EFFECTS OF WATER DEFICIT ON DESERT DATE BALANITES AEGYPTIACA L UNDER FIELD CONDITIONS IN SOUTH EGYPT

EFFETS DE L'EAU DEFICITAIRE SUR LE DATTIER DESERTIQUE BALANITES AEGYPTIACA L. DANS LES CONDITIONS DES CHAMPS AU SUD DE L'EGYPTE

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ABSTRACT

Seedlings of Balanites six years old were treated after the second year of the transplanting by different amount of water stress, viz : 120% , 90% , 60% and 30% potential evapotranspirations (ETp). Field experiment was carried out at kom Ombo Experimental Station, Aswan Governorate, Egypt.

The study aims to ensure the multiple benefits of Balanites and its suitability under Egypt climate in unused lands under scarce water conditions. A most useful tree, the fruit of which is edible, oily, and gummy, has been suggested as a source of biofuel. Its ability to perform under dry conditions has hardly been investigated. The properties of the plant and its oil have persuaded investor and policy makers to consider Balanites as substitute for fossil fuels to reduce greenhouse gas emissions.

The results revealed that the average water consumption rate Balanites plants is 7L week -1 throughout the growing season , which means that Balanites can survive and produce full yield with high quality seeds under minimum water requirements compared to other plants. Drought significantly reduced leaf area, biomass and relative growth rate, but had no effect on leaf water content and transpiration efficiency. For all treatments, vegetative growths were markedly decreased by climatic conditions (high air temperature and high light intensity) during the summer period (June to August). At active growth phase (in spring and autumn), significant re-increase in all parameters was observed. The yield of extracted oil was 30.6, 48.3, 32.2 and 24.5 kg/ha-1 at 120 %, 90 %, 60% and 30% of ETp, respectively. In addition, water stress had no significant effect on the saponin composition of Balanites seeds.

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In view of these results it may be concluded that irrigation to this species during the vegetative growth phase (spring and autumn) and stopping it during the rest phase (summer and winter) could be recommended at least under the experimental conditions of this study.

Key words: *Desert date, Biofuel, Irrigation, Saponin, Oil yield, Egypt.*

RESUME

Les jeunes plantes de six ans Balanites ont été traitées après la deuxième année de la transplantation par la différente quantité de stress hydrique : évapotranspirations potentielles (ETp) étant de 120%, 90%, 60% et 30%. L'expérimentation a été effectuée sur les champs de la « Kom Ombo Experimental Station, Aswan Governorate » en Egypte.

L'étude vise à assurer les avantages multiples de Balanites et sa pertinence dans le cadre du climat de l'Egypte dans les conditions de disponibilité limitée de l'eau. Un arbre très utile dont le fruit est comestible, huileux et collant, a été proposé en tant qu'une source de biocarburant. Les propriétés de la plante et son huile ont persuadé l'investisseur et les décideurs d'envisager la production de Balanites en tant qu'un remplaçant de combustibles fossiles pour réduire les émissions de gaz à effet de serre.

Les résultats ont monté que le taux de consommation moyenne d'eau de la plante Balanites est de 7L semaine-1 tout au long de la période de croissance. Cela signifie que Balanites peut produire le rendement total avec les graines de grande qualité conformément aux conditions minimales d'eau par rapport à d'autres plantes. La sécheresse a significativement réduit la surface de feuille, la biomasse et le taux de croissance relatif, mais n'exerce aucun impact sur la teneur en eau de feuille et l'efficience de transpiration. Dans tous les traitements, les croissances végétatives ont diminuées de manière significative en raison des conditions climatiques lors de la période d'été (de juin à août). Dans la phase de croissance active (printemps et automne), on a constaté, de nouveau, une augmentation de tous les paramètres. Le rendement de l'extrait d'huile était de 30,6, 48,3, 32,2 et 24,5 kg/ha-1 à ETp de 120%, 90%, 60% et 30% respectivement. De plus, le stress hydrique n'avait exercé aucun impact significatif sur la composition saponine de graines de Balanites.

Dans la lumière de ces résultats, on peut conclure que l'on pourrait recommander l'irrigation de cette espèce lors de la phase de croissance végétative (printemps et automne) et l'arrêt de l'irrigation lors de la phase de reste (été et hiver) au moins dans les conditions expérimentales de cette étude.

