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Dependence of *Dalbergia Melanoxylon* Natural Populations on Root Suckers Germination.

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1. Introduction.

The African black wood tree – *Dalbergia melanoxylon* Guillex Perr (Family Leguminoceae, Subfamily Papilionoidea), is also known as the

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African ebony and Mpingo in Swahili.

D. melanoxylon is a small, heavily branched tree, typically 4.5 to 7.5m tall but occasionally reaching 15m. The bark tree is pale grey to grayish, brown, papery, fairly smooth and flaking in long narrow strips (Bryce1967). Their stems are crooked, covered at first with short crisp hairs and are glabrous with pinnately, alternate compound leaves that are 6 to 22cm long (Figure 1). The podsare elliptically oblong or irregularly oblong, bluntly pointed, flat and thin. They range from 3 to 7cm long and 0.8 to 1.4cm wide. They are very light, glabrous and laxly and rather diffusely veined with one or two seeds (Figure 2). It is estimated that 1kg of *D. melanoxylon* pods contain 67,768 seeds. Ex-situ experiments has proved that only 50% of seeds from 1kg can germinate under controlled conditions, germination decreases to 20% in in-situ due to various factors from the environment [Sharman, 1995]. Seeds take 3 months to mature which in Tanzaniais from May to July. The trees take more than 70 years to mature to an appreciable harvesting age.



Figure 1. The structure of *D. melanoxylon* plant

1.1 Ecology and Distribution of D. melanoxylon

Dalbergia Melanoxylon grows under a wide range of conditions including semiarid, sub humid and tropical lowland areas (Bryce 1967). It is often found on dry, rocky sites at elevations from sea level to 1200m but is most frequently found in mixed deciduous forests and savannah of the costal regions (Brenan and Green way 1949). The minimum temperature in its native range is 18^0C and the maximum is 35^0C. *D. melanoxylon*is not resistant to frost. It prefers an annual rainfall average of 700 to 1200mm, evenly distributed in bimodal pattern of three to six months (Noad and Birnie1989). It thrives in

soils varying from loamy sands to clayey vertisols "Black cotton soil". The species is water and light demanding, and will not regenerate under heavy vegetation cover. A mature tree of *D. melanoxylon* tolerates fire (Kale1984).

In Tanzania, *D. melanoxylon* is distributed in seven floristic zones, which are dominated by miombo woodlands. *D. melanoxylon* is found between 600m to 1200m, having an annual rain between 760mm to 1400mm and temperature of 13^0C. Moist plateau cover Mpanda, Tabora and Kigoma. The dry tropical zone is found between 600m to 1200m, annual rain is 760mm and 1200mm and the temperature of 13^0C. Dry tropical zone covers Dodoma, Itigi, Mwanza and Shinyanga. Mpingois also poorly distributed in the wet tropical zone which in Tanzania covers Rau, Turian, Matombo, Minziro, Korongwe, Mheza, Dar es Salaam, Kibaha, Bagamoyo, Lindi and Mtwara. These area are also dominated by Miombo woodlands. Wet tropical zone is found in coast areas, around heavy rain mountains, on flat areas at 1140mm and mean temperatures of 13^0C. Wet tropicals extend to Iringa and Njombe on its south west and extend to coast belt southern Tanzaniawhich includes Mtwara and Lindi (Mbuya, Msanga and Tengnas 1994). Therefore *D. melanoxylon*inhabit both the rainforest environments and the open miombo woodlands which cover about two third of Tanzania. Rainfall is often marginal in the miombo woodlands and long periods of drought are not unusual. Land areas such as these are environmentally fragile, their vitality depend on a delicate balance being maintained between the plants, animal and human population which inhabit them (SOFO 1999). *D. melanoxylon* has adapted well to this marginal existence, and its long growing period and root suckers germination is an out come of this adaptation to harsh conditions

(Read 1994).



