EFFECT OF SEED ORIGIN AND SOIL TYPE ON GERMINATION AND GROWTH OF HEGLIG TREE (*BALANITES AEGYPTIACA (DEL.) L.VAR. AEGYPTIACA*)

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ABSTRACT

Seeds from eleven provenances of *Balanites aegyptiaca* were grown in two soils (silt and sand) in a randomized complete block design with four replicates. Germination was monitored for five weeks and growth parameters were evaluated at age 15 months. The results showed that soil has strong effect on germination and growth. Provenances exhibited high values in germination and growth under silty soil. Patterns of Provenances growth are similar in both soils, suggesting poor genotype-environment interaction at this stage. Ad Dinder provenance had grown fast, while Um Abdalla had grown slower. Cluster analysis showed grouping of provenances, but are neither related to soil type, nor to rainfall. Observed trends in provenances variation among provenances in adaptive traits, indicate genetic differences that can be utilized in conservation measures for this species.

KEYWORDS: *Balanites aegyptiaca*, provenance, germination, seedling growth

ملخص :

تمت زراعة بذور إحدى عشر مصدراً جغرافياً من بذور الهجليج في تربتين طفلية و رملية في أربعة مكررات عشوائية كاملة بهدف بحث تأثير المصادر الجغرافية والتربة على الإنبات والنمو. تمت متابعة الإنبات لمدة خمسة أسابيع والنمو لمدة خمسة عشر شهر. أظهرت النتائج التأثير المعنوي القوي للتربة على الإنبات والنمو. كان معدل الإنبات والنمو أعلى في التربة الطفلية. كان نمط النمو واحد في التربة الطفيليه و الرمليه مما يؤشر على ضعف تداخل المصدر مع التربة في هذه المرحلة. أظهرت منطقة الدندر أعلى معدل للنمو بينما أقلها منطقة ام عبد الله . بناءاً على صفات النمو تم

تجميع المصادر الجغرافية إلى مجموعات ، لكن هذه المجموعات غير مرتبطة بتربة المنشأ أو معدل الأمطار. الفروق المعنوية بين المصادر الجغرافية في صفات النمو تدل على وجود تباين وراثي لهذه الشجرة مما يساعد على استغلاله في برنامج الصيانة لهذا النوع.

INTRODUCTION

The extent to which populations differ for adaptive traits is important for selection of geographical sources for conservation or reforestation (Zobel and Talbert, 1984). The variation among sources in the adaptive genetic structure of the species is essential for the co-adaptation with the changing environments (Zobel and Talbert, 1984). Without this variation any attempt for conservation or improvement program is unsuccessful. The advantage of selection of matching seed sources with planting sites has been recognized for many years. The best tree improvement and conservation plans are those that have been used the proper seed sources and provenances. The fastest, cheapest and largest gains in forestry can be made by selecting and using the proper geographical sources of species (Zobel and Talbert, 1984). Many forest tree species including tropical trees exhibited a marked variation between and within provenances: *Eucalyptus camaldulensis* (Mohamood *et al*., 2003), *Eucalyptus urophylla (*Maelim *et al*., 2003), *Acacia crassicarpa, A. mangium and Eucalyptus urophylla* (Arnold and Cuevas, 2003), *Acacia nilotica* (Bimlendra *et al.*, 2002 and Shivanna *et al*., 2002), *Fagus sylvatica* (Nielsen and Jorgensen, 2003), *Casuarina equistifolia* (Zhong Chong *et al.*, 2001) and *Faidherbia albida* (Marunda, 1993).

