Effect of Water Deficit on Growth of Some Mango (*Mangifera indica* L.) Rootstocks

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Abstract: The present study aimed to investigate the effect of water deficit on the growth of mango rootstock seedlings. The experimented seedlings were obtained by seed propagation of two mango cultivars, namely: Sabre and Zebda. One year old mango rootstock seedlings (*Mangifera indica* L.) were grown in pots in a green house, where they subjected to four water levels, 100% (control), 80%, 60% and 40% available water. The results indicated that, Sabre stock seedlings gave the highest values of shoot growth, leaves number, leaf area, root/shoot ratio, succulence grade, T.S.S%, leaf proline and leaf nutrient content compared with that of Zebda rootstock seedlings.
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Key words: Mango, Water deficit, Osmotic potential, Proline, Leaf nutrient content.

1.Introduction

Mango is one of the most important fruit crop in Egypt, which meet a great demand in local market and in export. Mango trees in Egypt depend on irrigation to get their need of water in most cultivated area. Hence, the amount of given irrigation water depends on many factors such as: type of soil, climate condition in the cultivated area, methods and systems of irrigation, characteristics of the plant rootstock and others. On the other hand, irrigation is necessary to insure stable yield with high quality. However, insufficient irrigation amount might cause plant water deficit which, might lead to permanent wilting of shoot and fruit growth if unrelieved and plant dehydration leading to plant death.

According to Ashley, (1993), the exposure of rootstock seedling to some moisture stress at nursery may cause some degree of "hardening" against current and later drought periods. However, the degree of hardening will vary among varieties and species of used rootstocks.

It is remarkable that few studies have been carried out in Egypt to determine the optimal water requirements of different mango stock seedlings. The previous done work in the last ten years on the water requirements of the mango stock seedlings, brought about by seed propagation, indicated that, irrigation deficit affected growth and leaf content of mango (Romero *et al*, 2004; Cifre *et al*. 2005, Tognetti *et al*. 2005, Luvahu *et al.* 2007).Therefore, the present study aims to emphasize on the two mango stock cultivars grown under different water deficit and their effect on vegetative growth, leaf water deficit succulence grade, osmotic potential, plant proline content and leaf nutrient content.

2. Material and Methods

The experimentation was carried out during seasons of 2012 and 2013 in the green house of the research farm of Horticulture Department, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt. To study the suitable irrigation requirement for two seedling cultivars that can be used as mango rootstocks. Therefore, uniform and healthy one year old seedlings of mango stocks cultivars, Sabre (from south Africa) and Zebda(local rootstock) were chosen as plant material for this study. The irrigation treatment consisted of three replicates, each replicate consisted of three stocks.Mango stock seedlings of each cultivar were similar in growth on the base of seedling height (cm), planted in 15th February 2012 and 2013, into 30 cm porous clay pots, filled with 7 kg sandy soil. On 1st March, the irrigation treatments started as follow:

Treatment 1: Each pot received 100% available water (control) during whole period of experiment.

Treatment 2: Each pot received 80% available water during whole period of experiment.

Treatment 3: Each pot received 60% available water during whole period of experiment.

Treatment 4: Each pot received 40% available water during whole period of experiment.

The irrigation treatments were carried out by weighing the pots every three days and adding the depleted amount of water to attain the specific percentage of available water in the treatment.

The measurements:

1. The vegetative growth:

1.1. Shoot length in cm: the vegetative growth was expressed in one main shoot per seedling that was left to grow. The increase in shoot length was adjusted through calculating the difference between shoot length in cm at the beginning of the spring flush and the cessation of growth. The vegetative growth was collected from the seeding and dried under 70 °C for 48 hours to determine the dry weight.

1.2. Leaves number per seeding was recorded at cessation of growth.

Leaf area was determined according to Ahmed and Morsy (1999) as follows:

Leaf area = 0.7 ×Leaf blade length (cm) × blade length (cm) – 1.06 = ----- cm^2

The fourth distal leaf was used

2. The root and shoot dry weight :

The root system and shoot of seedling was separated at cessation of growth and washed with tap water, then dried under70 °C for 48 h, Root/shoot ratio was determined.

