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Studies on Seed Germination and Seedling Emergence of Mesquite, *Prosopis juliflora* (Swartz) DC. in Sudan Gezira

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Abstract Mesquite, *Prosopis juliflora* (Swartz) DC, was introduced in many semi-arid areas of Sudan to combat desertification and provide fuel wood and fodder. However, it spread rapidly into fertile, productive areas, and irrigation and drainage channels, particularly in some of the major irrigated schemes. Nursery experiments were conducted at the Faculty of Agricultural Sciences, University of Gezira, Wad Medani, Sudan, to investigate water uptake by seeds, germination-rate, sowing depth, acid scarification and animal feeding of intact pods on germination and seedling emergence. Pods were collected from town, or the National Tree Seed Center laboratory. Seeds were used immediately after extraction. Petri-dishes with filter paper or plastic pots were used. Treatments were arranged in CRB design, with 4-6 replicates. Data were subjected to ANOVA and DMRT. The results revealed that the seeds have high ability to absorb water and exhibited high rate of germination, especially in the second wk after sowing (96%). Seeds placed on the soil surface failed to germinate, while those buried at depths of 2.5, 5, 7.5 and 10 cm displayed 100, 75, 60 and 40% germination, respectively. Seedling emergence was delayed by deep burial and amounted to 100 and 50% at depth of 2.5 and 5cm, respectively. Seeds germinated and seedlings have emerged at high rates (100%), when treated with sulfuric acid (60%v/v) for 5 min. they germinated and seedlings emerged normally, when extracted from sheep droppings.

Keywords Mesquite, *Prosopis juliflora*, Seed Germination, Imbibition, Seedling Emergence, Acid Scarification, Animal Feeding Effect

1. Introduction

The genus *Prosopis* (mesquite), belongs to the family Leguminosae, sub-family Mimosoideae. At least 44 species have been described, and there is still much confusion over the taxonomy of the genus. Most species are native to the Americas, ranging from the southwestern USA, through Mexico and Central America into South America, as far as Argentina. It was then introduced to Australia, Dominican Republic, India, Venezuela, Iraq and the Sudan. At least three species, viz. *P. glandulosa* Torr., *P. juliflora* (Swartz) DC. and *P. ruscifolia* Gris., are aggressive woody weeds that cause major problems in grass land. Most species require at least 250 mm annual rainfall, but some have been found in areas with <100 mm. *P. juliflora* is a shrub native to Mexico, South America and the Caribbean. It is fast growing nitrogen-fixing and tolerant to arid conditions and saline soils. The shrub is known to hold the record for depth of penetration by roots. *P. juliflora* roots were found growing at a depth of 53.3 m at an open-pit mine near Tucson, Arizona. Study conducted by Elfadle and Luukkanen (2006)[1] suggest that the root system has allelopathic and allelochemical effects that inhibits the germination and spread of other plant species. Reports from the South American Center of Diversity revealed that mesquite survives and flourishes in heavy or sandy soils, as well as saline dry flats. Mesquite can tolerate drought and grazing. Some Argentine germplasm (2n = 28, 52, 56, 112) tolerated mild frost at 40° S latitude [2, 3]. The distribution probably ranges from Tropical Thorn through Sub-tropical Thorn to Dry Forest Life Zones (with little frost). Mesquite is reported to tolerate an annual precipitation of 150 to 1670 mm, annual temperature of 20.3 to 28.5°C, and pH around neutral[4].

In the Sudan, *Prosopis* spp were introduced in many semi-arid areas, to combat desertification and provide fuel wood and fodder[5]. However, this species have spread rapidly into fertile, productive areas, and irrigation and drainage channels, particularly in some of the major irrigated schemes like Zeidab, New Halfa and Gash Delta, Gezira, Khartoum, etc. Invading *P. juliflora* tends to form dense, impenetrable thickets, associated with unfavorable impacts on human economic activities. In addition, it suppresses the growth of other plant species by denying the plants the most

valuable growth factors, light and water. In northern Sudan (Gash delta of the Atbara River), the land has been almost completely taken over by *P. juliflora*[6]. Similarly, in the Awash basin of Ethiopia, it is aggressively invading pastoral areas in the Middle and Upper Awash Valley, and Eastern Harerge. It is one of the three top priority invasive species in Ethiopia, Sudan and Kenya and has been declared a noxious weed. Sudan has passed a law to eradicate it[7]. Moreover, it has already infested large tracts of land in the industrial and residential areas. The same trend was reported in other countries by El-Keblawy and Al-Rawai[8], Rout and Callaway [9].), Inderjit et al[10].