Heglig tree occurs over a wide range of environments and soil types (Badi *et al*., 1989; Hall and Walker, 1991; Hall, 1992). This was reflected in a considerable phenotypic variation in fruit, seed, leaves, crown shape and time of flowering and fruiting (Von Maydell, 1986; Elamin, 1990; Sands, 2001; Gebaur *et al*., 2002). A part from the difference in seed shape and its effect on germination (Sayda, 2002), nothing or little have been done regarding genetic variation of this species. The tree species was identified by FAO in the priority list for Africa. It was considered as an over-exploited tree, that deserves urgent action in germplasm collection, provenance testing and conservation measures

(FAO, 2001). In order to preserve the tree, a law banning cutting of Heglig was enacted in Sudan (Warag *et al.*, 2002). To meet these requirements a genecological study of the species is very essential. Genecology refers to the study of intraspecific variation of trees in relation to environment (Cambell, 1979; Forest Genetics Team, 2003).

The objective of this study is to investigate provenance variation in germination and seedling growth parameters under two soil types. That is to investigate among provenance variation and to test provenance by soil interaction.

Specifically:

1- To investigate variation among 11 provenances in germination and growth parameters.

2- To investigate the effect of soil (silt and sand) on germination and growth performance of different provenances.

MATERIALS AND METHODS

A randomized complete block design with four replications was used. Each block consists of two soil types (silt and sand). Eleven provenances were randomly assigned to the soil types. The geographical locations of the provenances vary according to soil type, latitude, longitude and altitude (Table 1). Seeds from each provenance were sown in polythene bags (25X35 cm when flat). The bags were arranged in sunken beds under open uncontrolled conditions. 15 bags per soil type were randomly assigned for each of the eleven provenances in each repilcation. Single seed was sown in each bag. The total number of experimental units was 15 X 11 X 2 X 4 = 1320. Irrigation was applied every three days and every week from the age of 3 months onwards.

Germination was counted every week for five weeks and the total germination percent was calculated. Shoot length, root collar diameter and number of branches were measured at age 9 months and 15 months. Five seedlings in the centre of each replication were measured per provenance per soil type.

Data Analysis:

Arcsine transformation was done for germination data. Data was analyzed using analysis of variance (ANOVA) procedure to determine the significance of provenances and soil type for the measured parameters. Duncan multiple range (DMR) test was used for mean separation. Also, cluster analysis procedure was used for grouping of the provenances according to the measured growth parameters.

Table 1: Site description of the studied *Balanites aegyptiaca* provenances in Sudan

Location	Code	Latitude ^oN	Longitude ^oE	Soil	Rainfall mm	Seed zone[1]
Id Alfrissan	IF	11.483	24.350	Sandy clay loam	700	5.2
Abu Zabad	ZA	12.350	29.250	Sand	450	5.2
Abu Jubeiha	GB	11.450	31.233	Silty clay	700	4.1
Kassala	KL	15.467	36.400	Silty clay	400	2.4
Ar Rawashda	RW	14.200	35.583	Clay	600	3.1
Ad Dinder	DD	12.600	35.033	Clay	700	4.1
Ad Damazin	DM	11.767	34.350	Clay	700	5.1
Um Abdalla	UM	11.733	30.800	Clay	700	6.2
Kass	KS	12.500	24.283	Sandy clay	750	6.3
Al Abasseya	AB	11.450	31.233	Silty Clay	700	4.1
Boat	BT	12.176	36.033	Clay	700	5.1

[1] seed zones according to Aelbaek and Kananji (1995).

RESULTS

The effect of soil on germination and the measured growth parameters was highly significant ($p = \leq 0.0001$) (Table 2). Also, the effect of provenance was highly significant ($p = \leq 0.01$) (Table 2). However, soil by provenance interaction was not significant for all of the measured parameters (Table 2).

Table 2: Significance levels of the effect of soil type and provenance and their interaction on germination and growth parameters of *Balanites aegyptiaca* seedlings

Factor	**Parameters**			
Effect	Germination	Height	Root collar diameter	Number of branches
Soil	0.0001	0.0001	0.0001	0.0001
Provenance	0.0001	0.0001	0.0001	0.01
Soil*provenance	0.33	0.9	1.0	0.8

Germination:

There is a large significant difference in germination between provenances and the two soil type used (Table 2). Total germination percent was higher in all provenances in silt soil type (ranged from 60.6% to 41%), than sand soil, which ranged from 48.8% to 17.1% (Table 3). Comparing total germination percent with climatic and soil conditions prevailing in the original locations of the provenances (Table 1) showed no apparent correlation.