Mots clés : *Dattier désertique, biocarburant, irrigation, saponine, rendement d'huile, Egypte.*

1. INTRODUCTION

Drought is probably the most important factor limiting crop productivity worldwide. In arid and semi-arid regions, where the amounts and patterns of seasonal rainfall are often erratic and unpredictable, deep rooting perennial species may exploit deep soil water reserves. This facilitates plant production in the situations of high light intensity coupled with drought, where shallow rooted annual crops would normally fail. The use of perennials may help buffer farmer's production against year to year fluctuations in yields common in annual crop species (Sean et al., 1998). Under such conditions, and ability to maintain cell water status (e.g. through osmotic adjustment) and cell integrity (by protecting cell against photo and chemical oxidation) may be an advantage. Drought tolerance is prevalent in plants that exit in areas where drought commonly occurs. Such plants encompass all physiological adaptations that extend the period of active growth by controlling water loss and turgor, and that enable cells to sustain water loss without damage to the metabolic systems. Effective control of water loss through stomatal closure, leaf drop or water uptake by enhanced root growth can all improve plant water status.

Heglig {Balanites aegyptiaca (L.Del.)} is the hardiest cultivated fruit tree grown all over in the drier areas (Suliman and Jackson,1959). It is a multipurpose tree that gives seeds, timber, fodder, medicines and potential industrial products (Abu-al-Futuh,1983). Heglig can be successfully cultivated even in the most marginal ecosystems of the subtropics and tropics where most of other fruit trees fail to grow or give very poor performance (Radwan, 2001). The tree has also been used as a live fence and windbreak.

Industrial Uses

B. aegyptiaca (L.) is a woody and medicinal tree growing in various ecological conditions (from 100 mm to 1000 mm annual rainfall), but mainly distributed in semi-arid and arid zones in tropical Africa (Von Maydell, 1983). This species is one of the most common in Sénégal. It is used for various needs such as fodder, medicines, charcoal and pesticides. The so-called desert date fruit of *B. aegyptiaca* has been the basis of an active trade for many centuries. The almond is rich in saturated fatty acids that is used as cooking oil. It also contains steroids (saponins, sapogenins, diosgenins) used as raw material for industrial production of contraceptive pills, corticoids, anabolisants and other sexual hormones (ONUDI, 1994). Various parts of the plants are used in folk medicines for the treatment of different ailments such as syphilis, jaundice, liver and spleen problems, epilepsy, yellow fever and the plant also has insecticidal, anthelmintic, antifeedant, molluscicidal and Contraceptive activities. Significant anti-inflammatory activity was evaluated in methanolic and ethanolic extracts of the bark of *B. aegyptiaca* in two different animal models. Hence, intensive and uncontrolled exploitation of *B. aegyptiaca* fruits, combined with low rate of natural regeneration has led to the drastic depletion of this species.

2. MATERIALS AND METHODS

Six seedlings per source per treatment in each block were assigned. Lot L0 was watered every three days to field capacity and lot L1 was subjected to three drought stress Cycles. In every stress cycle, water was with held until some seedlings show sign of wilting, after which irrigation for a recovery period was applied. The first cycle was for 10 days and 5 days for recovery. Cycle two ended in 14 days and 5 days recovery, while cycle three took 17 days and 7 days for recovery. Seedlings from L0 and L1 were measured for shoot height, root collar diameter, number of leaves and number of branches immediately before and after the stress treatment.

Leaf area and leaf weight were measured at the end of the stress cycles. Plotting paper was used for leaf area determination. Specific leaf area (SLA m^2 $100g^{-1}$) was calculated as leaf area divided by leaf weight. Specific leaf weight (SLW g cm^2) is a reciprocal of SLA which is weight divided by area. By the end of the recovery at cycle three (end of drought cycles), water was withheld from both treatments for one month and Death of seedlings was evaluated every week. A seedling is considered dead when all the leaves were completely wilted. At the end of survival test, all the seedlings were harvested and every seedling was separated into shoot, root and leaves. Shoot length, root length, and number of branches were measured. Leaves, shoots and roots dry weight were recorded and weight ratios were calculated.

Response of *Balanites Aegyptiaca* (L.) Del. Seedlings from Varied Geographical Source to Imposed Drought Stress.

Data analysis:

Two way analysis of variance (ANOVA) was done using SAS statistical analysis to determine the significance of treatments and provenances and the interactions on the measured variables. Duncan multiple range tests were used to compare the means. Correlation was analyzed to determine linear relationship between some parameters with seedlings mortality.

