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Effect of Different Soil Water Levels on Growth of Three Jujube *Ziziphus jujuba* Mill. Genotypes

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Abstract: Suckers of jujube grown at Maryout Experiment Station, Desert Research Center (north western coast of Egypt) were studied under irrigation at different levels of available soil moisture (100%, 75%, 50% and 25%) during two successive seasons 2008 and 2009 to disclose the effect of water stress on some morphological and physiological aspects. Increasing water stress significantly reduced rate of stem length, number of leaves/plant, leaf area and fresh and dry weight of different plant organs. Date genotype had the highest significant performance to increase vegetative growth comparing with other genotypes used under water stress. Thus it might be recommended from results of the present study to use date genotype under drought conditions.

Key words: Jujube · Water stress · Vegetative growth

INTRODUCTION

The jujube originated in China where they have been cultivated for more than 4,000 years and where there are over 400 cultivars [1]. Chinese jujube (*Ziziphus jujuba* Mill.) is an important native fruit tree of China and has been introduced to more than 30 countries. It is becoming increasingly important for its wide adaptation, easy management, early bearing, and rich nutrition and multi-use. As the center of origin and cultivation [2]. Trees and shrubs of the genus *Ziziphus* (Mill.) grow in arid regions in Africa, Australia and Asia and are important multipurpose fruit trees in many arid zone countries [3]. The present taxonomic systems of Chinese jujube are based mainly on morphological characteristics, utilization, or distribution, which cannot accurately reflect genetic relationship and result in serious nomenclature problems. In an agricultural context, water deficit is one of the most important environmental factors constraining plant photosynthesis and productivity in arid and semi-arid areas. Consequently, plant responses to drought have been extensively investigated from physiological and individual plant to ecosystem levels [4,5]. The Jujube is becoming more widely grown due to its adaptability to drought and tolerance [6]. An early response to water deficit is a reduction in leaf area and plant growth, which allows plants to reduce their transpiration, thus increasing water use efficiency (WUE) [7-9] and promoting interspecies competition capacity under drought [10] Deficit irrigation was associated with reduced canopy development shoot growth, tree height and leaf expansion of pomegranate tress [11]. The present expressed investigation aimed to study the effect of different available soil water levels on the growth of one-year-old suckers of three jujube (*Zizuphus jujube* Mill) genotypes, (Toffahi, Zaytoni and Date).

MATERLALS AND METHODS

This study was conducted during the two successive seasons 2008 and 2009 at Maryout Experiment Station, Desert Research Center (north western coast of Egypt). In this experiment 144 healthy suckers (48 of each genotype) were transferred to black plastic pots 25cm, in diameter and 30 cm in depth. Each pot was filled with 5.0 kg of Maryout soil (2.5 kg of loamy-clay (Table 1) +2.5 kg of sandy soil (Table 2).

The treatments were started in April and continued until the end of November in two successive seasons. Four gradient levels of available water were used in this concern to determine the drought tolerance of the studied genotypes through their influence on growth parameters and physiological activities. The different levels of available water used in this experiment were 100%, 75%, 50% and 25% of available water. Each of the previous water levels was applied to 12 suckers of each of

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Table 1: Some chemical properties of Maryout loamy soil.

				Cations (meq/l)				Anions (meq/l)				
Location	Soil texture	EC dSm^{-1}	pH	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	$SO4^{--}$	$CaCO_3$%	O.C %
Maryout	Loamy clay	3.3	7.8	10.7	2.43	19.3	0.56	5.2	2.2	5.8	34	3.03

Table 2: Some chemical properties of Maryout sandy soil.

				Cations (meq/l)				Anions(meq/l)				
Location	Soil texture	EC dSm^{-1}	pH	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_4^{--}	$CaCo_3$%	O.C%
Maryout	Sandy	2.6	7.2	0.23	0.05	0.16	0.01	0.06	0.33	0.05	0.5	0.06

Soil moisture content % at: Field capacity (0.33 bar) =19.3, Wilting point (15 bar) = 4.2 , Available water=15.1

the 3 studied genotypes. The 12 suckers of each of the studied genotypes were divided into 3 replicates each replicate comprised of 4 suckers.