Fig 2: *D. melanoxylon pods*



Figure 3: *D. melanoxylon* Seeds

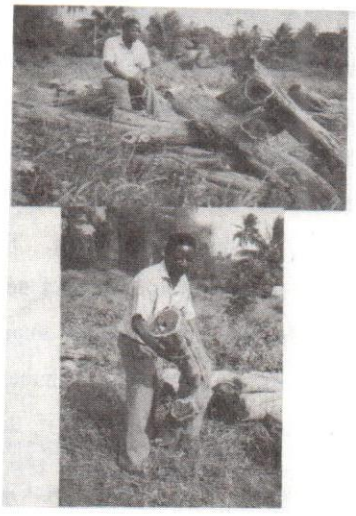


Figure 4. Harvested Mature mpingo wood from Kazimzumbwi forest reserve.

1.2 Regeneration and propagation

Regeneration is defined as a constant existence of plant individuals of varying sizes from asexual or sexual reproduction, *D. melanoxylon* regeneration can be naturally accomplished in two ways, by seed germination and by root suckers (Mugasha1978). The success of natural regeneration is subject to a number of factors, particularly the availability of sufficient, sound and viable seeds (Sharman 1995).

Germination of *D. melanoxylon* seeds has been estimated at only 20 – 50% within 8 – 20 days due to factors affecting germination of *D. melanoxylon* seeds in natural environments, (Mbuya et al. 1994). It has always been assumed that native trees regenerate sufficiently under natural condition. *D. melanoxylon*seeds are small, flat, thin, papery (figure 2 and 3) such that they need a thin layer of soil so that very little energy stored in the seed can easily push the soil for germination. It is possible that most seed are lost in thick cover of soil in in–situ regeneration. The temperature requirement for *D. melanoxylon* is 13 – 18^0C and needs moist soil to germinate optimally.

On the other hand, water supply in the field should be sparing so that seeds do not rot (Nshubemuki1993). Germination in the field decreases from 50 to 20% if the above factors are not met. Mature seeds remain viable for only few months after maturity so it is advised to plant seeds few days after picking them from the field (Noad and Birnie 1989).

In addition to use of seeds and root cuttings as means of propagating *D. melanoxylon* species, shoot cuttings, wildlings/saplings and coppices are also methods that can be used to propagate this species (MNRT 1988). Wildings are seedlings from the natural environment that can be nurtured in nurseries before they can be grown out into the field while coppices are shoot suckers that emerge from pruned/stumped trees.

These are devoid of roots and nurturing them in nurseries will allow the shoots to regenerate roots before they can be ready for planting out in the field. The challenges of using root and shoot cuttings would be destruction of the mature trees in the process of propagation if hard pruning is done.

So far, existence of *D. melanoxylon* and other endangered plant species in Tanzaniaare in critical conditions. When conservation strategies are being developed for these endangered species, all available information about propagating *D. melanoxylon* and other endangered species should be taken into consideration. Crucial to consider are the requirements for successful germination and seedling establishment (Masamba 1994) which are not much studied this is why this paper was based on factors affecting regeneration of the species in-situ and ex-situ.

1.3 Factors affecting Propagation

Factor contributing to lack of propagation practices include the lack of scientific knowledge of various species including *D. melanoxylon*, uncontrolled harvesting of the forest products, the change in the land use, rapid urbanization and excessively rising land requirement human settlement (MNRT 1988). Viable seeds of *D melanoxylon* are difficult to obtain. Difficulty of getting viable seeds is due to the structural morphology of the pods and seeds that are very thin, flat, papery and indehiscent and therefore readily become vulnerable to insect and fungal attack. Alternatively propagation could be conducted by using cuttings, wildings, coppices and root suckers but these methods involve destruction of the adult plants and hence accelerating deforestation.

2. Material and Methods.

2.1 In - situ experiments in Pugu Forest

Pugu forest reserve is located 25km south west of Dar es Salaam and 20km inland from the Indian Ocean covered with Kaolinitic Sand soil. The forest is between the altitude of 100 and 305m, and experiences a yearly rainfall of 760mm and temperature of between 18^0C – 20^0C. (Nshubemuki 1993). A total of 25 seedlings were chosen and used.

