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A Comparative Study of Natural Regeneration of *B. papyrifera* and Other Tree Species in Jebel Marra Darfur; Sudan

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Abstract: This study investigated the viability, germination rate and the phenomena of natural regeneration of *Boswellia papyrifera*, and discussed the possible factors affecting it. Harvest maturity seeds of *Boswellia papyrifera* were collected from three different sites in Jebel Marra. The completely randomized design was used to perform the germination and viability tests. Recurrent regeneration surveys were made over two seasons, to investigate the natural regeneration. *Boswellia* was found to have three types of seeds: insect infested, empty and viable. The germination rate of *Boswellia papyrifera* was found to range from 4-7% under different treatments. The storage of seeds significantly affects its viability. The results alos indicated that *Boswellia* has the ability to produce ample quantities of seedlings but these seedlings face difficulties of establishment. Main cause of poor regeneration are, frequent fires, grazing, water erosion and weed competition. Lack of natural regeneration ultimately affects the regular distribution of diameter classes, and consequently the performance of the tree in its ecological and production functions. Also surveys of natural regeneration indicated that about thirty tree species were found in the study sites where *Boswellia papyrifera* grows. However, only seedlings of *Albizia amara*, *Lannea fruticosa*, *Acacia seyal*, *Dalbergia melanoxylon*, *Dichrostachyos cinerea* and *Anogeissus leiocarpus* were found in all sites along with *Boswellia* seedlings, which indicates that they were in common association with *Boswellia paprifera*. In addition, results showed that competitive ground vegetation grew intensively on sites where *Boswellia* were cut down.

Key words: *Boswellia papyrifera*; Jebel Marra; seed germination; survival rate; natural regeneration

INTRODUCTION

The genus *Boswellia* is among the seventeen genera of the family Burseraceae. It is characterized by: Petals 5, imbricate in bud. Ovary 2-5 locule. Fruit with 2-3 stones, dehiscent. Flowers hermaphrodite[15].

The occurrence of *Boswellia* species extend from Ivory Coast to the Horn of Africa and south wards to northern Madagascar. It is also found in the Middle East as well as India[6]. The centre of geographical diversity of the genus is located in north east tropical Africa within the dry lowland areas where more than 75% of its species are endemic[16]. The known species of the Sudan is *Boswellia papyrifera*. *Boswellia papyrifera* in Sudan is a common savanna tree that occurs on rocks or hill slopes in high rainfall savanna, occurring in Bahr El Ghazal, Upper Nile and Equatoria[14]. It occurs in Blue Nile (around Jebel Garrie and Fung) and in the eastern Sudan extending from Gala-al-Nahal to Kurmuk[10]. In Kordofan it occurs in the Nuba mountains, where it grows gregariously on mountain slopes on shallow soils over rocks[13], it also occurs in Talodi, Rashad and Abu Giebeha in Kordofan[5]. In Dar Fur, *Boswellia* occurs around Zalingei, Rodom and Jebel Marra,it is found on piedmont and massifs 1070-1830 m. a. s. l., dominant on the upper hill slopes forming pure stands on the crests of the basement complex hills or stony soils, usually on quartz pebbles of the clay plains[3].

The species face problems of natural regeneration. Lack or absence of natural regeneration of *Boswellia papyrifera* was indicated by KHAN[10] in the Blue Nile province. Followed by ADAM[3] when he found only 9 seedlings per hectare, while KHAMIS[9] reported zero regeneration. Both surveys were conducted in dry season when *Boswellia* has already shed its leaves. This obviously means that the species is decreasing due to absence or difficulties of natural regeneration. This situation coupled with the recent tree use for furniture and fodder, jeopardizes the future presence of this tree. It is therefore, necessary to investigate the natural regeneration of the species, in order to set possible options for management of the species with local people's participation. It was also hypothesized that

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seeds may have short viability and possibly low germination rates, or they undergo a dormancy period and or possibly certain pest attacks the seeds. This study therefore, attempted to: test the germination rate of *B. papyrifera* seeds, assess the viability of seeds as affected by time, and the production of seedlings by the species, in order to understand potential and fate of the seedlings, and identify factors affecting regeneration.

