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Full Length Research Paper

Ecological study on *Dobera glabra* Forssk. at Jazan region in Saudi Arabia

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Research on *Dobera glabra* Forssk is very little. A study was carried out in Jazan (south western Saudi Arabia) on the ecology of *D. glabra*. The species was distributed over a large area, but with decreasing density towards the Red Sea coast. Generally, the density of the species is very little. This is combined with 0% survival of seedlings and samplings after 8 months made the species existence endangered and urgent intervention is required to conserve it. Although the frequency of flowering was normal, nevertheless fruiting is extremely little (0.29%) . The species regenerates well with seeds without any pretreatment, however, the seedlings require immediate protection from grazing and other human activities. Seedling growth is extremely slow. All attempts of vegetative propagation of *D. glabra* from cuttings, failed despite the use of suitable rooting media and growth hormones. Due to the importance of the species as a fodder during the dry season where most other resources are unavailable and as famine food for humans, further research is needed on how to conserve *D. glabra*.

Key words: *Dobera glabra,* germination, vegetative propagation, grazing, famine, foods, fodder.

INTRODUCTION

The use of wild plants as sources of food for humans seems more common and widespread in food insecure areas. Local people, from their own experience, know about the importance and contribution of these plants to their daily diet, as well as being aware of possible health and environmental hazards. *Dobera glabrea* (Forssk.) Poir. (Salvadoraceae) is distributed in India, Kenya, Saudi Arabia, Sudan, Tanzania, Ethiopia, Djibouti, Uganda and Yemen (Vogt, 1995). It is an ever-green tree with alternate thick skinny leaves. The flowers are white and the fruits are ovate purple when ripe (Vogt, 1995). Among the wild food plants found in the Afar Region (Ethiopia) is *D. glabra*, locally known as *'Garsa'* (Tsegaye et al., 2007). The plant grows in dry areas, on saline, heavy, or calcareous loam soils and on rocky hillsides. It grows abundantly in dry and moist lowland areas (400 - 1,300 m above sea level). *D. glabra* produces edible fruits and the seed is considered a typical 'famine-food' (Tsegaye et al., 2007). In Kenya the tree was reported as a source of traditional food plants (Anon., 1999). The Afar pastoralists appreciate its drought indicator qualities. They reported that new shoots, fruits and seeds are always produced during the dry season or if rains are delayed or failed. In normal times, when rains are on time or abundant, *D. glabra* does not produce much fruits and seeds. As such, when the tree blooms and produces fruits abundantly, people think that a drought may very well be under way and hence fear that food may become scarce. Afar people in Aba'ala wereda consider 'Garsa' as an important tree for camels. The tree is a good browse and is known as a mineral supple-ment to camels. Although the importance of *D. glabra* is highly appreciated as a food source and livestock feed and its adaptability to the area, there are some critical problems facing the species. Among many other pro-blems the main one as stated by the local people is that they do not see new regeneration of *D. glabra.* Only old trees are available. This was also reported from Yemen where *D. glabra* also doesn't produce any regeneration. Only old trees remained. (Tsegaye *et al.*, 2007).The more hardy and thorny species as *Ziziphus* and *Balanites* took over (Herzog, 1998). This is an indication to the fact that the plant is highly endangered and that extinction of the plant in the near future is inevitable if nothing is done (Tsegaye et al., 2007) . The socio economic surveys revealed that *D. glabra* is a highly valued plant species with diverse importance such as drought food and source of feed, a special mineral source feed, a tool for forecasting the droughts,