Growth parameters:

Soil effect on growth parameters was very highly significant (P= ≤ 0.0001) (Table 2). Growth parameters had higher values in the silt soil than sand soil (Table 4). Also, provenance effect was highly significant ((P= ≤ 0.0001 for shoot length and root collar diameter and P= ≤ 0.01 for the number of branches) (Table 2). Ad Dinder provenance had higher rate of growth, while Um Abdalla had the lower rate (Table 4). The interaction of soil by provenance was not significant for all growth traits (Table 2).

The cluster analysis showed grouping of provenances based on the aggregate of the growth parameters (Figure 1). However, the grouping was not associated with either soil type or with the rainfall prevailing in the original locations of the provenances (Table 1).

Table 3: Total germination percent *B. aegyptiaca* in silt and sand soil types

Provenance	Soil Type	
	Sand	**Silt**
Ad Damazin	42.9ab	60.6a
Id Alfrissan	48.8a	57.0ab
Kass	32.3abc	54.4abc
Boat	42.9ab	51.7abcd
Ar Rawashda	32.5abc	50.8abcd
Kassala	18.3c	48.9abcd
Um Abdalla	23.3c	48.9abcd
Ad Dinder	22.1c	46.9bcd
Abu zabad	21.0c	43.9cd
Abu Jubeiha	30.0bc	43.9cd
Al Abasseya	17.1c	41.0d

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

Table (4): Mean shoot length, root collar diameter (RCD) and number of branches for various sources of *Balanites aegyptiaca* seedlings (age 15 months) under silt and sand soils

Provenance	Silt			Sand		
	Shoot length cm	RCD mm	Number of branches	Shoot length cm	RCD mm	Number of branches
Ad Dinder	76.2a	9.6a	23a	48.0a	6.3ab	8.0b
Boat	51.9c	7.3abc	13a	45.6ab	5.3bcd	9.0b
Kassala	68.3ab	9.2ab	17a	48.1a	6.3ab	8.2b
Ad Damazin	48.9bc	6.5bc	12a	37.9ab	4.8bcd	8.0b
Ar Rawashda	55.0c	7.4abc	15a	50.4a	6.0abc	12.0ab
Um Abdalla	41.0c	5.7c	11a	29.5b	3.6d	8.0b
Al Abasseya	50.6c	8.0abc	19a	46.5a	6.3abc	13.0ab
Abu Jubeiha	45.5c	6.2c	15a	34.7ab	5.1bcd	10.0b
Kass	49.0bc	8.7abc	23a	51.1a	7.3a	20.0a
Abu Zabad	48.2bc	6.4bc	16a	39.5ab	4.3cd	6.0b
Id Alfrissan	45.5c	7.1abc	11a	35.1ab	4.7bcd	7.0b