Growth rates were measured monthly and monitored for a period of 1 year. Meteorological data of the area were also recorded from a nearly weather station airport. Plant height was measured from ground level to the tip of seedling using a ruler while stem diameter was measured 10cm from the ground using vernier calipers. Seedlings were assessed to see if are seed germinated or root suckers germinated, normally seed germinated seedlings have a tap root.

2.2 Ex - situ experiments in UDSM Nursery

Seeds collected from Pugu and National Tree Seed Agency were subjected to different germination treatments. The experiment was arranged in a split plot design with seed soaking and non soaking treatments as the main plots and moisture level in the potting media as subplots. This was followed by observations on seed germination and seedling growth rates.

A total of 360 seeds were soaked in water for 6 hours before sowing while another total of 360 seeds were sown without prior soaking treatment. Each of these 2 main treatments was then subdivided into three sub treatments that were assigned to 3moisture level treatments namely low, median and high moisture in the potting mixture. The topsoil part of the potting mixture was obtained from Kunduchi quarry. The potting mixture comprised of topsoil, rough sand and organic matter in a ratio of 1:1:1 that gave a total porosity of 55%.

Each sub treatment was replicated four times making a total number of 360 seeds for each main treatment making a total of 720 seeds for the whole trial.

All seeds for the trial were sown on 19 November, 2005. Moisture treatment levels applied per day in the first month (20 Nov –17 Dec. 05) were 100ml for low moisture level, 200ml for median level and 300ml for high level. During the subsequent two months moisture treatment was applied as 200ml for low level, 300ml for median level and 400ml for high level per day per pot. For the rest of months water was given as 400ml for low level, 800ml for median level and 1200ml for high level. Number of pots per replicate was 12pots, which are 36pots per subplot and 72 pots for the all treatments. In each pot 10 seeds were sown.

Sown seeds were inspected every day for germination and germination dates were recorded weekly for a period of 3 weeks. Seeds were considered germinated when the radical was about 2cm long and cotyledon had emerged from the seed coat.

Germination % data obtained were first transformed into arcsine transformation before computation but the original data was used in the

summaries of the means (Zar 1984). Results from each experiment were analyzed separately. Means and Least Significant Difference (LSD) for germination percentages for both seed treatments and moisture levels were computed to get inference.

2.3 Growth Parameters Recorded

Germination was monitored for 1 month while subsequent seedling growth rate was monitored for 7 month. The following parameters were recoded:-

1. Germination dates determined as the first day of appearance of the young seedling on the ground.
2. Germination percentages as the proportion of germinated seeds every week over total number of sowed seeds.
3. Seedling height/month – This was measured in cm from soil level to the tip of seedling using a measuring tape.

The above parameters obtained were subjected to statistical ANOVA.

2.4 Data Analysis

Data analysis was accomplished according to Zar, 1984. LSD was used for mean separation to determine statistical differences between treatment means. Data were summarized into relevant tables and figures to give results to facilitate presentation and discussion.

3. Results and Discussion.

3.1 Germination Experiments (Ex-situ)

3.1.1 Main effect of seed treatment on seed germination

Germination percentage ranged from 2 to 15% in soaked seeds and 0.5 – 15% in non-soaked seeds starting from 7 days after sowing to 21days when all viable seeds had germinated (Table 1). The difference in seed germination percentage due to seed treatment was not statistically significant.

Table 1. Effect of seed treatment and moisture level on seed Germination (Ex¬ Situ).