3. Physical and Biochemical characteristics of the seedling rootstock:

3.1. The physical parameters measured were:

3.1.1. Water saturation deficit:

Leaf disks (1 cm^2) were taken from adult leaves (the fourth distal adult leaf) at cessation of growth and weighed, then put in distilled water for 45 min. Leaf disks, thereafter were dried at 70°C for 24 hrs. The saturated disks were used to adjust the W.S.D. and R.W.C.

$$\text{W.S.D.} = \frac{\text{Sat. wt. - fresh wt.}}{\text{Sat. wt. - dry wt.}} \times 100$$

2-1-2. Succulence grade =

$$\frac{\text{Leaf water content in (g)}}{\text{Leaf surface (cm}^2\text{)}} \quad (g / cm^2)$$

2-2- Biochemical characteristics:

2-2-1 Osmotic potential of leaf sap was determined at growth cessation according to Hifny and Abdel-all (1981) who found that TSS % in leaf cell sap showed an identical trend to that of osmotic potential values, 5 g of fresh leaf blade was mixed with 25 ml distilled water with electrical mixer where TSS % was measured in the filtrate using hand refractometer.

2-2-2Proline content of leaf:

Proline content was colorimetrically estimated at 520 µm from leaf extract according to method of Bates *et al*. (1973).

2-2-2 Leaf nutrients (N,P and K) content:

Total nitrogen was determined by a micro-kjldahl (Jackson,1967) at the end of growth season.

Phosphorus was determined by using flam photometer according to Murphy and Riely (1962).

Potassium was determined by using atomic Absorption spectrophotometer according to Brandifeld and Spincer (1965).

Statistical Analysis :

Analysis of variance (ANOVA) was performed using two way ANOVA from SAS software (1989).

3.Results and Discussion

1. Effect of different water deficit on seedling growth:

1.1. Growth increase:

Data in Table (1) showed an increase in shoot length (cm) during the growth period under different water stress, in the two studied mango stock cultivars. The results showed that the control treatment (100% available water) had increased the growth of most seedling shoots, which recorded the maximum height, while the lowest plant height was resulted from40% available water treatment. Differencesin growth increase (plant height) among the two studied stock cultivars were insignificant at 100% available water levels, on the other hand, the differences of shoot growth of both stock seedlings was significant under the effect of low available water, (40%,60%or80% available water). Sabre seedlings induced the highest growth increase at 80%, 60% and 40% available water

The treatment of 40% available water showed the least increase in seedling growth when compared with those resulted under higher available water percentages. The present result was in agreement with those of others who found that the little increase in shoot growth that caused by water deficit had resulted from the direct adaptation under high stresses of water deficient.

(Tahir*et al*. 2003 and Perez *et al*. 2007) who suggested that Abscisic acid might play the main hormonal role regarding drought tolerance. An increase in ABA- leaves content may depress growth of plants which suffering from high water stress (Loveys and Kriedemann, 1973) Moreover, re-watering the wilted vine plants decreased ABA content of soft wood to 50%. The ABA could regulate water transpiration, water uptake and the morphogenetical adaptation to high water stress. It might also increase the permeability of root-tissues to water and decreased the ion transport in root-xylem.

1-2 Number of leaves and leaf surface area (cm^2):

Data in Table (1) indicated that a significant increase was observed in number of leaves in plants under 100% available water compared to those under 60% and 40% of available water. Water deficits decrease leaf growth by slowing rates of cell division and expansion due to turgor loss and increased synthesis of abscisic acid (Tezara *et al*.2002).Water deficit also causes low leaf initiation (Boyer,1976). Reducing the number of leaves could be a phenomenon by the plants to minimize the surface transpiration (McCree, 1985). In mango, water deficit causes a reduction in leaf development (Luvaha *et al.* 2005, Abdel-Razik and Abd-Raboh, 2007). Sabre stock seedling induced higher leaves number and leaf surface area at all water levels.

1-3 Root and shoot growth:

As can be seen in (Table 1) root (d.wt) and shoot growth (d.wt) expressed as dry weights in the two rootstocks cultivars was proportional to the percentage of water availability in the two seasons (2012 and 2013). 100% available water caused the maximum significant root and shoot dry weight, followed descendingly by that of 80% and 60% available water, while the least obtained root and shoot growth was induced by 40% available water in the two studied cultivars and in the two studied seasons. The data indicated that the decrease in water availability caused a marked reduction in dry weight of roots and shoots. Differences among the two studied cultivars in roots and shoots at all water levels were significant.