Information on the biology of *P. juliflora* in the Sudan is rather limited, despite its potential hazard as a noxious weed. The objectives of this investigation are to study some factors affecting mesquite seed germination and emergence

2. Material and Methods

Collection of Pods

The experiments undertaken in this study included germination aspects and seedling growth, as influenced by soil and environmental factors. All experiments were conducted under laboratory or nursery conditions at the Faculty of Agricultural Sciences, University of Gezira, Nesheshiba, Wad Medani, Sudan.

Pods were collected from Wad Medani area, Gezira state, Central Sudan, or brought from the National Tree Seed Center laboratory (NTSCL), Soba, Khartoum state. The pods were kept in paper bags and stored under laboratory conditions until needed. Seeds were extracted from pods (using sharp scissors), and used immediately after extraction. In all experiments, unless stated otherwise, Gezira soil was used. The soil was sieved through a 2 mm mesh screen. Gezira soil is characterized by containing 15% sand, 32.5% silt, 52% clay and 0.5% organic matter with PH 7.8[11]. Petri-dishes (6 cm i.d) with similar size filter paper were used in water uptake (WU), i.e. imbibition, germinate- rate (GR) and seed treatment/scarification (ST) experiments. Plastic pots (14 cm in height and 13 cm i.d.) with drainage holes at their bottom were employed in seedling emergence (SE) experiments, i.e. seed burial depth (SBD), and STs. Treatments were arranged in complete randomized block (CRB) design, with 4-6 replicates. Data, unless stated otherwise, were subjected to ANOVA and Duncan's Multiple Range Test (DMRT). Details of individual experiments are given below.

Water Uptake (Imbibition) by Seeds

An experiment was conducted under laboratory conditions during April. Seeds (50) were, as mentioned earlier, placed on filter paper in Petri-dishes. The filter paper was moistened with 2.5 ml of distilled water (DW), and incubated in the dark (Ali, 1998). Seeds were weighed before moistening, and re-weighed after incubation for 1, 2, 3, 4, 5, 6, 12, 18, 24, 48 and 72 hr. WU was expressed as % of the dry-weight (D.wt.) of seeds.

Germination (G) and Germination-rate (GR)

P. juliflora seeds (10) were treated as above in the Petri-dishes and were examined for germination daily for a period of 14 days. Germination was expressed as percentage of the total number of incubated seeds.

Effect of Sowing Depth (SD) on Seed Germination (SG) and Seedling Emergence (SE)

Seeds were placed on the soil surface or planted at 2.5, 5.0, 7.5, 10.0, 20.0 and 30.0 cm depth. The pots were irrigated every 24hr. Germinating seeds and emergence of seedlings were counted daily and expressed as percentage of the total number of planted seeds.

Effect of Acid Scarification and Sheep Feeding on Seed Germination (SG) and Seedling Emergence (SE)

Seeds were soaked in concentrated H_2SO_4 (60% v /v) for 5 min and washed in running tap water for another 5 min. Treated and untreated seeds (5 each) were placed in Petri dishes, as above, and tested for germination. Moreover, seeds (5/pot) were planted at 2.5 cm depth. Emerged seedlings were counted daily for 15 days. Untreated seeds were included as controls.

Three sheep were fed intact pods, beside their normal diet. Seeds were extracted from droppings after 24–36 hr and washed with tap water. These seeds were subjected to the above-mentioned germination and emergence tests. The control seeds were those obtained from normal pods.