MATERIAL AND METHODS

Boswellia papyrifera seeds collected in April 2001, from site one, two and four were mixed together. The seeds collected were ripe, mature and dry. They were released from capsules and wings removed. The damaged and unhealthy looking seeds were discarded. These seeds were subjected to different tests.

Germination Test: For the germination test, *B. papyrifera* seeds were subjected to five treatments namely; cold water, hot water (100C°), sulphuric acid with different concentrations, namely, 33%, 66%, and 98%. In all the treatments, *Boswellia* seeds were soaked in their respective solution for 15 minutes. For each treatment seeds were sown in Petri dishes using blotters and each treatment was replicated four times at a rate of 25 seeds per Petri dish. The completely randomized design (CRD), after GOMEZ and GOMEZ[7] was used. The germination tests were carried out at the agronomy Laboratory of the University of Zalingei. Germination counts were made daily for three weeks. The materials used in this test were 400 *B. papyrifera* seeds, Blotters, cold water (Tap-water), hot water (100ºC), sulphuric acid with 33%, 66%, and 98% concentrations, 16 Petri dishes and a table.

Viability Test: From the seed lot used for germination tests, 900 seeds were sown in polyethylene bags at the forest nursery in Golol-Jebel Marra in April 2001; the completely randomized design was used. Here, three seeds per polyethylene bag were sown, where 75 bags were used per replicate. The days to first germination were counted and the total number of days the experiment lasted was recorded. The remaining seeds from the lot were stored in perforated polyethylene bags at room temperature for 12 months. In April 2002, the same experiment was replicated to test the effect of time on seed viability. The materials used in this experiment were 900 × 2 (1800) *B. papyrifera* seeds, nursery plots and polyethylene bags.

Regeneration Surveys: The sample plots used were originally designed for the inventory of the growing stock in four different sites. These sample plots were simultaneously used as main plots for regeneration and ground vegetation sampling. Those main plots were circular in shape and 0.1 hectare in area. The radii of these plots were 17.84 m., along the diameter of the circles 10 quadrats of 1 m X 1 m werelaid out in each main plot at 3.5 m spacing in all sites. The total number of quadrats was 670 (670 m square). These quadrats were distributed as follows: 210 quadrats in site one, 210 quadrats in sites two, 200 quadrats in site three and 50 quadrats in site four.

Regeneration counting and recording was performed four times, twice in each season (In July and September 2001 and 2002 respectively). In the first count, regenerations of all tree species were recorded but in the 2nd, 3rd, and 4th counting only seedlings of *Boswellia papyrifera* were recorded. In the same regeneration plots, ground vegetation (grasses and herbs) were recorded where only their frequencies were considered.

Data Analysis: Regeneration counts were made manually; numbers of seedlings per hectare and seedlings survival rates were calculated for each site for two seasons. Finally the average survival rate was computed for each season. following the method described by Adam *et al*[1].

Where:

- Survival rate (%) = Total number of seedlings per site in September/ Total number of seedling per site in July x100.
- July: Onset of rainy season; September: End of rainy season
- Average survival rate (%) = Sum of Survival rates in the sites /the number of sites.

RESULTS AND DISCUSSION

Germination Rates: Seed germination started after five days from the beginning of the experiment and continued for 13 days. The experiment lasted for three weeks however, no further seed germination took place after the first two weeks. The same was reported by OGBAZGHI[12]. The first observation out of the experiment was that, the cotyledons were seen to be pushed by the rapid elongation of the hypocotyls thus, germination of this type is said to be epigeal. Concentrated sulphuric acid (98%) was found to be destructive to the seeds; therefore seeds treated with this level of acid concentration did not germinate at all. The non germinated seeds were checked and were found to be composed of 39% empty seeds and 55% insect infested seeds. Table 1 shows the germination

Table 1: Effect of treatment on the germination rate of *B. papyrifera* seeds

Treatment	% Germination					
	Rep1	Rep2	Rep3	Rep4	Total	Mean
Cold water	8	12	4	4	28	7
Hot water	8	8	4	4	24	6
H_2SO_4 (33%)	4	4	8	0	16	4
H_2SO_4(66%)	8	8	4	4	24	6

Table 2 shows the analysis of variance for the effect of treatments on the germination rates of *Boswellia* seeds. It was found that there is no significant difference at ($P \leq 0.05$) between different treatments.

rates of *Boswellia papyrifera* under the different treatments. The germination was found to range between 4–7%, this germination rate is very low. *Boswellia papyrifera* was reported to have germination rates of less than 8% under treatment with different hormones[2]. In Eritrea, OGBAZGAHI[12] reported germination rates of 80–94% for seeds from untapped *Boswellia* stands and 14–16% for seeds from tapped stands, however it is important to note that OGBAZGHI[12] did his germination tests on the basis of healthy and filled seeds.