Increasing the available water caused a marked increase in root and shoot dry weights. This is apparently due to the role of water in the early plant growth processes such as cell division and cell enlargement in the mango seedlings.

There is differential sensitivity of roots and shoots to water deficit. Root growth being less sensitive to water deficit and this caused the increase in root to shoot ratio (George, 2007). The reduction of dry weights of root and shoot under water stress were apparently caused by increased water deficit to the plants which may have also impacted negatively on nutrient uptake (Luvaha, 2005).

These results are in harmony with those of others, who found that a decrease in soil moisture induced a high decrease in dry weight of plant roots (Tahir *et al*. 2003). They added that the mango rootstock selected for drought resistance showed a high respiration intensity, a minimum water deficit and large number of absorbing rootlets particularly after drought periods.

1-4Root/ shoot ratio

The root / shoot ratio expressed as dry weight was increased with increasing water deficit (table 1). The values of Root/shoot ratios for the sevier stressed seedlings (40% of available water) were significantly higher than those of control treatment (100% of available water).According to Luvahu *et al*. (2007) the ratios of R/S were measured in seedling that was subjected to high water deficient 40% available water. They added that, Abscisic acid (ABA) accumulated in the hypocotyl region in water deficit plants can inhibits growth. This however has no effect on root growth.

Comparing the values of root/shoot ratios of the two studied seedling under the effect of percentages of available water 100 %, 80%, 60% and 40%, the results in table (1) indicated that Zebda stock at seeding elucidated higher Root/shoot ratios. As while the differences was insignificant between the two stocks under 40% available water.

Table (1):**Effect of different water deficit on the vegetative growth of mango seedlings cessation of growth.**

Variety	Treatment	Growth increase 2012	Growth increase 2013	Leaves number 2012 Beg	Leaves number 2012 End	Leaves number 2013 Beg	Leaves number 2013 End	Leaf surface area 2012 Beg	Leaf surface area 2012 End	Leaf surface area 2013 Beg	Leaf surface area 2013 End
Sabre	100%	18.81	19.18	29	46	26.33	40	59	85.91	57.32	79.62
	80%	14.86	16.70	25	32	26	31	58.57	84.59	56.16	82.31
	60%	8.90	10.02	24	27	26	29.33	56.18	81.35	55.43	76.08
	40%	6.45	6.59	24.33	27	27.66	29	50.69	57.52	56.16	58.23
Zebda	100%	23.83	25.05	25.66	34.33	28.33	37.33	55.95	73.63	56.20	75.75
	80%	13.39	14.63	26.66	30.33	24.33	29.66	58.09	74.92	56.25	72.69
	60%	6.31	7.00	24.33	28.00	25.00	28.33	52.96	70.72	54.17	70.97
	40%	4.03	5.28	26.00	26.33	25.33	26.33	53.23	55.05	52.34	55.11
LSD 0.05											
Cultivar		2.76	3.42	3.46	3.58	1.72	1.82	8.19	12.77	6.57	7.42
Treatment		3.91	4.83	4.9	5.06	2.43	2.58	11.58	18.06	9.29	10.5
C X T		5.53	6.84	6.93	7.16	3.44	3.65	16.38	25.54	13.14	14.85

Table (1) Continue :

variety	Treatment	Root dry weight 2012	Root dry weight 2013	Shoot dry weight 2012	Shoot dry weight 2013	Root / Shoot ratio 2012	Root / Shoot ratio 2013
Sabre	100%	40.89	44.49	66.03	69.0	61.92	64.48
	80%	33.064	35.53	48.12	46.6	68.71	70.24
	60%	35.0	36.91	36.02	37.52	97.17	98.37
	40%	25.4	26.3	24.02	24.9	105.74	105.62
Zebda	100%	31.57	33.01	48.1	49.04	65.63	67.31
	80%	29.03	30.79	34.9	35.19	83.18	87.49
	60%	29.66	30.23	29.1	29.03	101.92	104.13
	40%	22.6	26.16	20.96	24.2	107.82	108.09
LSD 0.05							
Cultivar		4.22	4.35	3.07	5.18	8.23	9.002
Treatment		5.97	6.16	4.35	7.33	11.64	12.73
C X T		8.44	8.71	6.15	10.37	16.47	18.005