The level of the available water was adjusted using the following equation:

Amount of added water at 100% of available water (A.W.L) (Liter) = (Soil field capacity percentage - Soil wilting point percentage) x soil dry weight (kg)

Field capacity was determined as described by Israelsen and Hansen [12], while the wilting point was determined by using the method described by Furr and Reave [13].

Growth Measurement: At the end of the flowering season (end of Nov.) the 4 suckers of each replicate of each irrigation treatments were pulled from the pots of the three studied genotypes were conducted of the following measurement: Increment of stem length (cm), average leaf area (cm^2), average number of leaves/ plant, fresh weight of plant organs (leaves, stem and root), dry weight of plant organs (leaves, stem and root) there washed and air dried, specific leaves dry weight (SLDY) was calculated according to Youssef [14]using the following equation: SLDY(g/cm^2) = dry weight of leaves/leaf area (cm^2) and specific stems dry weight (SSDW) was calculated according to Youssef [14] using the following equation: SSDW (g/cm)= dry weight of stem / stem length.

Statistical Analysis: The obtained data were subjected to computerized statistical analysis using MSTATC package for analysis of variance (ANOVA) and means of treatments were compared using LSD at 0.05 according to Snedecor and Cochran [15].

RESULTS AND DISCUSSION

Increment of Stem Length (cm) and Leaf Area (cm^2): Data presented in Fig 1a and b revealed that stem length and leaf area were significantly affected by irrigation treatments in both seasons. Irrigation at 100% from available water level recorded the highest significant stem length and leaf area (16.38 cm and 6.14 cm^2, respectively). On the other hand, the three studied jujube genotypes significantly affected the stem length and leaf area in both seasons. Date genotype had the highest significant increase in stem length and leaf area compared with the other genotypes used. The highest significant stem length and leaf area was recorded with Date genotypes (12.92 cm and 5.59 cm^2, respectively) followed by Zaytoni genotype (11.61 cm and 5.13 cm^2, respectively) and Toffahi genotype (11.11cm and 4.56 cm^2, respectively). Similar trend was noticed in the second season. On the other hand, Toffahi genotype subjected under depletion of 25% of available water showed the lowest significant stem length and leaf area (4.49 cm and 3.97 cm^2, respectively). These results are in agreement with those obtained by Kassem and Issa [16] he found that shoot fresh, dry weight, plant height, shoot number, shoot length, leaf dry weight, leaf area and leaf number gave a good correlation with the amount of applied water. Also, Laz and Ismail [17] reported that increasing water stress reduced rate of stem length and leaf area on the seedlings of Jujube.

Stem Fresh and Dry Weight (g): Data presented in Fig. 2a and b revealed that stem fresh and dry weights were significantly affected with irrigation at different available water levels in both seasons. Irrigation at 100% of available water recorded the highest significant stem fresh and dry weights (8.82g and 5.31 g, respectively). It was clearly noticed that 100% available water level was followed by available water levels at 75%, 50% and 25% in affecting stem fresh and dry weights in both seasons. On the other hand, the three studied jujube genotypes significantly affected the stem fresh and dry weights in both seasons. Date genotype had the highest significant increase in stem fresh and dry weights compared with the other genotypes used. The highest significant stem fresh