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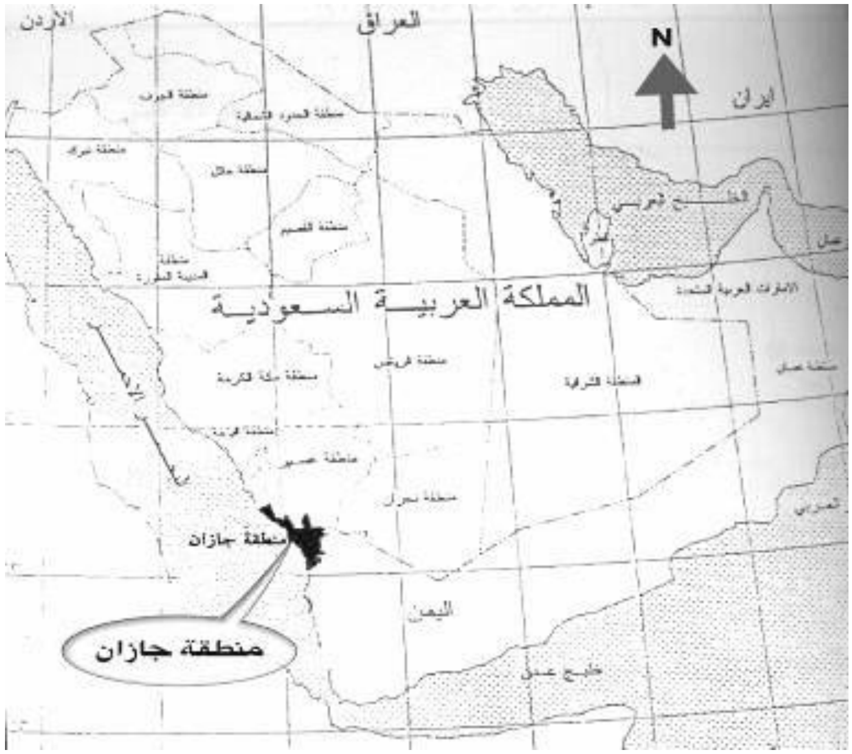

Figure 1. The Study area.

thus an early warning tree, etc. No germi-nation viability variation was observed as a result of storage (3 months). However, treating *D. glabra* seeds has brought a positive effect in shortening the germi-nation time, and best results were observed when the seed is soaked in cold water for 24 h. The general total ash content is high, 21% for the leaves and 8% for the fruit on average. The result implies that *D. glabra* is high in mineral content as believed by the pastoralists. The crude protein content is also high to support animals' requirement if browsed well. Laboratory analysis on the nutritive value of the edible part of *D. glabra* also reveal-ed that this plant has nutritive value nearly comparable to the most common wild food fruits. A critical look at the findings of the different studies and experiments indicates that there is an urgent need to take measures through appropriate propagation and protection means. Results from all germination trials also indicate that the best way to propagate the plant is by using the seeds as in almost all the germination trials about 80% of all the seeds ger-minated. The fact that the plant produces more biomass during the sever drought times is a very great mystery. Further detailed studies targeted at the physiological and adaptation ecology of the plant may result in information that may help the combat against desertification anywhere in the world and specifically in the study area (Tsegaye et al., 2007). The seed of *D. glabra* is com-posed of the outer coreaceous exocarp and the meso-carp and both contained germination inhibitors (Schaefer (1989) . The removal of the exocarp increased the germi-nation per cent from 8 - 57%, whereas removal of the mesocarp increased the germination to 70% (Schaefer (1989) . Tsegaye et al. (2007) reported that *D. glabra* seeds need no pre-treatment to germinate and hence direct sowing is the best way for regeneration and the seeds can not be stored well. The tree grows naturally in Saudi Arabia in depressions, however, the numbers are diminishing, sparsely distributed and only few trees remained.

The present study was undertaken with the following objectives:

1. To study the distribution of *D. glabra* in its natural habitat in Jazan.
2. Determination of flowering and fruiting times.
3. Germination of seeds on various media and determination of the germination % and rate.
4. To study the possibility of vegetative propagation of the species.