2- Physical and chemical characteristics of the vegetative growth:

2-1- Physical parameters:

2-1-1: Water saturation deficit (W.S.D.):

Water saturation deficit was increased by decreasing the percentage of available water. Fig (1) showed that water saturation deficit of mango seedling leaf was increased by decreasing the available water in the two mango studied stock cultivars. The lowest values of water saturation deficit were noticed at 100% available water (the control), while the highest values were noticed at 40% available water in the two studied stocks cultivars. At the levels of 100, 60 and 40% available water, Zebda showed higher value of saturation deficit more than Sabre stock cultivars, while at 80% available water Sabre stock cultivar showed the highest value. Differences among stocks were mostly insignificant.

This finding was in agreement with that obtained by Tahir *et al*. (2003) on mango, who found that water saturation deficit was decreased by increasing soil moisture and added that the rootstock selected for drought resistance showed a minimum water saturation deficit values.

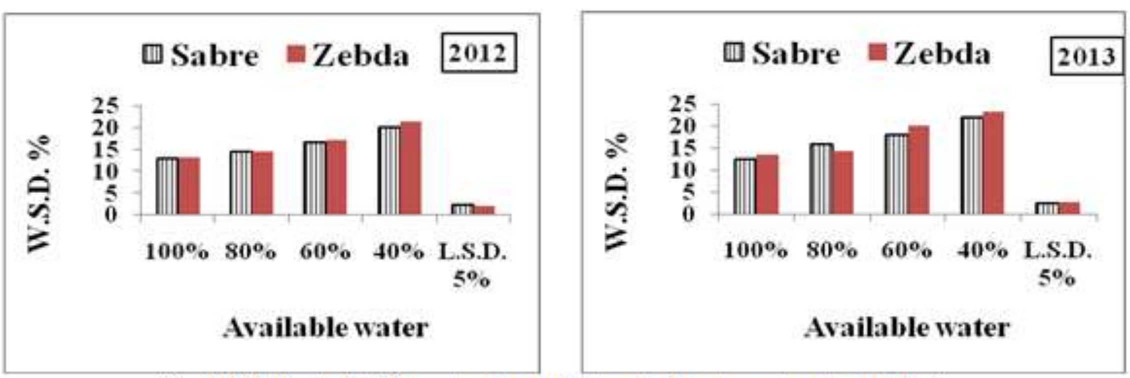

Fig. (1): Effect of different water deficit on leaf water saturation deficit.

2-1-2Succulence grade of leaves:

Data in fig (2) indicated that, succulence grade under different available water treatment was increased as the available water increased. The maximum values of leaves succulence grade were obtained at the control treatment (100% available water). On the other hand, the lowest values were obtained at 40% available water. This may be due to the increased water uptake by increasing available water percentage, which increases the relative water content and succulence grade of leaves. Sabre seedlings showed higher succulence grade of leaves at 60 and 40% available water levels than stock cultivar Zebda in the two seasons. Differences among stocks were significant at the previous two water levels at the first season. These results were in harmony with those obtained by Abdel-Razik and Abd-Raboh (2007), who found that, succulence grade in some mango cultivars was correlated with soil moisture level.