Seed Viability: Table 3 shows the effect of storage (time factor) on the viability of *Boswellia papyrifera* seeds. Seeds sown in 2001, immediately after harvest maturity gave germination rate of 4.7% while seeds sown after 12 months storage gave germination rate of 2.3%. In this experiment first seeds germinated after three weeks and seed germination continued until the fourth week. This time lapse of seeds in the soil to germination is relatively long compared to 5 days in Petri dishes. It indicates that *Boswellia* seeds require light to germinate. Ecologically speaking, it would be expected that all seeds requiring light for their germination belong to species of plants which necessarily germinate on the surface of the soil[11].

Natural Regeneration of the Stands: Table 5 shows the natural regeneration of all trees in the stand. Natural regeneration applies to germinants, seedlings and saplings. With the exception of *Boswellia papyrifera*, all tree species listed had all forms of regeneration whereas *B. papyrifera* had very limited number of saplings in site four. *B. papyrifera* dominates the sites in terms of seedlings abundance (6955 seedlings per hectare). Seedlings from *Albizia amara*, *Lannea fruticosa*, *Acacia seyal*, *Dalbergia melanoxylon, Dichrostachyos cinerea* and *Anogeissus leiocarpus* occur in all sites. This indicates that only the mentioned species are in common association with *B. papyrifera*.

Natural Regeneration of *Boswellia papyrifera*: Table 6 shows the number of seedlings per site, per hectare, and survival rates of *B. papyrifera* seedlings. *Boswellia papyrifera* seeds do germinate well in nearly all sites provided they are insect- infested free and filled. With the exception of site three, seedlings of *B. papyrifera* were found in all the three sites. It appears from the table that higher number of seedling occur in site two followed by site one and site four respectively. Site three with zero seedlings is a permanent grazing site all year round for over thirty years. This site is annually burnt around April (after seed maturity and dispersal) and above all its land form is too steep.

The number of seedlings per unit area is quite promising. The survival rate of seedlings appears to be rather low (27.6-31.8%). Compared to survival rates of 19-27% in Eritrea[6]. The number of seedlings per unit area indicates that *B. papyrifera* is a prolific seed producer compensating those empty and insect infested seed losses. The time of the year at which regeneration surveys of *Boswellia papyrifera* were made is very important. This is because *B. papyrifera* loses its leaves towards the end of the rainy season and can't be differentiated from any straw. This is probably the reason why ADAM[3] and KHAMIS[9] found almost zero regeneration as their surveys were made in the dry season. The number of seedlings in season 2001 was higher than in 2002. The reasons might be the late start of the rainy season 2002, where first showers in 2002 occurred on 31st of May while in 2001 the rainy season started in the 13th of May and continued raining in May to the amount of 40 mm. Again, in 2002, the month of June was almost rainless and above all the total rains of 2001 were 593 mm at Thur station compared to 230 mm in 2002 at the same station. But, in spite of all this, the seedling survival rate was almost similar in the two seasons (Table 6)

It was found that seedlings survived poorly in areas with dense ground vegetation. Such areas are places where nomads settle with their livestock for a while. The animal's droppings increase the soil fertility and encourage the extensive and intensive growth of weeds and seedlings as well. When the rainy season advances, these weeds compete with seedlings of *Boswellia papyrifera*. In the steep areas water erosion

Table 2: The analysis of variance showing the effect of different treatments on the germination % of *Boswellia* seeds

S.V	Df	SS	MS	Fcal.	Ftab.
Total	15	127			
Treatment	3	19	6.3	0.7 ns	3.49
Error	12	108	9		