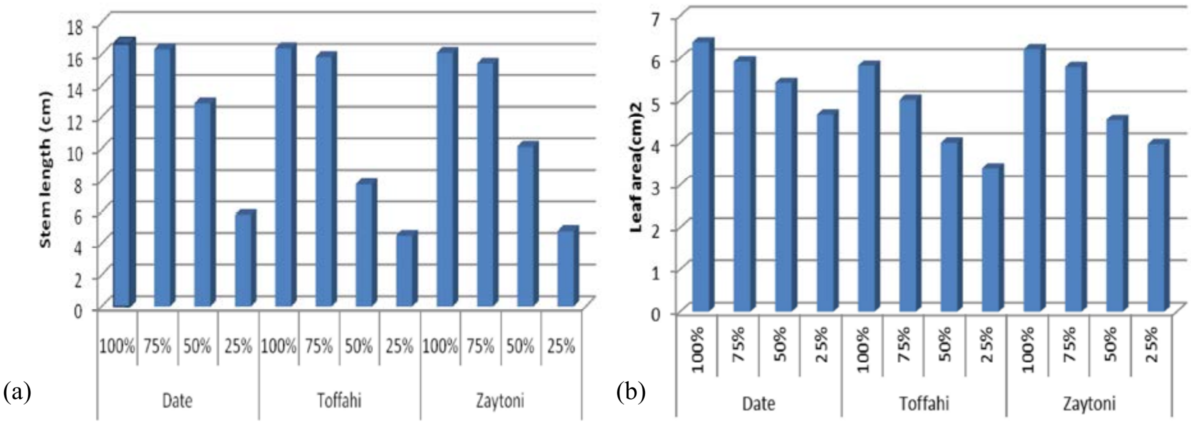


Fig. 1a,b: a) Effect of irrigation at different levels of available water (100, 75, 50 and 25%) on the average increment of stem length.
b) Effect of irrigation at different levels of available water (100, 75, 50 and 25%) on the average increment of leaf area

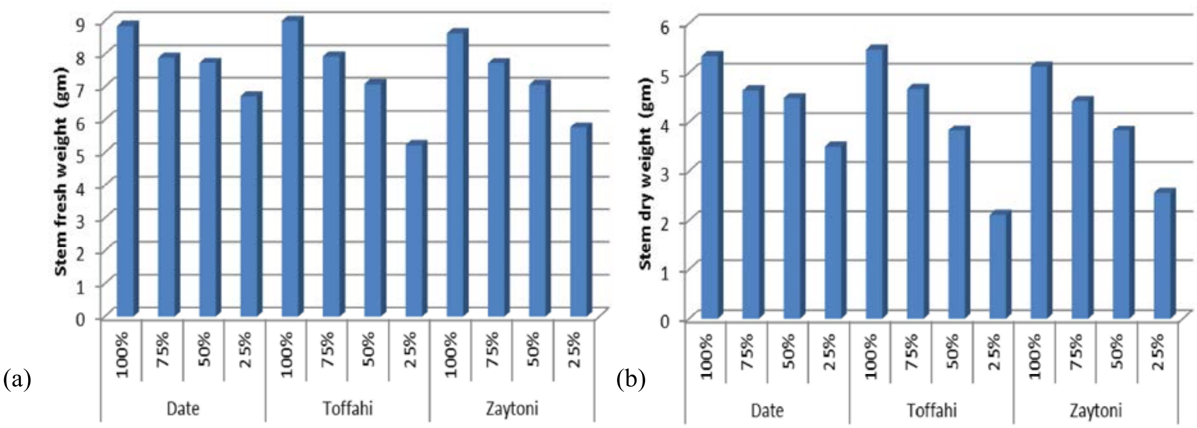


Fig. 2a,b: a) Effect of irrigation at different levels of available water (100, 75, 50 and 25%) on the average stem fresh weight.
b) Effect of irrigation at different levels of available water (100, 75, 50 and 25%) on the average stem dry weight.

and dry weights were recorded with Date genotypes (7.80 g and 4.49 g, respectively), while stem fresh and dry weights were insignificantly affected by Toffahi genotype and Zaytoni genotype in both seasons.

The interaction between different available water levels and three jujube genotypes treatments showed that Date genotype was the best treatment with 100% of available water compared with other interactions used for producing the highest stem fresh and dry weights. Furthermore, Toffahi genotype irrigated by 25% of available water showed the lowest significant stem fresh and dry weights (5.22g and 2.11g, respectively) in the 1st and 2nd seasons. These obtained results in parallel with those found by Kassem and Issa [16] who found a positive effect of irrigation on plant growth parameters such as shoot fresh, dry weight and Laz and Ismail [17] on the seedlings of Jujube reported that increasing water stress reduced rate of fresh and dry weight of different plant organs.