MATERIALS AND METHODS

The study area

The study was carried out in Jazan (1632 km from Riyadh) in the south western part of Saudi Arabia (42° and 43°.8 longitude and 16°.22 and 18°.10 latitude) (Figure 1). It is a tropical area and borders Yemen from the south and east and the Red Sea from the west. Maximum temperature in summer reaches up to 50°C and the

Table 1. Annual Rainfall (Hroob Meteorological Station, 1970 - 2006).

mm	Year	mm	Year
52.5	1990	536.2	1970
391.4	1991	456.5	1971
501.5	1992	854.1	1972
901.5	1993	588.8	1973
519	1994	661.9	1974
1378	1995	642.1	1975
370	1996	1088.3	1976
64.5	1997	1233.5	1977
737.3	1998	1479	1978
962	1999	872.2	1979
710.9	2000	511	1980
300.4	2001	304.5	1981
246.9	2002	297	1982
327	2003	135	1983
503.5	2004	522.5	1984
402.75	2005	528.1	1985
453.75	2006	677.3	1986
		415	1987
		390.5	1988
		679	1989

mean minimum and maximum temperature is 26 and 35°C, respectively. Relative humidity is relatively higher in winter and lower in summer. Generally, the mean relative humidity is > 60% all the year around Jazan receives relatively higher rains compared with other parts of Saudi Arabia. For instance Hroob Mountain receives about 654 mm of rainfall annually and the mean is never less than 597 mm. However, the mean annual rainfall is comparatively much less along the coast (100 mm). These rains are irregular, but more commonly fall in winter and spring (Table 1).

Distribution of *D. glabra* in Jazan

The natural distribution of the species was determined in 22 locations and the coordinators and the corresponding altitudes were determined using a GPS.

Measurements of seedlings and trees

Measurements of seedlings and survival rate: A total of 24 seedlings, which were inaccessible to animals or protected somehow, were selected randomly. Total length of seedlings was measured in the beginning and after four months to determine the relative growth in total height. The following equation was used:

$$\text{Height RGR} = (\log_e H_2 - \log_e H_1) / t_2 - t_1 = \text{cm cm}^{-1}\ \text{month}^{-1}$$

Where;
RGR= Relative growth rate
H_1= First total height measurement
H_2= Second height measurement (after 4 months)
t_1= Date of first measurement
t_2= Date of second measurement

The survival rate of seedlings was determined as a percentage on 4 monthly basis as follows:

$$\text{Survival rate} = \frac{\text{The number of survived seedlings}}{\text{The total number of seedlings}} \times 100$$

Measurements of tree diameter, total height, crown and density: Five locations namely: Shegaig, Alhago, Al Husseini, Hroob, Aidabi and Alaarda were chosen for the measurements. Five trees were randomly chosen in each location and measured. In each location, 100 x 100 m quadrats were established in each location for the determination of tree density.

(a) Measurement of tree diameter: A caliper was used to measure the diameter at breast (1.3 m) height (DBH)**.**

(b) Measurement of total height: A measuring stick was used to measure the total tree height from the ground level to the top most point of the crown.

(c) Measurement of tree density: Tree density was determined by counting the number of trees/0.1 ha in each location.

Flowering and fruiting

Flowering and fruiting were monitored on five randomly selected trees each in two locations (Al Reeth Road and Alhago) due to the relative difference in altitude. Monitoring of flowering and fruiting continued for two months. Five out of the ten trees in the two locations were randomly selected. Five 50 cm long branches were randomly chosen from each tree to count the number of flowers and fruits one month after pollination. Eighteen ripe fruits were weighed, oven dried and the oven dry weight was determined. The number of fruits and seeds in one kg was counted.

Regeneration experiments

Germination of seeds: Ripe fruits of *D. glabra* were collected randomly and seeds were extracted from the fleshy layer of the fruit. The seeds were not pre-treated and sown directly in pots (30 cm diameter) at the rate of 25 seeds per pot in six types of soil mixtures in a completely randomized block design as follows:

a. Sand.
b. Sand + peat moss (1:1).
c. Sand + clay (2:1).
d. Sand + clay (1:2).
e. Clay + peat moss (1:1).
f. Clay.

Each soil type was replicated four times. Pots were irrigated every other day and the germination percent, speed and rate were recorded for one month. The rate of germination speed, germination percent and germination time were calculated using the following equations:

$$CV = \frac{\sum_{1-1}^{c} Ni}{\sum_{1-1}^{c} NiTi}$$

Where;
CV = rate of germination speed
N= the number of germinated seeds/day
T= Days since start of experiment till germination every day.

$$MGT = \frac{\sum_{i-1}^{c} TiNi}{S}$$

Where;
MGT = Mean germination time
Ni = Number of germinated seeds in day 1.
Ti = Days
S = total number of seeds

$$\mathbf{PG} = \frac{\sum N \times 100}{100}$$

Where;
PG = percent germination
N = total number of seeds.