Key: S.V, Source of variation. Df, degree of freedom, SS, Sum of squares, MS, mean squares, Fcal., F calculated, F tab., F tabulated. ns: There is no significant different between treatments at ($p \leq 0.05$)

Table 3: Effect of time on the viability of *Boswellia papyrifera* seeds

Season	Percent germination					
	Rep. 1	Rep.2	Rep.3	Rep.4	Total	Mean
2001	4.4	4.8	4.0	3.1	16.30	4.7
2002	1.8	2.7	2.2	2.7	9.40	2.3

Rep: Replicate

Table 4 shows the analysis of variance of the effect of time on the viability of *Boswellia papyrifera* seeds. It was found that there is highly significant difference at ($P \leq 0.01$) between seeds sown immediately and those stored for 12 months.

Table 4: ANOVA showing the effect of time on the viability of *B. papyrifera* seeds

SV	Df	SS	MS	Fcal.	Ftab.
Total	7	8.10875			1%
Treatment	1	5.95125	5.95125	16.55**	13.4
Error	6	2.1575	0.0359583		

** There is highly significant difference between treatments at ($P \leq 0.01$). Symbols as in table 2

Table 5: Analysis of natural regeneration for all sites in the study area (Jebel Marra)

Species	Number of seedlings					%	Per ha
	Site1	Site2	Site3	Site4	Total		
Acacia senegal (L.) Willd.	7	3	0	0	10	1.01	149
Acacia seyal Del.,	28	27	8	9	72	7.28	1074
Albizia alymeri Hutch.	0	0	0	1	1	0.10	14
Albizia amara (Roxb.) Boiv.	6	4	1	1	12	1.21	179
Anogeissus leiocarpus (DC) Guill. & Perr.	1	4	1	5	11	1.11	164
Azanza garckeana (F. Hoflm.) Exell & Hillcoat	0	0	0	3	3	0.30	44
Balanites aegyptica (L.) Del.	0	0	0	1	1	0.10	14
Boscia salicifolia Oliver	0	0	1	0	1	0.10	14
Boswellia papyrifera (Del.) Hochst	127	326	0	13	466	47	6955
Capparis fascicularis DC.,	0	0	0	1	1	0.10	14
Combretum aculeatum Vent.,	0	1	0	0	1	0.10	14
Combretum glutinosum Perr. Ex Dc.,	0	1	0	0	1	0.10	14
Combretum molle R. Br. Ex G. Don	0	0	0	1	2	0.20	29
Commiphora africana (A. Rich) Engl.	2	3	2	0	7	0.70	104
Dalbergia melanoxylon Guill. & Perr.,	17	34	1	2	53	5.35	791
Dichrostachys cinerea ((L.) Wright & Arn	84	100	16	10	210	21.23	3134
Dombeya quinqueseta (Del.) Exell	0	5	0	0	5	0.50	74
Gardenia ternifolia Scum. & Thonn	0	0	0	7	7	0.70	104

Table 5: Cotitnued

Grewia bicolor Juss.	0	1	0	3	4	0.40	59
Grewia flavescens Juss.	0	1	0	0	1	0.10	14
Grewia villosa Willd.	0	1	0	3	4	0.40	59
Lannea fruticosa (Hochst., ex A. Rich.) Engl	9	20	1	8	38	3.84	567
Lannea schimperi (Hochst.,ex A.Rich.) Engl.	1	0	7	0	8	0.80	119
Lonchocarpus laxiflorus Guill. & Perr.,	0	1	0	3	4	0.40	59
Sclerocarya birrea (A. Rich.) Hochst.	16	0	1	0	17	1.72	253
Securidaca longipedunculata Fresen	2	1	0	1	4	0.40	59
Securinega virosa (Roxb., ex Willd.) Baillon	0	0	0	2	2	0.20	29
Stegnotaenia araliacea Hochst	0	0	0	2	2	0.20	29
Stereospemum kunthianum Cham.	2	4	0	18	24	2.42	358
Strychnos spinosa Lam..	0	0	0	2	2	0.20	29
Terminalia laxiflora Engler & Diels	0	0	0	1	1	0.10	14
Ziziphus spina-christi (L.,) Desf	0	5	0	0	5	0.50	74
Total	304	546	40	99	989	100	