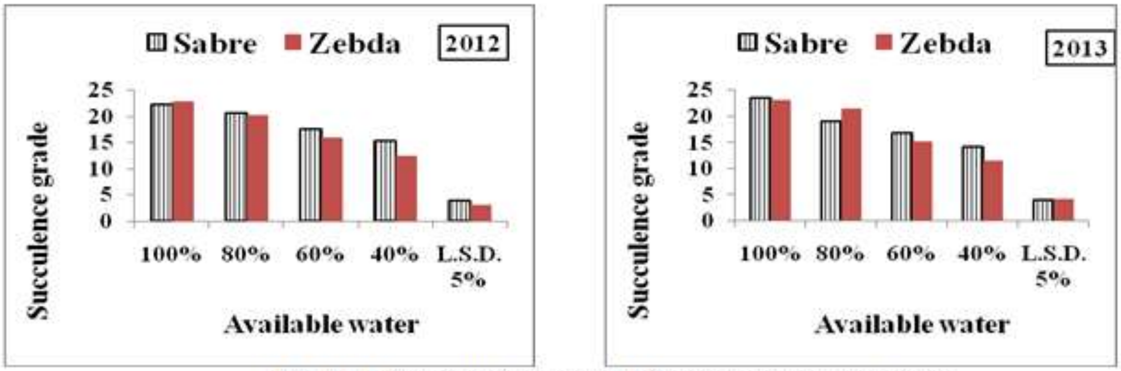

Fig. (2): Effect of different water deficit on leaf succulence grade.

2-2 Biochemical characteristics:

2-2-1 Osmotic potential as TSS % of leaf sap.

The results in fig (3) indicated that total soluble solids percentages of leaf filtrate in both cultivars had increased by decreasing the available water, so that the highest values were at 40% of available water, while the lowest values at 100% available water. It is worthy to mention that the increase in TSS % values in mango leaf filtrate might increase the resistance of leaves to drought. It was true for the two stocks in both seasons. Sabre seedings showed higher TSS % values of leaf cell.sap at all the levels of avaible water than Zebda rootstock, Hifny *et al* (2013) stated that values of leaf osmotic potential might follow the similar trend of TSS% during the active period of shoot growth.

The results were in harmony with those obtained by Mehanna *et al*. (2012) who found that leaf water potential of olive cvs. increased by increasing rate of water stress.

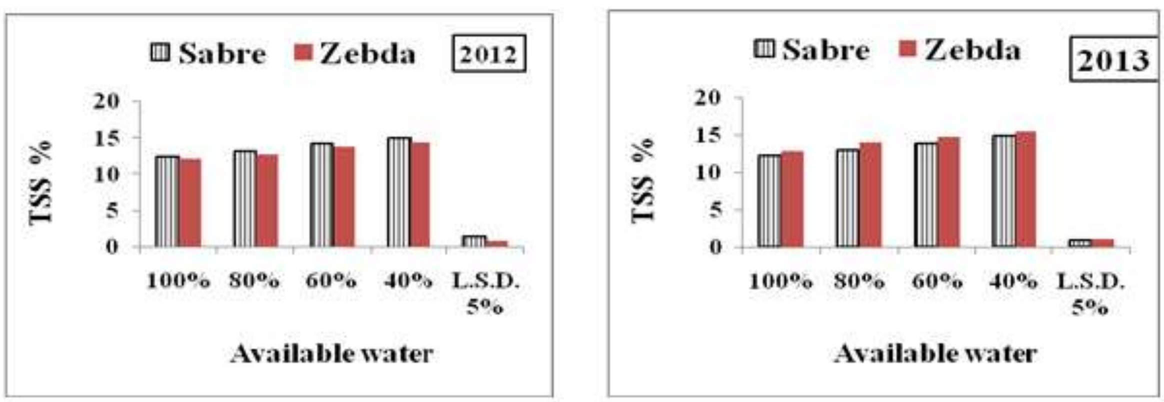

Fig. (3): Effect of different water deficit on TSS % in leaf sap.

2-2-2 Proline content% (f. wt.):

Data in fig.(4) indicated that, when water decreased, high value of proline was induced, such that the lowest value of proline was induced at 100% available water, while the highest value was induced at 40% available water. Differences among stock cultivars concerning proline content (%) in mango leaves were insignificant in the two seasons. Sabre seedlings produced the higher proline level in their leaves at all levels of available water in the two seasons. High proline content indicates that the seedling leaves suffer from drought more than that of low proline content. In other words, production of high proline content in the leaves indicates that such plant is less tolerant to drought than that of low proline content. It could be concluded that Sabre rootstock cultivar sensitive to drought than Zebda rootstock.

This results were in agreement with those obtained by Abdel-Razik and Abd-Raboh (2007), who found that mango plant produced a high values of proline as a result of high water stress.