Seed treatment	Moisture level	Germination %				Mean	LSD
		26 NOV.05	02DEC.05	10DEC. 05	17DEC.05	Mean	
Soaking	Low (100ml)	3.8	1.6	13.3	10.8	7.4	14.32 5%
	Mediam (200ml)	2.5	6.6	18.1	21.5	12.2	18.40 5%
	High (300ml)	0.00	0.8	11.6	12.5	6.2	13.15 5%
	Mean Soaked	2.1	3.0	14.4	14.9	8.6	
Non soaking	Low (100ml)	0.8	3.3	15.7	16.5	9.9	15.89 5%
	Mediam (200ml)	0.00	0.8	14.9	19.8	8.9	15.72 5%
	High (300ml)	0.8	1.6	11.7	10.8	6.2	13.16 5%
	Mean Non soaked	0.5	1.9	14.1	15.7	8.4	
LSD	5%	2.99	4.43	5.61	3.65		
	1%	14.99	22.21	28.12	18.28		

3.1.2 Effect of moisture level on seed germination

The effect of potting media moisture level on seed germination is as shown in Table 2. Generally germination increased from low to median moisture level. High moisture level was associated with low germination percentages at each date. The median moisture level was the most favourable in effecting seed germination. Here, germination ranged from 1.3 during the first week to 21% three weeks later when all viable seeds had germinated. This is opposed to 0.4 and 11.6% respectively for seeds received high moisture level. Percentage germination due to seed treatment was 15% and percentage germination due to moisture level was 21%. However the differences due to treatment and due to moisture level were not statistically significant. Other literature had reported that in–situ germination of *D. melanoxylon* seeds could decrease from 50% to 20% depending on the available factors affecting germination (Noad and Birnie 1989).

A new observation during this research as the factor affecting seed germination was the amount of water available for seed germination.

Table 2: Mean seeds germination in response to different moisture level.

Moisture level	26 Nov	02 Dec	10 Dec	17 Dec
Low	2.33	2.28	14.53	13.65
Median	1.25	3.73	16.55	20.68
High	0.41	1.24	11.67	11.64

Germination is the resumption of growth of embryo which begins with imbibitions of water followed by activation and mobilization of enzymes in the embryo which breaks down the food reserves in the

endosperm and provides the required energy for its development. Embryo growth is accompanied by cell division and expansion resulting into swelling and spitting of seed coat to enable the emergence of the radical (Muguga 1993). Optimum water is the primary and potential condition for reactivation of enzymes in embryo for cell division, expansion, swelling and splitting of seed coat for germination provided other factors as temperature and aeration are optimum.

Dalbergia melanoxylon seeds have thin seed coat and are fragile in such that higher moisture level used in germination experiment of this study could have caused excess moisture in relation to the seed size hence causing hypoxic conditions that killed the metabolic reactions of the fragile endosperm and embryo resulting into seed death. Low moisture level used in this experiment could not have reactivated enough the enzymes in embryo and therefore could not activate cell division, expansion, swelling and splitting of seed coat for emergence of radical.

3.1.3 Effect of seed treatment on seedling growth (height)

As indicated in table 3, the mean height of seedlings from soaked seeds was 48cm while mean height of seedlings from non soaked seeds was 51cm. Non-soaked seed were associated with high seedling growth mean and soaked seed were associated with low mean seedling growth. However the differences observed in seedling growth were not statistically significant.

Table 3. Seedling height during the months of January to July 2006

Treatments		Seedling height (cm)								LSD
	Moisture level	Dates							Mean	
		19/1	19/2	19/3	19/4	19/5	19/6	19/7		
Seeds soaked	Low	4.187	26.43	40.8	55.25	91.00	83.73	84.5	56.55	40.12 5%
	Median	4.23	20.45	31.5	62.75	74.25	58.5	58.5	44.31	37.23 5%
	High	3.36	12.44	22.62	73.5	71.25	48.75	66.25	42.59	35.06 5%
	Soak mean	3.925	19.77	31.47	63.83	78.83	63.66	69.75	48.00	
Non soaked	Low	6.19	25.5	46.15	35.75	80.75	90.5	100.25	55.01	40.78 5%
	Median	3.29	24.82	34	85.25	48.75	66.75	67.5	47.19	39.30 5%
	High	5.19	19.78	35.27	50.0	61.75	76.00	77.25	49.99	38.66 5%
	Non soak mean	4.89	20.10.	38.47	40.33	63.75	77.75	81.66	51.00	
	LSD 5%	9.99	40	23.32	21.75	131.48	333	73		
	1%	50.09	202	116.85	109.06	558.72	1671	368		