3. Results

Water Uptake (Imbibition) by Seeds

Weight of moistened seeds of *P. juliflora* gradually increased with time during the first 18 hr after incubation. However, the increase was not significant. A surge in seed weight took place during the period 18-24 hr, and then slowly increased for the rest of the incubation period. Significant differences in seed weight were revealed 24-72 hr after incubation (Table 1). The results showed that the seed weight increased by 18.5% in 3 days.

Water imbibition by seed followed the same trend as seed weight. Imbibition progressively increased with incubation period and maximum WU was attained 48-72 hr after incubation (Table 1).

Table 1. Seed weight (mg/seed) and water uptake (µl/ seed) by *P. juliflora* seed at varying periods

Parameter	Time after incubation (hr)											
	0	**1**	**2**	**3**	**4**	**5**	**6**	**12**	**18**	**24**	**48**	**72**
Mean seed weight	29.1c	29.22c	29.33c	30.17c	30.16c	30.48c	30.88c	31.12bc	31.68abc	33.72ab	34.16a	34.48a
S.E. (±)	0.908											
Mean WU (imbibition) /seed	-	0.12c	0.23c	1.08c	1.06c	1.38c	1.78c	2.02c	2.58bc	4.62ab	5.06ab	5.38a
S.E.(±)	0.916											
C.V.%	6.51%											

Means followed by the same letter (s) are not significantly different according to Duncan's Multiple Range Test.

Table 2. Percentage of germination (G) and germination rate (GR) at different days after incubation (DAI)

Time after incubation (days)														
Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14
GR/day	1	2	1	1	2	7	4	4	10	3	2	5	2	4
% GR/day	2	4	2	2	4	14	8	8	20	6	4	10	4	8
%G	2	6	8	10	14	28	36	44	64	70	74	84	88	96

Germination and Germination Rate

Seed germination (G) progressively increased with the incubation period. Germination increased slightly during the first 5 days (14%). A surge in germination (44%) was displayed during the period 6-8 days after incubation (DAI). On day 9, another surge in germination occurred (64%) and, then germination gradually increased during the rest of the incubation period (70-96%; Table 2). GR was inconsistent and low during the first 5 days of incubation (2-4%). There was a surge in the GR on day 6 (14%), which declined on day 7-8 (8%). The highest GR (20%) was attained 9 DAI. An inconsistent sharp decline in the GR commenced during the rest of the period (4-10%; Table 2).

Effect of Sowing Depth on Seed Germination and Seedling Emergence

Seeds placed on the soil surface or buried at depth below 10 cm failed to germinate. However, seeds were able to germinate at a burial depth of 2.5-10 cm. At these depths, germination decreased with increased depth. Seeds buried 2.5 cm deep, displayed complete germination (100%). At this depth 50, 85 and 100% of the seeds germinated 1, 2 and 3 days after planting (DAP), respectively. Seeds planted 5 cm deep displayed 30, 45, 65 and 75% germination at 2, 3, 4 and 5 DAP, following the same order. Seeds buried 7.5 cm deep resulted in 10, 20, 40, 50 and 60% germination at 2, 3, 4, 5 and 6 DAP, respectively. However, at 10 cm planting depth 10% germinated after 3 days, 25% after 4 days, 35% after 5 days and 40% after 6 days (Fig. 1).

Emergence (SE) was observed at 2.5 and 5 cm planting depth only. At 2.5 cm planting depth, 35 and 75% of seedlings emerged within 1 and 2 DAP. Complete SE was observed one day later. At a burial depth of 5cm, SE was 15% and 50% at 3 and 7 DAP, respectively (Fig 2).

