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Effect of Hoagland and Arnon Nutrient Solution on the Growth and Yield of Mango (*Mangifera indica L.*) by Using Stem Injection Technique

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Abstract:
The present study was conducted to see the effect of various levels of Hoagland and Arnon nutrient solution on the growth and yield of mango on a sandy-loamy clay soil by using stem injection technique. The data obtained revealed that maximum plant height (352.08 cm), number of flowers (569.24), number of fruits per tree (1005.80), maximum plant girth (82.37 cm), fruit weight (142.79 gm), fruit length (20.45 cm), and fruit yield (65.51 kg/plant) were recorded in T_5 (100 ml/tree) respectively. However, the treatment T_1 showed poor results for all the parameters which indicate that too low or high nutrient solution application may negatively affect the vigorous growth and yield parameters of mango. Results suggest that the treatment T_5 for the mango trees cv. (Anwar Ratole), were found appropriate for the best possible growth and yield of mangoes as it showed bumper growth with lush green leaves and showed a moderate fruit setting.

Keywords: Mango, Anwar Ratole, Stem Injection Technique, Hoagland and Arnon - Nutrient Solution, Makhdum Rasheed, Multan.

INTRODUCTION

Mango (*Mangiferindica 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 rain adversely affects 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 (Zuazo *et al.,* 2011).

The most common and traditional method of applying fertilizer to mango trees is through the soil. This comprises digging the soil under the plant canopy, mixing fertilizer with the soil followed by irrigation (Levin *et al.,* 2017). The disadvantage of this method is that it is labor intensive and has low efficiency of fertilizer use by the plant. Sometimes, the nutrients are directly sprayed on the plant foliage, from where they are absorbed by the plant. This method is also laborious as the spray operation becomes difficult in case of large and tall trees (Tejero*et al.,* 2010). The stem injection method takes a small quantity of the nutrient solution which is required by the plant, thus making it very economical. The method involves efficiency of the plant usage, saving of fertilizer, no harmful effect on the plant, convenience and economy of application (Naor*et al.,* 2012). Moreover, when plants are attacked by insect pests, an insecticide may also be applied through the same holes. It will save labor and expenditure on spraying operations, thus making it extremely economical.

Keeping the above facts in view the present research study was focused to evaluate the effect of different levels of (Hoagland and Arnon - Nutrient Solution) on the growth and production parameters of mango by using stem injection technique.

MATERIALS AND METHODS

Field Experiment

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 2017-18 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. The research was carried out on a randomized complete block design (RCBD) having seven different rates of nutrient solution doses with three replications. Each replication consists of three trees (Suresh, 2014). Total sixty-three (63) trees of mango cv. (Anwar Ratole) of uniform size and age twelve were selected for this study. The10% Hoagland and Arnon nutrient solution doses i.e. (T_1 = 20 ml/tree, T_2 = 40 ml/tree, T_3 = 60 ml/tree, T_4 = 80 ml/tree, T_5 = 100 ml/tree, T_6 = 120 ml/tree, and T_7 = 140 ml/tree) was applied to the trees through a stem injection technique in such a way that four holes, one on each side, were drilled in the stem about a meter above the ground level at an angle of 45 degrees with the help of a small electric hand drill.

The debris from the holes was cleaned by inserting and pulling out the hand drill repeatedly. The depth (20 cm) and diameter (1.4 cm) of the holes was kept uniform for all trees. Then the nutrient solution was divided into four parts, filled in the holes by a syringe and their

opening was sealed with mud by placing a piece of leaf on them. Weeding, hoeing, irrigation and other agronomic practices prior to the inception of treatments were applied as proposed by (Zude *et al.,* 2015). Data were analyzed 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 nutrient solution via stem injection technique as presented in Table 1.

Plant Height

Growth parameters observed during the field experiment like plant height; responded positively to the different nutrient solution treatments as shown in Table 1. At first harvest, the maximum height of plant (352.08 cm) was recorded with the treatment T_5, followed by T_6 (351.01 cm), and T_7 (349.95 cm) respectively. Whereas, minimum height of mango plant was recorded for the treatment T_1 (333.24 cm), where nutrient solution was applied 20 ml/tree respectively. As plants receives optimum amount of nutrient solution it directly improves cell permeability which enhances photosynthetic process and results in plant height. Similar results were obtained by Shah *et al.* (2018) for peach, who concluded that the plant height was highly influenced by different levels of fertigation treatments.