3. RESULTS

Drought cycles and geographical sources effects were significant on most of the measured variables, while the interactions were not significant for any of the variables. Leaves and shoot variables of seedlings subjected to drought cycles have lower values while root traits and survival were significantly higher than the regularly watered seedlings.

Shoot Parameters:

Provenances showed significant differences in shoot length, root collar diameter, number of branches and number of leaves before and after the drought cycles and at the final destructive harvest (Tables 1, 2 and 3). In general, DD and RW have the highest values in most of the traits and GB and IF have the least (Table 2).

Table 1: Mean shoot length, root length, number of branches and root collar diameter of Two Seasons (Summer & Winter) in B. aegyptiaca under Four irrigation levels during 2008/2009.

	Shoot length (cm)		Root length (cm)		Number of branches		Root collar diameter (cm)		Number of Leaves	
	S	W	S	W	S	W	S	W	S	W
120%	30.6^{a}	29.4^{ab}	43.0^{ab}	48.3^{a}	43.0^{ab}	48.3^{a}	2.9^{a}	3.1^{ab}	79^{ab}	80^{ab}
90%	24.4^{ab}	23.0^{abc}	34.2^{ab}	46.8^{a}	34.2^{ab}	46.8^{a}	3.8^{a}	3.4^{ab}	708^{ab}	54^{b}
60%	29.1^{ab}	30.2^{a}	47.4^{a}	50.3^{a}	47.4^{a}	50.3^{a}	3.0^{a}	3.2^{ab}	778^{ab}	90^{a}
30%	29.3^{ab}	27.9^{ab}	46.6^{a}	41.3^{a}	46.6^{a}	41.3^{a}	2.4^{a}	2.1^{b}	67^{ab}	65^{ab}
S (p)	0.001		0.6		0.01		0.0006		0.01	
TRT*S (p)	0.53		0.13		0.98		0.32		0.45	

Means with the same letter in the same column are not significantly different at P= 0.05 using Duncan multiple range test.

Leaves Parameters:

Leaf area, leaf weight, specific leaf area and specific leaf weight were highly significant between provenances (Table 3). Stress treatments reduced the values in most of the traits. DD and DM exhibit highest values in leaf area and weight, while GB and IF are the least. In contrast, SLA is higher in IF and GB.

Table 2: Mean leaf area, leaf weight, Specific leaf area and specific leaf weight of Two Seasons (Summer & Winter) in B. aegyptiaca under Four irrigation levels during 2008/2009.

	Leaf area LA (cm^2)		Leaf weight LW(g)		Specific leaf area SLA m^2 100g$^-$		Specific leaf weight SLW cm^2 g$^-$	
	S	W	S	W	S	W	S	W
120%	3.99^{a}	2.35^{a}	0.06^{ab}	0.039^{a}	0.69^{ab}	0.65^{ab}	0.015^{a}	0.015^{a}
90%	3.10^{b}	2.39^{a}	0.05^{ab}	0.037^{a}	0.63^{ab}	0.61^{b}	0.016^{a}	0.016^{ab}
60%	2.12^{cd}	1.41^{c}	0.03^{cd}	0.021^{de}	0.67^{ab}	0.69^{ab}	0.015^{a}	0.014^{ab}
30%	2.28^{bcd}	2.24^{ab}	0.04^{bc}	0.036^{abc}	0.60^{b}	0.62^{b}	0.017^{a}	0.016^{ab}
Treatment (p)	0.0001		0.0001		0.8		0.8	
Season (p)	0.0001		0.0001		0.09		0.8	
TRT*S (p)	0.05		0.2		0.4		0.3	

Means with the same letter in the same column are not significantly different at P= 0.05 using Duncan multiple range test.

Biomass:

The difference in total weight, shoot weight, leaf weight, and root weight is very highly significant between the sources. Water stress reduced shoot and leaf weight and increased root weight and root to shoot ratio.

Table 3: Mean leaves weight, shoot weight, root weight, root : shoot ratio, leaves weight ratio of Two Seasons (Summer & Winter) in B. aegyptiaca under Four irrigation levels during 2008/2009.