Growth of seedlings: Three seedlings were randomly selected from each soil type and measured after 2.5 months for height and diameter 2 cm from the soil surface using a digital micrometer. A second measurement of the same seedlings was recorded after 4 months to determine the rate of vertical and radial growth of seedlings. The following equations were used:

Height RGR = (loge H_2 - loge H_1) / t_2 - t_1 = cm cm^{-1} month^{-1}

Where;
RGR= Relative growth rate
H_1 = First measurement of height
H_2 = Second measurement of height
t_1 = Days after first measurement
t_2 = Days after second measurement

Diameter RGR = (loge D_2 – loge D_1) / t_2 - t_1 = mm mm^{-1} month^{-1}

Where RGR= Relative growth rate
D_1 = First measurement of diameter
D_2 = Second measurement of diameter
t_1 = Days after first measurement
t_2 = Days after second measurement.

Vegetative propagation: Vegetative propagation experiments were carried out using cuttings. A number of healthy 50 cm long branches of *D. glabra* were cut. Lateral and basal cuttings were obtained using sterile scissors. Plastic pots (25 cm diameter) filled with perlite were used as growth medium for cuttings. Three growth hormones were prepared as follows:

1. Indole-3-butyric acid (IBA): 500, 1000, 2000 and 3000 ppm.
2. Naphthaleneacetic acid (NAA): 500, 1000 and 2000 ppm.
3. IBA + NAA: 500 + 500 ppm and 1000 + 1000 ppm.
4. Control (untreated).

Each cutting was dipped into each concentrate for five seconds and then left for five minutes to allow hormone absorption. Then the cuttings were transferred to the potting medium and irrigated daily by mist. The experiment was designed as completely randomized block design and continued for 3 months and cuttings were checked for rooting.

RESULTS

Distribution of *D. glabra* in Jazan

Table 2 summarizes the results of the distribution of *D. glabra* in Jazan. The species is distributed over a wide area of Jazan ranging from 128 to 1102 m above sea level (16°39'37.03" - 17°41'34.18" N-42°27'04.37" - 43°11'16.08" E).

Measurements of seedlings and survival rate

In 4 months period only 8 seedlings survived (33.3%) and the rest have diminished. After 8 months the survival rate was 0%. The mean relative growth rate in total height was 0.08 cm cm^{-1} month^{-1} calculated over 4 months.

Measurement of tree diameter, height, crown and density

The results of tree diameter, total height and crown are summarized in Table 3. It is evident that tree height, diameter and crown were significantly affected by location. For instance, the maximum mean total height and mean crown diameter were recorded at Aidabi (10.7 m and 10.9 m, respectively; 242 m above sea level, 17°14'34.12" N – 42°57'02.25" E), whereas the minimum mean diameter and mean crown diameter were recorded at El Shegaig (3.95 m and 4.88 m, respectively, 8 m above sea level,

Table 2. Distribution of *Dobera glabra* in Gizan area.

Location	Altitude m	Latitude and Longitude	
		E	N
Amood	956	43° 01'16.31"	17° 34'09.58"
Wadi Ree	1102	43° 03'29.33"	17° 24'26.61"
Al Dayer	733	43º 07'11.53"	17° 21'16.05"
Beni Malek	683	43° 07'19.74"	17° 19'42.78"
Aiban	632	43° 02'23.16"	17° 14'07.66"
Akar	296	43° 02'56.20"	17° 12'09.06"
Al hemaira	273	43° 03'40.44"	17° 073'0.98"
Malaki	181	42° 59'20.00"	17° 05'10.88"
Aidabi	242	42° 57'02.25"	17° 14'34.12"
Arag	178	43° 01'34.70"	16° 57'57.74"
Al Aarda	238	43° 06'27.84"	16° 58'53.36"
Gabal Sahal	241	43° 07'05.30"	16° 55'13.15"
Al Sood	254	43° 07'43.16"	16° 55'02.35"
Al Gabri	254	43° 11'16.08"	16° 39'37.03"
Al Khoba	255	43° 11'16.08"	16° 49'05.06"
Cement Factory	129	43° 03'26.05"	16° 42'45.65"
Al Hago	181	42° 40'05.44"	17° 28'51.40"
Al Sada	537	42° 45'30.66"	17° 38'50.73"
Al Reeth	802	42° 44'26.39"	17° 36'33.55"
Beni Magra	128	42° 27'04.37"	17° 41'34.18"