Root Fresh and Dry Weight (g): The obtained results in Fig 3a and b revealed that root fresh weight and root dry weight were significantly affected by applied treatments in both seasons. Available water level at 100% recorded increasing root fresh weight and root dry weight (21.83 and 14.45g, respectively) as compared with the analogous available water level at 25% (8.62 and 4.81g) in both seasons, respectively). Furthermore, the three studied jujube genotypes which were used in this study had also significant effect on the same parameters mentioned before in both seasons. It was clearly noticed that root fresh weight and root dry weight was highly significant in

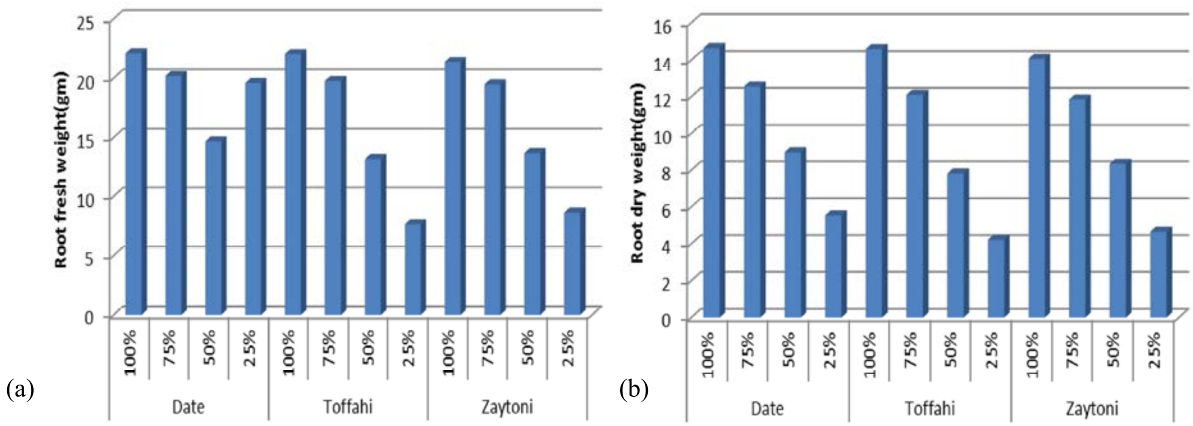


Fig. 3a,b: a) Effect of different available soil water (100, 75, 50 and 25%) on the average root fresh weight (g)
b) Effect of different available soil water (100, 75, 50 and 25%) on the average root dry weight (g)

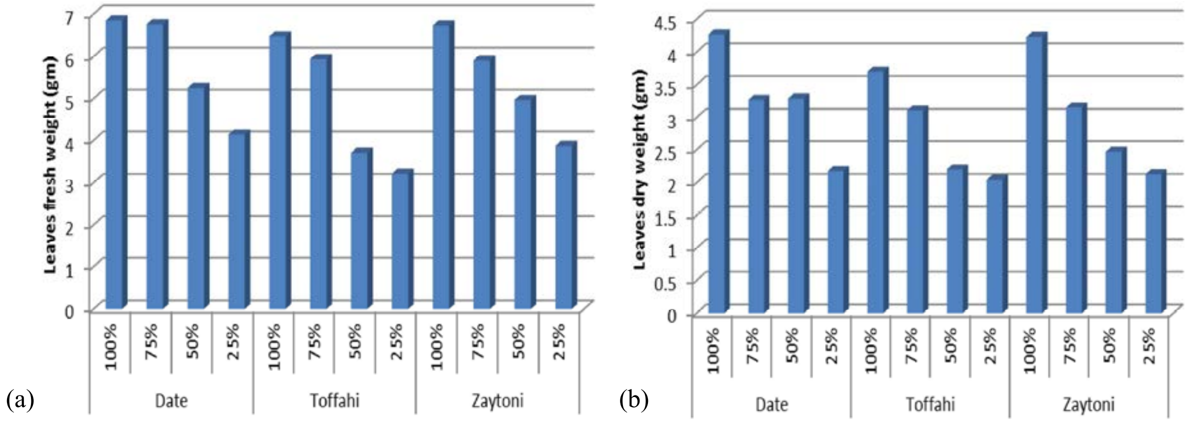


Fig. 4a,b: a) Effect of different available soil water (100, 75, 50 and 25%) on the average leaves fresh weight (g)
b) Effect of different available soil water (100, 75, 50 and 25%) on the average leaves dry weight (g)