3.1.4 Effect of moisture level on seedling growth (height)

Astable 4 shows, the highest mean height was observed in seedlings treated with low moisture, and it ranged from 5.2cm in January to 90cm July, 2006. The lowest height was observed in seedlings that were treated with median moisture and it ranged from 3.8cm in January to 63cm July. Seedling growth in high moisture was moderate. From these observations it is evident that low moisture was associated with higher seedling growth while median moisture was associated with lower seedling growth. Only moisture levels and not seed treatment imparted a significant effect on *D. Melanoxylon* seedling growth rate.

Table 4. Effect of moisture on seedling growth (height)

Moisture Level	Dates						
	19/1	19/2	19/3	19/4	19/5	19/6	19/7
Low	5.2	26.00	44.00	46.00	86.00	87	90
Median	3.8	22.7	32.8	32.8	53	62.2	63
High	4.3	16.00	29.00	62.00	67.00	62.00	72.00

***D. melanoxylon* growth (In – situ)**

3.1.5 Growth in stem height

The actual seedling stem growth in height of *D. melanoxylon* in Pugu forest natural environment during the months of April 2006 to March 2007 is shown in Fig 5 (a). Seedling growth height ranged from 50.52cm in April 06 to 59.60cm in March 07, giving an average growth height of 57.1cm. The highest growth height was observed between May and April 06 due to higher rainfall in these months in which a growth of 4.09cm was observed. The growth height observed between the rest of months ranged between 0.5cm to 0.9cm due to moderate or low rain in these months.

The relative growth rate as indicated by fig 5b ranged between 0.081cm from April, 2006 to 0.17973cm on March 2007. The average monthly growth rate during these 12 months was 0.13046 (Fig. 5b).

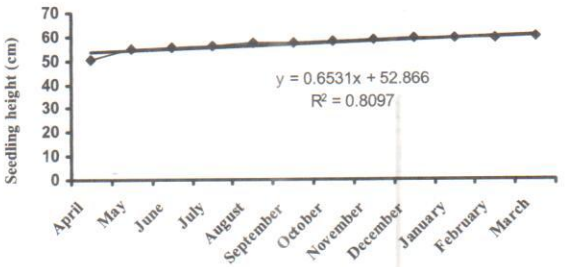


Fig. 5a. In-situ Growth of *D.melanoxylon* in Pugu Forest

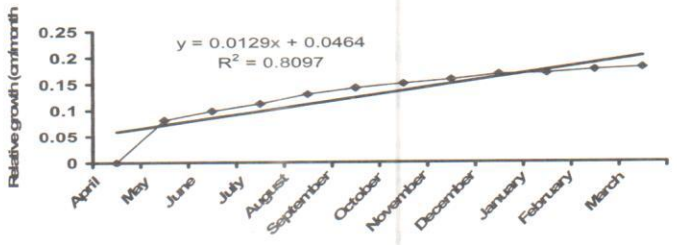


Fig 5b. Incremental growth (height) of D. melanoxylon in Pugu Forest

3.1.6.Grow in Stem girth

Fig 6(a) has indicated growth of *D. melanoxylon* in stem diameter (stem girth) between April 2006 and March 2007. The stem diameter increased from 0.79cm April 06 to 1.01cm March 07. The average mean in stem diameter growth for these 12 months was 0.00cm. The highest stem diameter growth of o.12cm was observed between May and April 2006 due to higher rain in these months, stem diameter growth observed between the rest of months ranged between 0.01cm to 0.05cm (Fig 6a). The incremental growth in stem is indicated on figure 6b.

With the exception of young *D. melanoxylon* seedlings whose survival can be threatened by higher moisture level as reported in ex–situ seedling growth during this study, adult *D. melanoxylon* trees are water demanding, needs constant supply of water through the time of their existence rather than seasonal moisture available during the rainy season.