Table 3. Growth parameters of *Dobera glabra.*

Location	DBH (cm)	Total height (m)	Crown diameter (m)
Al Shegaig	19.8 d	3.95 c	4.88 c
Al Hago	67.6 ab	7.66 b	8.17 b
Horoob	49.4 bc	7.46 b	6.83 bc
Al Aidabi	74.2 a	10.74 a	10.9 a
Al Aarda	44.4 c	7.69 b	8.2 b
L.S.D.	21.24	1.84	2.25

Means followed by the same letter in a column are not significantly different.

17°43'10.21" N - 42°00'30.57" E). There were no significant differences between the remaining locations. Similarly, the maximum tree diameter was recorded in Aidabi (74.2 cm) and the minimum in El Shegaig (19.8 cm). The maximum tree density occurred in Al Aarda (40/ha) and the least density was 10/ha (Aidabi).

Flowering and fruiting

Flowering started in mid January and flowers opened in February. However, the maximum flowering was recorded at the end of February. By the end of March, most of the flowers were pollinated and small sized fruits started to show. Generally, the frequency of flowering is high; nevertheless the ratio of fruiting was extremely low. The average period from pollination to fruit maturity was 2.5 months. One month after fruiting, only 1% of the fruits remained and the majority were lost. The results of the mean fruit weight during the period April-June were summarized in Table 4. There were no significant differences between weights of fruits collected randomly from five trees. The mean moisture content of seeds and fruits was 63.2 and 43.1%, respectively and the number of seeds and fruits/kg was 323 and 152 respectively. The fruits were 24.9 long and 19.5 mm wide on average, whereas, the average dimensions of seeds were 18.8 and 14.9 mm in length and width, respectively.

Germination experiments

The type of soil had a significant effect on germination speed, total days of germination and the germination %

Table 4. Mean weight of fruits of *Dobera glabra.*

Date	21 June	6th June	20 May	6th May	21 April	6th April
Tree No.			**Mean weight (g)**			
1	66.0	38.7	26.2	16.1	7.6	2.6
2	65.0	40.0	27.1	16.7	8.9	2.7
3	65.5	38.0	25.7	13.8	5.5	2.5
4	66.0	39.0	25.8	15.2	6.9	2.6
5	64.0	38.5	25.7	15.0	6.9	2.6

Table 5. The effect of soil on germination of *Dobera glabra.*

Soil type	Germination %	Germination time (days)	Mean germination speed
Sand	91.0 a	21.19 a	0.047 a
Clay	64.0 b	28.7 a	0.035 b
Sand + Clay (2:1)	80.0 c	24.61 abc	0.04 b
Sand + Clay (1:2)	77.0 d	26.72 ab	0.038 b
Clay + peat moss	70.0 e	25.3 abc	0.039 b
Sand + peat moss	77.0 d	24.36 bc	0.047 a
L.S.D.	0.16	4.31	0.006

Means followed by the same letter in a column are not significantly different.

(Table 5). The germination speed was significantly higher in sand and sand + peat moss than in other types of soil. There was no significant difference in germination speed in clay, sand + clay (2:1), and (1:2), clay + peat moss and sand + peat moss. Total days of germination were significantly less in sand as compared to other types of soil (Table 4). The highest germination % occurred in sand (91%) and the least (64%) was in clay soil. Germination started after 17 days with one seedling in sandy soil.