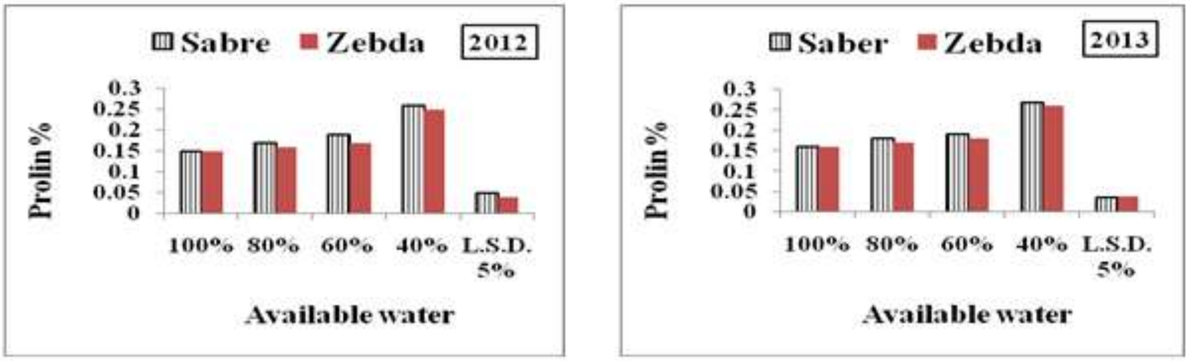

Fig. (4): Effect of different water deficit on proline content in leaf sap.

***2-2-3 Leaf nutrient (N,P,K) content:**

Nitrogen content% (d.wt.):

Data in Table(2) showed that the highest values of leaf nitrogen content was induced at 100% available water, while the lowest nitrogen value was induced at 40% available water. This was true for two mango stocks.

Sabre stock possessed higher values of leaf nitrogen content at the 80%,60% and 40% available water levels than that of Zebda. Differences between the two stock kind regarding N content were not significant. These results were in harmony with those obtained by Tahir *et al*. (2003), who found that leaf nitrogen content was decreased by decreasing the available water percentage. They added that, under soil water stress nitrogen solubility was decreased and the plant did not receive the necessary nitrogen amount.

Phosphorus content% (d.wt.):

As for phosphorus Table (2) indicate that the highest value of leaf phosphorus content under the effect of 100% available water and the lowest values were noticed at 40 % available water for the two studied stock cultivars.

Sabre stock leaves contained the higher values of leaf phosphorus than Zebda stock, but differences among the two studied stocks was insignificant at all availble water pecent. The results were in harmony with those obtained by luvaha,(2005),who stated that water deficit negatively affect on nutrient uptake and transport.

Potassium content% (d.wt.):

Table (2) showed that leaf potassium content in the two mango studied stocks were increased by increasing water availability. The highest values of potassium content were found at 100% available water followed descendingly by 80%,60% and 40% available water for the two studied stock cultivars. Sabre seedling leaves insignificantly showed higher potassium content in all water deficit treatments than those in Zebda seedling stock cultivar.

Potassium has long been associated with the water economy of plants. Its availability in soil is decreased by lack of soil moisture. A good supply of the plant with potassium ions might avoid the effect of drought. Thus lack of moisture in the soil increases the plant need for potassium (Walter, 1968).

The present results ascertain those obtained by Abdel-Razik and Abd-Rabboh (2007), who found that the increase in available water causes the increase in leaf potassium content.

Table (2) Effect of different water deficit on leaf nutrient content.

Variety	Treatment	N% (d.wt)		P% (d.wt)		K% (d.wt)	
		2012	2013	2012	2013	2012	2013
Sabre	100%	1.82	1.84	0.091	0.087	1.27	1.19
	80%	1.78	1.81	0.087	0.084	1.16	1.09
	60%	1.66	1.70	0.082	0.083	1.09	1.03
	40%	1.47	1.51	0.078	0.081	1.07	0.99
Zebda	100%	1.85	1.86	0.086	0.091	1.22	1.24
	80%	1.76	1.75	0.085	0.087	1.14	1.07
	60%	1.57	1.6	0.082	0.081	1.05	1.01
	40%	1.42	1.45	0.079	0.081	0.97	0.99
LSD 0.05							
Cultivar		0.125	0.115	0.007	0.009	0.072	0.077
Treatment		0.177	**0.163**	0.010	0.013	0.102	0.109
C X T		**0.250**	**0**.231	4.89	1.84	0.144	0.154

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