Among 25 seedlings investigated in Pugu forest, 14 were found to germinate from root suckers which is 56% of the investigated seedlings. These are characterized by absence of tap root, easily fall down by erosion and grow slowly.

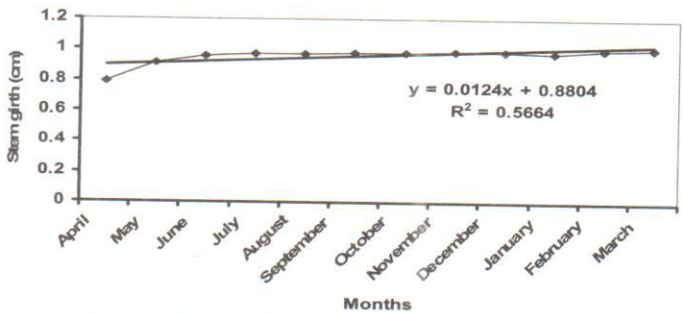


Figure 6a. In-situ seedling growth (girth) in Pugu Forest

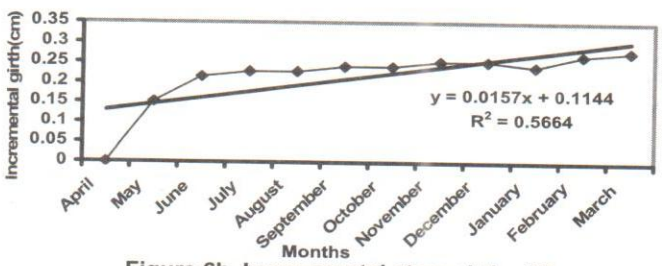


Figure 6b. Increamental stem girth of D. melanoxylon in Pugu Forest

4. Conclusion and recommendation

This paper is reporting that seeds and young seedlings of *D. melanoxylon* are vulnerable to higher moisture level available while grown trees are water demanding. Since seeds are indehiscent, papery, thin and flat, they easily get rotten when irrigated with high moisture. This implies that most seeds produced in natural environment yearly die during the rainy season. This is why 56% of investigated in-situ seedlings were found to originate from root suckers.

From this paper it can be concluded that the moisture level is key to ex – situ and in – situ seed germination and regeneration of *D. melanoxylon.* It is therefore recommended that future researches should Endeavour to increase seed viability by harvesting seeds immediate from their maturity and storage in sealed containers, conducting physical selection and viability test before sowing of seeds. Conduction of studies on symbiotic relationships and hybridization with related species such as *D. sissoo*, conduct tissue culture or use of growth hormones to improve growth rate is also recommended. This should include collection and evaluation of germ plasma *Dalbergia melanoxylon* and related species.

Difficulties in germination and low survival of young seedlings in the natural environment do not match with the speed of harvesting of the mature trees necessitating the need for ex-situ propagation methods for sustainable aforestation and conservation of *D.melanoxylon.* This paper therefore recommends that, there is a need of propagating *D. melanoxylon* species as a National program. Researchers are also advised to search if root suckers germinated seedlings can grow to

harvestable stage or not and for how long.

The existence of *D. melanoxylon* should not be left to depend on the naturally occurring trees. For a successful propagation of this species and sustainable conservation, the Nation needs to establish nurseries for seedling production that can be used for replanting in selected areas having favorable ecological conditions. Ex-situ nurseries are the only places where optimal amount of water for seed germination and survival of young seedling can be controlled.

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ABSTRACT

Dependence of *Dalbergia Melanoxylon* Natural Populations on Root Suckers Germination.

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Dalbergia Melanoxylon (Leguminoceae, Papilionoidea) is a small tree that gives small, thin flattened and indehiscent pods enclosing delicate seeds. It is valuable because it produces the most expensive timber and carvings in the world.

This paper disclosed why seeds germination and young seedling growth are vulnerable to available water. The in-situ survey indicated the dependence of the species to root suckers germination and that the adult mpingo are water demanding.

Key words: Regeneration, African Blackwood, ebony tree, music plant, Mpingo, Root sucker, vegetation, floristic zones, Germination

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