Growth of seedlings

Soil type had a significant effect on the relative growth of seedlings. The maximum relative growth of diameter occurred in sand + clay soil (1:2) (0.108 mm) and clay soil (0.101 mm) and the difference was not significant (Table 6), followed by clay + peat moss (0.085 mm) and sand + clay (2:1) (0.084 mm) and the least was recorded in sand + peat moss (0.065 mm). Regarding the relative growth rate of seedling height, the maximum occurred in clay (0.088 cm) and sand + clay (1:2) (0.073 cm), whereas the minimum occurred in sand and sand + peat moss (0.029 and 0.037 cm, respectively.

Vegetative propagation

After 5 months, neither callusing nor rooting occurred in all treatments.

DISCUSSION

D. glabra is distributed over a wide range in the study area ranging from 8 m to 1102 m above sea level. However, the density of the species decreases towards the Red Sea coast. In contrast, Tsegaye et al. (2007) reported that *D. glabra* is distributed between 400 and 1300 m above sea level in Ethiopia. The maximum tree height and diameter recorded in this study were 15 m and 98 cm, respectively. In contrast the average height, stem diameter and crown diameter were 3 m, 17 cm and 4 m respectively in the Kalah plain in Ethiopia, Nevertheless, Azene et al. (1993) reported a maximum of 8 m in height. The density of the species is low (40, 13 and 10 trees/ha in Al Aaarda, Al Aidabi and Al Shegaig, respectively) probably due to human activities and grazing in the area. In the Kalah plain in Ethiopia, the density was 41 trees per hectare and it is higher along river channels which make it one of the major riverine vegetation communities (Aynekulu et al., 2007). The present study suggests that seedling survival is one of the main problems facing *D. glabra*. This was indicated by the fact that within 4 months only 33.3% of the seedlings survived and the rest have diminished. After 8 months the survival rate was 0%. This is in agreement with Herzog (1998) who stated that only old trees existed and no seedlings seen in Yemen. The more hardy and thorny species as *Ziziphus* and *Balanites* took over (Herzog, 1998) . Tsegaye *et al.* (2007) also reported the non existence of young seedlings in Ethiopia. The diameter-frequency distribution of *D. glabra* indicated that the majority of the trees are ma-

Table 6. The relative growth rate (RGR) of seedlings of *Dobera glabra.*

Soil type	Diameter RGR (mm)	Height RGR (cm)
Sand	0.074 [bc]	0.029 [d]
Clay	0.101 [a]	0.088 [a]
Sand + Clay (2:1)	0.084 [b]	0.045 [cd]
Sand + Clay (1:2)	0.108 [a]	0.073 [ab]
Clay + Peat moss	0.085 [b]	0.066 [bc]
Sand + Peat moss	0.65 [c]	0.037 [d]
L.S.D.	0..012	0.020

Means followed by the same letter in a column are not significantly different.

ture (56% have diameter range between 15 - 20 cm) but having fewer seedlings and saplings that makes the population less viable which necessitates appropriate management intervention (Aynekulu, 2007). Added to this problem, is the very slow relative growth rate of the seedlings (0.008 cm^{-1} $month^{-1}$). This has confirmed the early finding of Azene et al. (1993) who reported that the seedlings growth was extremely slow. Flowering commenced in mid January and at the end of March. Fruiting started at the end of March. Although the frequency of flowering was generally satisfactory, however, fruiting is extremely low. For instance, only 2 (0.29%) flowers successfully produced fruits out of a total of 695 flowers. This was probably due to feeding on flowers by some insects or other types of animals or perhaps due to problems related to the fertility and/or viability of the flowers. The germination % and speed were significantly more in sandy soil alone or mixed with peat moss than in clay and other types of soil. Thus, it may state that germination of *D. glabra* is best in light and porous soil as compared to heavy soil. It is evident that the relative radial and vertical growth rate of seedlings was extremely little regardless of the type of soil. All cuttings used for vegetative propagation failed completely to callus and rooting. This has confirmed the findings of Tsegaye et al. (2007), who reported zero rooting in 72 cuttings taken from branches of D*. glabra*. It isn't uncommon that some plant species have little or no capability to regenerate vegetatively despite the use of growth hormones (Ofori et al., 1996; Shiembo et al., 1996; Lebrun, and Roggemans 1998 and Itoh et al., 2002).

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