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

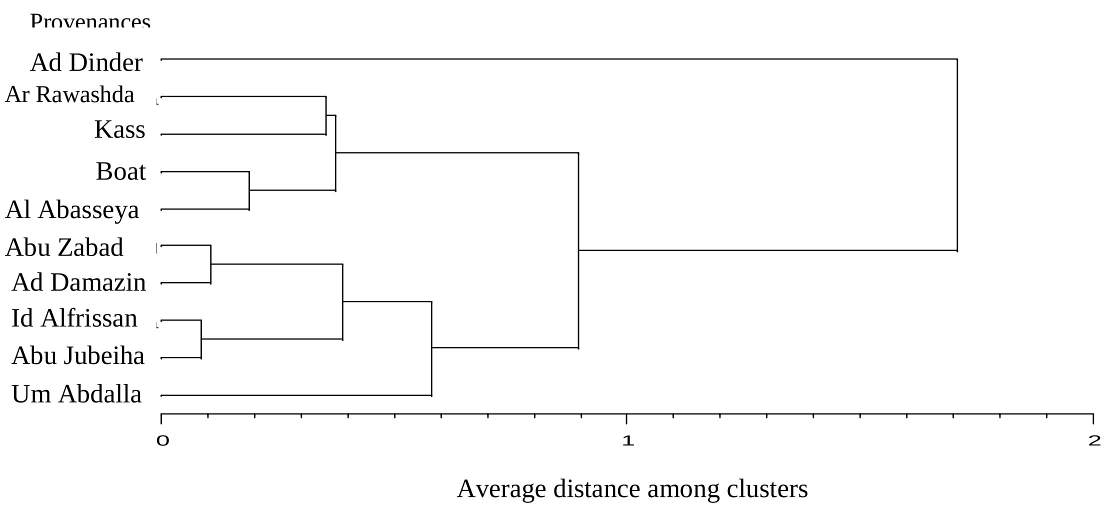

Figure 1: A dendrogram showing average linkage cluster of the studied provenances based on measured growth parameters

DISCUSSION

Soil type had strong impact on germination. All provenances exhibited reduced germination in sand soil (ranged between 17% - 48.8%). Lower germination percentages were recorded by Elnour *et al*., 1993 that ranged from 11 to 22%. However, silt soil significantly increased germination to the range of 41 to 60.6%. This result is similar to the germination of 33 to 61% cited by Hall and Walker, 1991), average germination in Tanzania (60%) (Hines and Eckman, 1993) and to the recorded data in Sudan (53.3%) (Elnour, 1994). In most of the provenances germination commenced on day 10 and ended on day 31. This in line with Teel (1984), who reported that germination, takes from 1- 4 weeks. No correlation was observed between germination and original soil of the seed sources. This is evident in the case of Ad Dinder and Id Alfrissan where they had the higher total germination percent but they were from clay and sand soils, respectively. However, from the data, there is a difference in germination trend where Id Alfrissan starts germination earlier and ceased 3 weeks before Ad Dinder. This supports the conclusion of Elfeel *et al.* (2007) that Id Alfrissan provenance is more adapted arid conditions, since it had higher survival under water stress conditions.

Similar to germination, the effect of soil on growth is high. Total growth in silt is faster than that in sand. Similar trend was obtained for this species by (Zorad *et al*., 1998). This may be in accordance with the performance of the species in its natural range. The best development of the tree is on low-lying alluvial sites with sandy loam soil (Suliman and Jackson, 1959; Von Maydell, 1986; Hall and Walker, 1991), and the poor development is on sandy soil (Schmidt, 2000). The Ad Dinder provenance had grown fast, while those from Id Elfrissan, Abu Jubeiha and Um Abdalla had grown slow. Other provenances had no consistent ranking. Earlier findings (Elfeel, 2004) showed that those four provenance, were found in less deteriorated habitats. On the other hand earlier data revealed that all other provenances were severely affected by mechanized cropping, over grazing, selective felling for furniture (Elfeel, 2004). The consequence may be removal of some genotype or gene complexes from these sites that affected the population genetic process resulting in unclear differentiation of these provenances. This may further be supported by the results of the cluster

analysis, where Ad Dinder and Um Abdalla (Nuba Mountains) which were well separated (Figure 1) are from less affected areas.
The absence of interaction between provenance and soil in growth parameters observed in this study reflects that provenances perform similarly in both soils. However, this should not mean that seeds can be transferred across different zones as this is an early stage of growth (15 month old seedlings) and that will not answer the presence or absence of late failure. Also, the observed differences in survival among these provenances (Elfeel *et al.*, 2007), and grouping according to ecological conditions indicates adaptation of provenances to their respective sites.
The high pattern of provenance variation showed by grouping and clustering of provenances (Figure 1) indicates genetic differences among them. This type of variation in adaptive traits is necessary for deciding the number of populations to be included in a conservation plan (Gradual *et al*. 1997). The clear differentiation of Ad Dinder and Um Abdalla provenances, suggests presence of many provenances for this species in Sudan. This should be considered when transferring seeds between zones or when making conservation plans for this tree species.

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