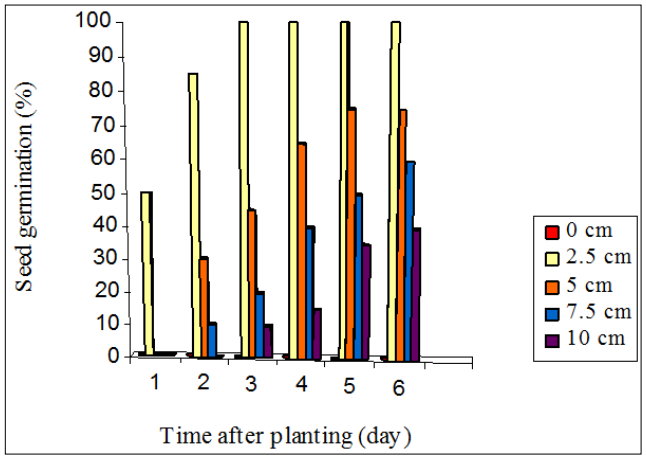

Figure 1. Effect of sowing depth on seed germination

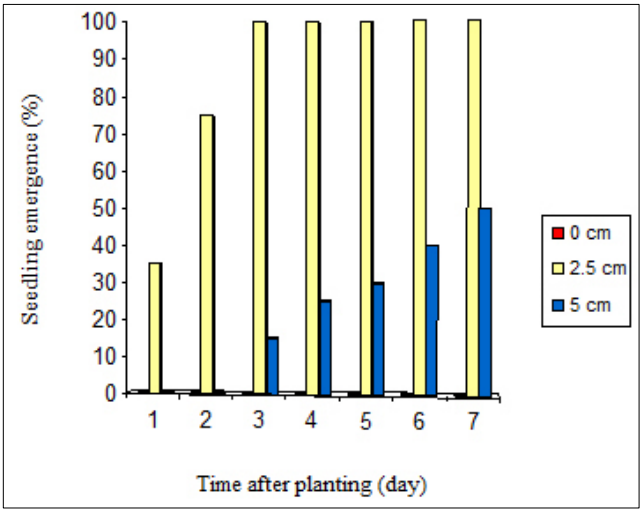

Figure 2. Effect of sowing depth on seedling emergency

Effect of Acid Scarification and Sheep Feeding on Seed Germination and Seedling Emergence

P. juliflora seeds treated with sulfuric acid (60%v/v) for 5 min. displayed very rapid seed germination as 50, 90 and 100% germination was achieved after 1, 2 and 3 days of incubation, respectively. Germination of untreated seeds was initiated one DAI (5%), increased to 20% on the second day, amounted to 65% at 9 DAI and remained constant for the rest of the incubation period. Differences in germination between scarified seeds and untreated ones were significant (P=0.05) (Fig. 3). SE of acid scarified seeds was rapid as 45% of the seedlings emerged 3 DAP and complete emergence commenced one day later. SE from untreated seeds was also initiated 3 DAP and was low (10%) at 6 DAP. SE progressively increased from 20 to 65% during the period 7-13 DAP. The differences in SE between acid scarified seeds and the control were significant (P= 0.05) (Fig. 4).