Plant Girth

Different nutrient solution levels varied significantly in respect of plant girth as shown in Table 1. The lowest plant girth was observed for treatment T_1 (75.25 cm), and maximum plant girth was recorded for T_5 with (82.37 cm) followed by T_6 (82.16 cm) and T_7 (81.48 cm) respectively. The present results are supported by the findings of Mostert *et al.* (2007), who concluded that high fertilizers doses 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 nutrient solution treatments as shown in Table 1. At first harvest, the maximum number of flowers were recorded for treatment T_5 with (569.24 flowers), followed by T_6 with (519.15 flowers) and T_4 with (475.79 flowers) respectively. While the overall minimum number of flowers per panicle, once again recorded for treatment T_1 with (345.25 flowers). This effect can be positively correlated to the fact that optimum amount of nutrient solution plays a vital role in metabolism and nutrient uptake. Proper amount of nutrient solution application boosts up the vigorous growth of mango which eventually increases the number of flowers per panicle per tree, which confirm the findings of Arshad *et al.* (2017) for bell pepper where water soluble fertilizers $NPK_{(20\text{-}20\text{-}20)}$ was applied to the plants and found a remarkable increase at the flowering stage.

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 (1005.80 fruits) followed by T_4 (941.60 fruits) and T_6 (904.64 fruits) respectively. The lowest number of fruits per plant was recorded for treatment T_1 (759.70 fruits) per plant. The increase in number of fruits mainly depends on the environmental and agronomic factors; therefore, the plants receiving more amount of nutrient solution may 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 number of fruits mainly in Anjou pears was expressively increased with high fertilizers doses up to some extent; however, over dose may reduce the plant growth, which tends to less number of fruits per tree.

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

Treatment	Plant Height	Plant Girth	Number of flowers per Panicle	Number of fruits per tree	Average Fruit Weight	Fruit Length	Fruit yield
	cm	cm			gm	cm	kg / plant
T_1	333.24 b	75.25 b	345.25 d	759.70 c	97.69 d	17.60 c	31.68 d
T_2	335.50 ab	77.16 ab	349.46 cd	796.20 bc	101.50 bc	18.46 ab	44.20 cd
T_3	339.95 ab	78.78 ab	379.98 c	845.30 b	110.85 b	19.67 ab	56.29 b
T_4	341.68 ab	80.90 a	475.79 ab	941.60 a	126.15 ab	19.40 ab	61.74 a
T_5	352.08 a	82.37 a	569.24 a	1005.80 a	142.79 a	20.45 a	65.51 a
T_6	351.01a	82.16 a	519.15 a	904.64 ab	129.85 ab	20.08 a	51.39 b
T_7	349.95 a	81.48 a	448.82 ab	891.80 ab	127.06 ab	19.15 ab	45.22 c

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

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 was found usually more in those plants which received optimum required doses of nutrient solution as compared to those that received less number of nutrient solutions respectively. The maximum fruit length (20.45 cm) was recorded for treatment T_5, followed by T_6 (20.08 cm) and T_4 (19.40 cm) respectively. Once again, the overall minimum fruit length (17.60 cm) was observed for treatment T_1. As mango requires an ample amount of nutrients during summer season, therefore increasing the amount of fertilizers doses 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 nutrients 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 nutrient solution will result in high fruit weight. The overall maximum fruit weight (142.79 gm) was recorded for treatment T_5 followed by T_6 (129.85 gm) and minimum fruit weight (97.69 gm) was recorded for treatment T_1 respectively. The results showed that appropriate amount of fertilizers can increase the fruit weight. These results are 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 nutrient solution levels had a significant effect on fruit yield per tree (Table 1). The treatment T_5 increased the fruit yield up to (65.51 kg/plant), followed by T_4 (61.74 kg/plant) respectively. The minimum fruit yield was recorded for treatment T_1 (31.68 kg/plant). Optimum fertilizers doses increase 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

nutrient solution, 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 doses of Hoagland and Arnon nutrient solution by using stem injection technique may bring an optimistic effect to the mangoes production. The data obtained revealed that maximum plant height (352.08 cm), number of flowers (569.24), number of fruits per tree (1005.80), maximum plant girth (82.37 cm), fruit weight (142.79 gm), fruit length (20.45 cm), and fruit yield (65.51 kg/plant) were recorded in T_5 (100 ml/tree)respectively. The trees showed bumper growth and eventually became lush green and even badly malformed branches of the trees started growing rapidly and showed a moderate fruit setting. However, the treatment T_1 showed poor results for all the parameters which indicate that too low or high nutrient solution application may negatively affect the vigorous growth and yield parameters of mango. This method of fertilization may also be extended to other tropical as well as temperate fruit trees. The method involves efficiency of the plant usage, saving of fertilizer, no harmful effect on the plant, convenience and economy of application. Moreover, when plants are attacked by insect pests, an insecticide may also be applied through the same holes. It will save labor and expenditure on spraying operations, thus making it extremely economical. Hence it can be concluded that the treatment T_5 for the mango trees cv. (Anwar Ratole), were found appropriate for best possible growth and yield of mangoes. 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.

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CONFLICT OF INTEREST

All the authors have declared that no conflict of interest exists.

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