	Leaves weight (g)		Shoot weight (g)		Root weight (g)		Root: Shoot ratio leaves weight ratio			
	S watered	W	S watered	W	S watered	W	S watered	W	S watered	W
120 %	1.8^{a}	1.7^{a}	1.6^{a}	1.3^{a}	6.1^{a}	6.0^{a}	4.3^{b}	5.8^{ab}	0.23^{a}	0.22^{a}
90%	1.2^{bc}	1.1^{b}	0.9^{bc}	0.9^{ab}	4.2^{ab}	4.5^{ab}	5.5^{ab}	5.2^{ab}	0.21^{a}	0.21^{a}
60%	1.2^{bc}	1.1^{b}	1.0^{abc}	1.3^{a}	4.7^{ab}	4.6^{ab}	5.2^{ab}	4.9^{b}	0.22^{a}	0.19^{a}
30 %	1.2^{bc}	1.1^{bc}	0.8^{bc}	0.9^{ab}	4.6^{ab}	4.3^{b}	5.7^{ab}	5.1^{ab}	0.25^{a}	0.21^{a}
Treatment (p)		0.09		0.3		0.9		0.09		0.03
Season (p)		0.0001		0.0001		0.0008		0.02		0.3
TRT*S (p)		0.8		0.2		0.9		0.07		0.93

Means with the same letter in the same column are not significantly different at P= 0.05 using Duncan multiple range test

Survival:

Water stress significantly reduced seedlings mortality .Stressed seedlings start dying one week later than well-watered seedlings. IF and ZA have higher survival and DD, JZ and RW have the least. Positive correlation was observed between seedlings mortality with Specific leaf weight, soil type, leaf weight and leaf area, (r= 0.82 p= 0.01 and r= 0.79 p= 0.02, r= 0.63 p= 0.09, r= 0.54 pd respond to stress.

4. DISCUSSION

Seedlings of Balanites exposed to drought conditioning exhibit prolonged stress resistance and enhanced survival, suggesting that drought conditioning manipulated the adaptive traits in these seedlings. Similar findings were reported for other species (Stewart *et al*., 1994; Cregg, 1994; Mayne *et al*., 1994; Ranney *et al*., 1991; Polley, 1999; and Devitt *et al*., 1997).

The positive correlation of seedling mortality with leaf area and weight, reflect that these traits may be associated with drought tolerance. It is evident that small leaf is the most important factor in the survival of desert plants (Orshansky, cited in Kozlowski, 1976). This can further be explained by a marked reduction of leaf area and weight when Balanites seedlings were exposed to drought stress. Specific leaf area has negative relationship with seedlings mortality. Beadle (1995) stated that SLA is linearly related to relative growth rate, while Cregg (1994) observed that SLA is correlated to the climate of the source. Our data showed that SLA is related to the soil type, increasing in sandy and sandy clay loam soils and decreasing in clay soil. However, in general, provenances with higher SLA have lower rate of growth, but with higher survival.

Kozlowski (1976) cited that thickening of leaves by deposition of epicuticular waxes is one of the most important adaptive characters for drought avoidance. Our findings were in contrast with this. The study reported very high positive correlation of SLW with seedlings mortality. This means that seedlings with thick leaves have higher mortality. Our explanation to this contrasting result is that SLW may not have strongly responded to water stress. This can clearly be seen from approximately more or less the same values of SLW between well-watered and stressed seedlings in all provenances (Table 3).

There is a clear relationship between survival of the seed sources and original soil in their natural range. IF and ZA sources with higher survival are from sandy clay loam and sandy soil and RW and DD with least survival from clay soil. This indicates that provenances are genetically adapted to their respective sites, which may call for restriction in transfer of seeds between zones, especially of different soils. The significance of genetic control on drought tolerance occurred in many forest tree species (Abrams et al., 1990; Stoneman *et al*., 1994).

More than two-thirds of biomass was partitioned to the roots, indicating that this tree is well adapted to drought prone environments. The increased root to shoot ratio in stressed seedlings in most of the provenances may be related to the fact that under water stress conditions plants increase the allocation of photosynthate for root production to increase the surface area for absorption. The difference in adaptive response of Balanites seedlings to water stress among provenance indicate that establishment of Balanites under severe environments can be improved by selection of matching provenances in terms of their drought tolerance. There is strong evidence that (IF) provenance is well adapted to the drought. It has higher survival in both treatments, lowest leaf weight, smallest area, highest root to shoot ratio and germination data showed that it starts germination earlier, increasing very fast reaching peak and stopping (Elfeel, 2004).

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