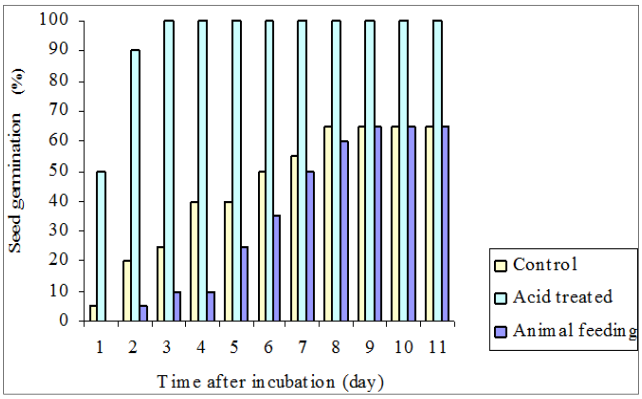

Figure 3. Effect of seed treatment on seed germination

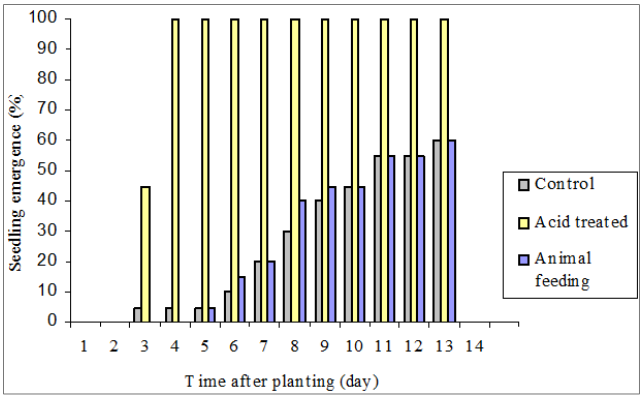

Figure 4. Effect of seed treatment on seedling emergency

Germination of seeds extracted from sheep droppings and untreated seeds was initiated 1-2 DAI. Germination progressively increased with incubation period for up to 8 days, and no further increase was recorded during the rest of the incubation period. During the first 6 days of incubation, untreated seeds resulted in higher germination than those extracted from sheep droppings. However, germination was similar during the rest of the incubation period (50-65%). During the first 6 days of incubation, germination of seeds extracted from sheep droppings ranged from 5-35%, while germination of untreated seeds ranged from 5-50%. Differences in germination between seeds extracted from sheep droppings and untreated ones were not significant (P=0.05) (Fig. 3).

Seedlings from seeds extracted from sheep droppings started to emerge 5 DAP, while SE of untreated seeds was initiated 3 DAP. SE of both treated and untreated seed was low (5-20%) during the first 7 DAP. A surge in SE was witnessed 8 DAP, especially in seeds extracted from sheep droppings (*ca*.40%). Emergence progressed at a lower rate later. SE from seeds extracted from sheep droppings was higher than that of the control during the period 6-9 DAP, but emergence was almost similar later on. Differences in SE between seeds extracted from sheep droppings, and the untreated seeds, were not statistically significant (P=0.05) (Fig. 4).

4. Discussion

The results of the present investigation revealed that intact *P. juliflora* seeds imbibed very limited amounts of water when soaked in water for up to 18 hr. However, imbibition was high during the period 24-72 hr. Uptake of water is essential for activation of seed metabolism. Metabolic activity provides the necessary energy for embryo growth [12]. These findings suggest that dormancy in *P. juliflora* is imposed mainly by the seed coat. Coat imposed dormancy is of wide occurrence in legumes and has been reported as a major characteristic governing their weediness[12]. The importance of seed coat imposed dormancy in *P. juliflora* is further substantiated by the increase in germination and water uptake following pre-soaking in sulfuric acid (60% v/v) for only five min. This treatment damaged the seed coat and permitted water entry resulting in 100% germination. Such results are in agreement with those obtained by Johanston et al. for hemp Sesbania (*Sesbania exaltata* (Rnf) Cory) [13], Ali for *Sesbania arabica* Steud[12], Eastin for Drummond Rattlebush (*Sesbania drummondii* Durand Oak) [14] and Mohammed for mesquite[15]..

Under favorable conditions, germination of *P. juliflora* seeds was very rapid, and was initiated one DAI. It progressively increased with time and reached 96% within two wk. Germination rate was maximum (20%) 9 DAI. It is for these reasons the plant is a successful noxious weed, and is at present infesting large tracts of the irrigated and rain fed areas in the Sudan.

On the other hand, *P. juliflora* seeds pass through the digestive system of grazing sheep, goats, cows (>100 million heads) and possibly other animals, unchanged. However, this might lead to their dissemination for long distances. Results revealed that seeds collected from sheep's droppings were free from the pericarp and displayed 65% germination and 60% emergence. Such results are in agreement with those obtained by Ali for *S. arabica*[12] and Mohammed (2001) for mesquite.

P. juliflora seeds failed to germinate when placed on the soil surface. This indicates that germination is possibly inhibited by light and inadequate moisture that prevail on the soil surface. However, seeds can germinate from soil depths up to 10 cm, but the highest germination and emergence were encountered at 2.5cm. Germination and emergence at this depth were very rapid, and were initiated one DAP. This suggests that the soil seed bank will always contain seeds of *P. juliflora* ready to germinate when moved to a shallower depth by agricultural implements.

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