Table 6: Number of seedlings per site per hectare, and survival rate of *Boswellia papyrifera* seedlings

Site	Season 2001					Season 2002				
	July		September			July		September		
	Seedlings per site	Seedlings per /hectare	Seedlings per site	Seedlings per site/hectare	Survival rate	Seedlings per site	Seedlings per site/hectare	Seedlings per site	Seedlings per site/hectare	Survival rate
1	127	6047	27	1258	21.33	112	5333	22	1047	19.64
2	326	15523	125	5952	38.34	226	10761	81	3857	35.80
3	0	0	0	0	0	0	0	0	0	0
4	13	2600	3	600	23.07	10	2000	4	800	40.0
Mean	155.3	3304	51.7	1099	27.58	116	2468	35.66	758.66	30.81

Table 7: Ground vegetation, frequencies of species per site and their habit

Species	Site1	Site 2	Site3	Site4	Habit
Acanthospermum hispidium DC.,	X	X	X	0	H
Andropogon gayanus Kunth, Enum.	0	0	0	XX	Mg
Anthephora nigritana Stapf & Hubbard	R	0	0	X	Mg
Aristida adscensionis L.,	XX	XX	X	0	Sg
Asparagus africanus Lam.,	R	R	X	0	Wcl
Bidens bipinnata L.,	X	X	D	R	H
Brachiaria brizantha (Hochst., ex A. Rich.) Stapf	0	0	0	R	Mg
Cassia absus L.,	0	0	R	0	H/usb
Cassia italica (Miller) Lam., ex. Fw. Andr.	0	0	X	0	H/usb
Cenchrus biflorus Roxb., Fl.	X	X	X	0	Sg

Table 7: Continued

Cissus cornifolia (Baker) Planchen	X	X	0	R	Usb
Commelina kotschy Hassk.	R	R	0	X	H
Craterostigma plantagineum Hochst	X	X	0	XX	H
Cyperus esculentus L.,	R	R	X	0	H
Cyperus rotundus L.,	R	R	R	0	H
Cyphostemma crotlarioides (Planchen) Descoings	X	X	0	R	H
Dactyloctenium aegyptium (L.,) Willd.,	X	R	X	0	Sg
Farsetia stenoptera Hochst.	R	R	X	0	H
Ferula communis L.	X	X	0	XX	H
Glorosia superba L.,	R	R	0	R	H
Gynandropsis gynanadra (L.) Briq.	R	R	0	0	H
Haemanthes muliflorus Martyn	0	0	0	R	H
Hyparrehenia rufa (Nees) Sapf.	0	0	0	X	Lg
Hyperrhenia filipendula (Hochst.) Stapf	D	D	X	R	Lg
Ipomea nil (L.) Roth.,	0	0	X	0	Cl/h
Laggera pterodonta (DC.) Schultz Bip., ex Oliver	X	X	0	XX	H
Leonotes nepetifolia (L.) Aiton f.	X	X	0	X	H
Pennisetum polystachion (L.) Schultz.,	XX	XX	XX	X	Mg
Peristrophe bicalculata (Retz) Nees	R	R	X	R	H
Pulicaria undulata (L.) C. A. Mey.,	X	X	0	X	H
Rhynchelytrum villosum (Parl.) Chiov.	R	R	0	X	Mg
Setaria pallide-fusca (Scumaher) Stapf & Hubbard	X	X	X	R	Sg/mg
Solanum incanum L.,	R	R	R	0	H
Spermacoce chaetocephala DC.,	X	X	X	R	H
Stylochiton borumensis N. E. Brown	R	R	X	0	H
Stylosanthes fruticosa (Retz) Altson	R	0	0	R	Sbh
Tephrosia bracteolate Guill. & Perr.,	0	0	XX	0	H
Thithonia rotundifolia (Miller) Blake	XX	X	0	X	H
Tribulus terrestris L.,	R	R	XX	0	H
Trichodesma Africana (L.) Lehm.,	R	R	0	R	H
Urginea altissmia (L.f.) Baker	R	R	0	X	H
Zalea pentandra (L) Jeffrey	X	R	0	R	H
Zornia glochidiata Reichen., ex DC.	X	X	XX	X	H