Date genotype (16.64 and 10.43g, respectively) compared with other treatments used. The Interaction between different available water level and the three jujube genotypes. Treatments revealed that Date genotype irrigated by 100% of available water level gave the highest root fresh weight and root dry weight (22.11 and 14.65g, respectively) compared with other interactions under study. On the other hand, Toffahi genotype irrigated by 25% of available water level showed the lowest significant root fresh weight and root dry weight (7.65 and 4.23g, respectively). These results are in agreement with those obtained by Laz and Ismail [17] on the seedlings of Jujube reported that most reduction in plant growth occurred when the A.W.L. decreased from 50% to 25%.

Leaves Fresh and Dry Weight (g): Fig. 4a and b cleared that leaves fresh weight and leaves dry weight were affected significantly by applied treatments in both seasons. Irrigation at 100% available water recorded higher leaves fresh and dry weight (6.68 and 4.06 g, respectively). It was clearly noticed that 100% available water level was followed by available water level at 75%, 50% and 25% of leaves fresh weight and leaves dry weight in both seasons.

Regarding to the three jujube genotypes treatments, leaves fresh weight and leaves dry weight was significantly affected by the different three jujube genotypes treatments used in both seasons. While, Date genotype had the highest significant ability promotion for increasing leaves fresh weight and leaves dry weight (5.75 and 3.25 g) in the both seasons, followed by Zaytoni genotype and Toffahi genotype in first season. The second season followed the same trend. Furthermore, the different available water levels and three jujube genotypes treatments cleared that, Date genotype irrigated by 100% and 75% and Zaytoni genotype irrigated by 100% of

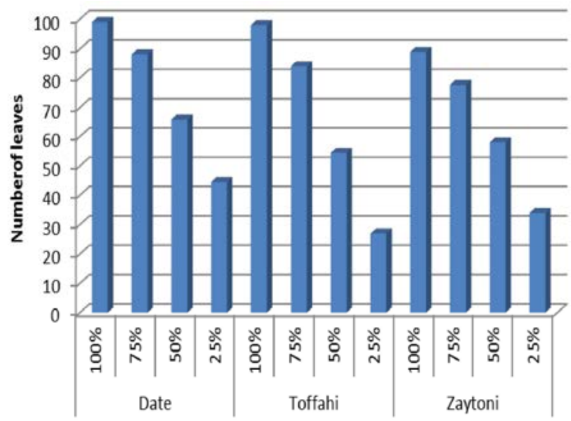
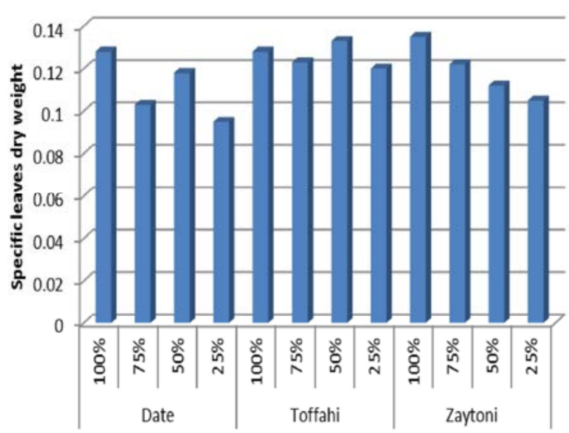


Fig. 5: Effect of different available soil water (100, 75, 50 and 25%) on the average number of leaves/plant

