.37 fruits) and minimum fruit weight (95.87 gm) was recorded for treatment T_1 respectively. The results showed that high pulse irrigation along with the appropriate amount of fertilizers can increase the fruit weight. The result is in agreement with the report of Arshad, (2017) for cucumber, who reported that the individual fruit weight increased by the application of the appropriate amount of irrigation water and fertilizers.

Fresh Fruit Yield

Different irrigation levels had a significant effect on fruit yield per tree (Table 1). The irrigation treatment T_5 increased the fruit yield up to 64.28 kg/plant, followed by T_4 (60.59 kg/plant) respectively. The minimum fruit yield was recorded for treatment T_1 (33.56 kg/plant). High pulse irrigation increases the vegetative growth and chemical composition of fruits which results in more fruit length and fruit weight and ultimately affects the fruit yield. It was also observed that the yield of fruits per unit area showed a little lesser yield in T_6 and T_7; which might be due to the excess amount of water in the root zone which decreased the vegetative growth and reduces the fruit length and diameter and results in less fruit yield. These results are in agreement with the findings of Parvizi *et al.* (2015), who also concluded that different level of irrigation water with proper dozes of fertilizers increased the fruit yield of pomegranate.

CONCLUSION

The outcome of the experimental study explained that different irrigation treatments by using drip irrigation technique along with the constant NPK fertilizers application may bring an optimistic effect to the mangoes production. The data obtained revealed that maximum plant height (443.63 cm), number of flowers (558.60), number of fruits per tree (987.00), fruit length (20.07 cm), and fruit yield (64.28 kg/plant) were recorded in T_5 (twice application of water for 62.5 minutes). However, the maximum plant girth (77.90 cm) and fruit weight (140.18 gm) was found in T_6 (twice application of water for 75 minutes) respectively. The treatment T_1 showed poor results for all the parameters which indicate that too low or high irrigation application per day through drip irrigation system may negatively affect the vigorous growth and yield parameters of mango. Hence it can be concluded that the twice application of water comprised of (62.5 minutes) longer duration by using 4 drippers (flow rate 16 LPH) for the mango trees, were found appropriate for best possible growth and yield of mango cv. (Anwar Ratole). As an area under study was sandy-loamy-clay; therefore, these suggestions are applicable for only these soils while the results may vary for other types of soil.

CONFLICT OF INTEREST

The authors declare that no competing interests exist.

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