Key: D = Dominant and refers to the occurrence of the species in all the subplots, XX = Common and refers to occurrences of the species in the range of 50 –75, X = Frequent and refers to the occurrence of >25 and < 50%, R = Rare and refers to the occurrence of the species in <25% of the subplots, 0 = absent. H= herb, Mg = medium grass, Sg = Short grass, Wcl= Woody climber, Lg = long grass, Cl/h = Climbing herb, Sbh = Shrubby herb

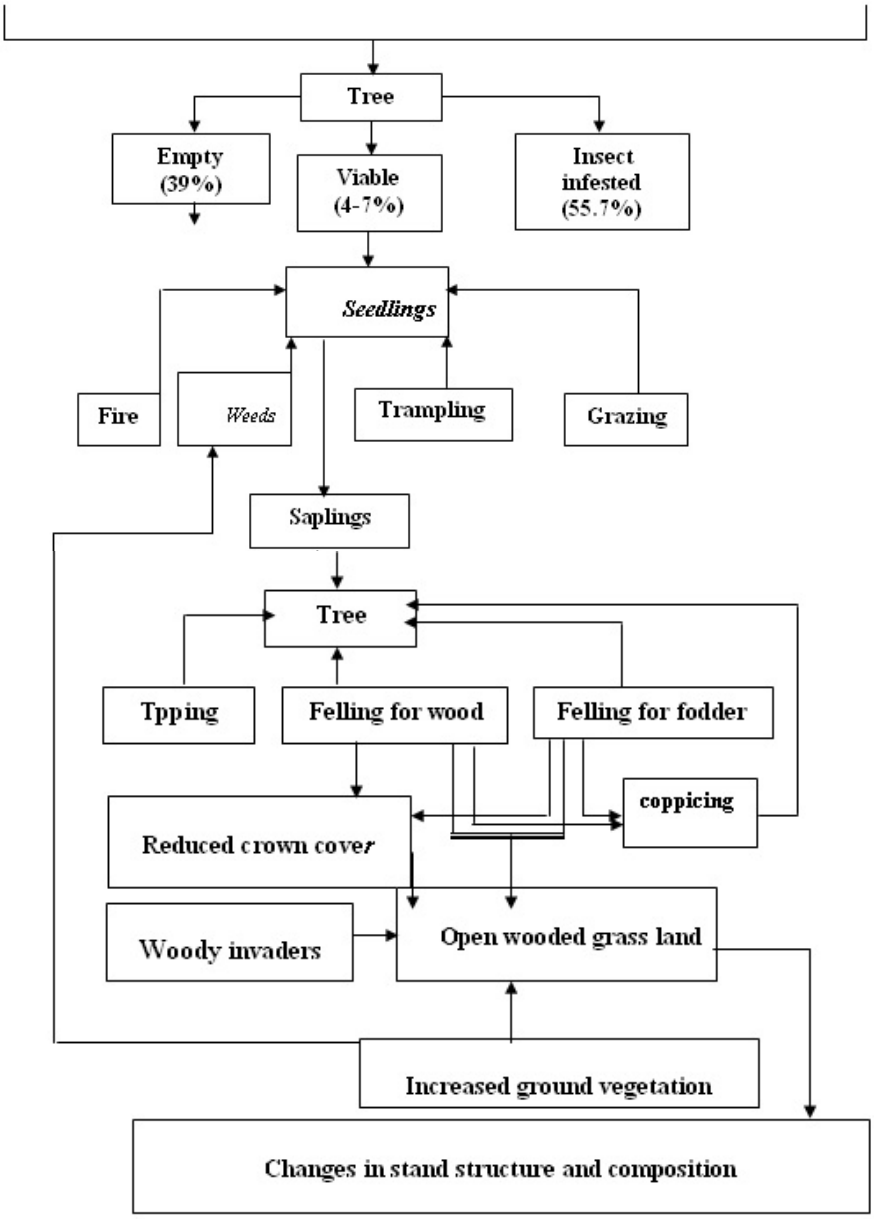

Fig. 1: *Boswellia papyrifera*'s model for natural regeneration in the study area

destroys and washes the seedlings since they are succulent and very tender such as in site three and four. Among the three sites where *Boswellia papyrifera* seedlings were found, larger sized seedlings (saplings) were found in site four This site is the only one inaccessible for livestock. Therefore, seedlings have chance to develop perhaps even to mature trees if the site is protected from fire incidents.