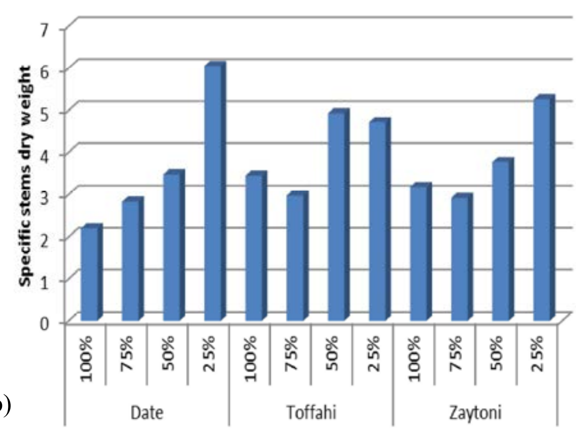
available water level gave the highest leaves fresh weight. In addition, Date genotype and Zaytoni genotype irrigated by 100% of available water level gave the highest leaves dry weight comparing with other interactions. On the other hand, Toffahi genotype irrigated by 25% of available water level showed the lowest significant leaves fresh weight in both seasons. In addition, Date genotype irrigated by 25%, Toffahi genotype irrigated by 50% and 25%, and Zaytoni genotype irrigated by 25% of available water level showed the lowest significant leaves dry weight in both seasons. This result agree with that found by Laz and Ismail [17]reported that increasing water stress reduced rate of fresh and dry weight of leaves on seedlings of Jujube.

Number of Leaves / Plant: Fig. 5a cleared that number of leaves/plant was affected significantly by applied treatments in both seasons. Irrigation at 100% available water recorded higher number of leaves/plant (95.33 in both seasons). It was clearly noticed that 100% available water level was followed by available water level at 75, 50 and 25% of number of leaves/plant in both seasons. Furthermore, in both seasons, Date genotype had the highest significant number of leaves/plant compared with other genotypes. The highest significant number of leaves/plant was recorded with Date genotypes (74.42 in both seasons). On the other hand, number of leaves/plant was not significantly affected by Toffahi genotype and Zaytoni genotype (65.88 and 64.67, respectively) in both seasons. The interaction between different available water level and three jujube genotypes treatments showed that Date genotype and Toffahi genotype irrigated by 100% of available water level gave the highest number of leaves/plant in both seasons. On the other hand, Toffahi genotype irrigated by 25% of available water level showed the lowest significant number of leaves/plant (27.00). These results were in agreement with those reported previously by Draz [18] who studied the response of bitter almond seedling to different water regime. Kassem and Issa [16] and Sole Riera [19] reported that leaf area and leaf number decreased with reduction in amount of applied water. Laz and Ismail [17] reported that number of leaves/ plant decreased by increasing water stress on seedlings of Jujube.

Specific Leaves Dry Weight and Specific Stem Dry Weight: Fig 6a and 6b revealed that Specific leaves dry weight and Specific stems dry weight were significantly affected by applied treatments in both seasons. Available water level at 100% recorded increasing in specific leaves dry weight (0.13 g/cm^2), while available water level at 25%



(a)



(b)

Fig. 6a,b: a) Effect of different available soil water (100, 75, 50 and 25%) on the average specific leaves dry weight
b) Effect of different available soil water (100, 75, 50 and 25%) on the average Specific stems dry weight

recorded increasing in specific stems dry weight (5.34 g/cm), respectively). Furthermore, the three studied jujube genotypes which were used in this study had also significant effect on the same parameters mentioned before in both seasons. It was clearly noticed that Specific leaves dry weight and Specific stems dry weight was highest significant in Toffahi genotype (0.12 g/cm^2) and (4.01 g/cm), respectively compared with the other treatments used. The interaction between different available water levels and the three jujube genotypes. The treatments appeared that Zaytoni genotype irrigated by 100% of available water level gave the highest specific leaves dry weight, while date genotype irrigated by 25% of available water level gave the highest Specific stems dry weight as compared with other interactions under study.

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