A group of factors are found to be responsible for the poor natural regeneration of *Boswellia papyrifera* either singly, or jointly with their interactions, these factors are:

- Members of the family Burseraceae produce empty seeds (sterile)[15]. *Boswellia papyrifera* being a member of this family produces large quantities of empty seeds.
- A certain insect of the order Hymenoptera attacks large quantities of seeds
- Grazing animals destroy germinants and seedlings by trampling and by browsing the saplings. Therefore, areas accessible to livestock devoid seedlings and saplings.
- Nomads (cattle breeders), cut down *Boswellia* trees in the late dry season and at the beginning of the rainy season, and by so doing, they render the

Boswellia forest into open wood land thus giving chance for weeds (ground vegetation) to grow intensively and strongly compete with seedlings. Field observations showed that *Boswellia papyrifera* seedlings are very sensitive to weed competition[2].

- Seedlings in areas inaccessible to livestock are threatened by annual fire hazards.
- Seedlings in steep areas are washed by the downward movement of rain water.
- Unstable climatic conditions especially erratic rainfalls, lead to seedling mortalities.

For clear understanding of the regerneration processes of *Boswellia papyrifera* see figure 1 below. In addition to the above mentioned factors[12], mentioned that intensive tapping of *Boswellia trees* for gum productionleads to the production of large quantities of empty non-viable seeds that affect regenerationt. This statement needs to be further tested as THONNER[15], relates the production of sterile seeds to the characters of family Burseraceae. The factors behind the lack of natural regeneration of *Boswellia* in the study area are similar to those in Eritrea. However, land clearing for agriculture is an important factor in Eritrea[12], whereas fires seem to play no role there.

The Ground Vegetation: Table 7 describes the ground vegetation (grasses and herbs) in the study area. This enormous number of species indicates the biodiversity of the study area. On the other hand this high number of grasses and herbs is a recent phenomenon in the *Boswelli*a stands because, in the near past only two or three species of grasses and herbs were found in the *Boswelli*a stands[3]. This is clearly because the trees have been cut down greatly, the tree canopies have been reduced to 17.5%[2], and hence big gaps were created in the forest. These gaps created suitable conditions for the growth and survival of the ground vegetation. The height of ground vegetation and their density created strong chances of competition to the seedlings of *Boswellia papyrifera*. Therefore a high mortality is recorded even at times where animals have not entered the sites and fires have not yet started (see survival rates, Table 6). Again in the dry season, the dried ground vegetation acts as a fuel to increase fire effectiveness.

Conclusions: Seeds of *Boswellia papyrifer*a are three types: empty, insect infested and viable; the latter are the smallest in number. The germination rates of *B. papyrifera* range between 4-7% under different treatments. The seeds of the species have no dormancy and thus better germination rates are obtained from seeds sown immediately after harvest maturity. Seed storage significantly affects viabilityIt is often concluded that natural regeneration of *Boswellia papyrifera* is poor. However, if filled and insect infested free seeds were used, the germination rate will be high. The germination percentage obtained in this study is low, but the number of seedlings per unit area is high. The real problem therefore, is seedlings establishment and their development to saplings and mature trees. The phenomenon of difficult seedling establishment and development though recent, but the overall result will be a total disappearance of the species in the near future if man and his grazing animals continued to disturb the stand in the present manner. KHAN[10], working in Jebel Garrie mentioned that *Boswellia* can produce seedlings in certain areas, but he emphasized that *Boswellia* seedlings remain in a stagnant situation without developing to saplings or mature trees for up to 10 years. If this statement is correct then the climatic conditions might be responsible for the greater part of difficult seedling establishment. Because AHMED[4] stated that, *Boswellia* replaced *Anogeissus leiocarpus* which used to occur in these sites in former times, when the climate was cooler and more moist. To support the effect of climate, IBRAHIM[7], reported a precipitation deficit of 40-50% compared to the preceding 15 years. Since then, it is now over 20 years, accordingly if the same percentages are considered; it is possible that conditions are becoming more unfavorable even for the occurrence of *Boswellia papyrifera* and possibly another successor is on the way.

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