GERMINATION OF WOODLAND MAHOGANY *(TRICHILIA EMETICA)* FOLLOWING MANUAL SEED COAT SCARIFICATION AND POTASSIUM NITRATE TREATMENTS

H.P. Msanga

National Tree Seed Centre, P.O. Box 4012, Morogoro, Tanzania

&

J.A. Maghembe

SADCC/ICRAF Agroforestry Project, Makoka Research Station, P.O. Box 134, Zomba, Malawi

Received March 1992

MSANGA, H.P. & MAGHEMBE, J.A. 1993. Germination of woodland mahogany (*Trichilia emetica*) following manual seed coat scarification and potassium nitrate treatments. Experiments were carried out in the laboratory and nursery to study the effect of manual seed coat scarification and soaking in potassium nitrate (KNO_3) on the germination of seeds of woodland mahogany (*Trichilia emetica*). Seeds without treatment attained a total germination of 28 % in the laboratory and 33 % in the nursery. Seeds with complete removal of aril alone or complete removal of aril associated with partial removal of seed coat at the radicular end without soaking in KNO_3 gave 88/99 % germination in the laboratory and 77/93 % in the nursery. Trends in germination value were similar to cumulative germination percentages. Germination times were shortest (13 days) in seeds where aril removal was associated with partial removal of the seed coat and longest (31 days) in unscarified seeds. Application of KNO_3 produced a slight adverse effect of germination. The main cause of poor germination was due to the impermeability of the aril to water. It is recommended that aril alone should be completely removed before sowing seeds of *T. emetica*.

Key words: *Trichilia emetica* - seed coat scarification - potassium nitrate - germination

MSANGA, H.P. & MAGHEMBE, J.A. 1993. Percambahan mahogani hutan (*Trichilia emetica*) setelah pelelasan biji benih secara manual dan rawatan potassium nitrat. Kajian-kajian telah dijalankan di dalam makmal dan ditapak semaian untuk mengkaji kesan pelelasan biji benih manual dan direndam dalam potassium nitrat (KNO_3) ke atas percambahan biji-biji benih mahogani hutan (*Trichilia emetica*). Biji-biji benih yang tidak dirawat mencapai jumlah percambahan sebanyak 28% di dalam makmal dan 33% di tapak semaian. Biji-biji benih yang keseluruhan arilnya dibuang atau aril dibuang keseluruhannya dengan pembuangan lapisan biji benih dihujung radikal tanpa direndam dalam KNO_3 memperolehi 88/99% percambahan di makmal dan 77/93% ditapak semaian. Bentuk nilai percambahan adalah serupa dengan peratus percambahan longgokan. Masa percambahan paling singkat (13 hari) pada biji benih yang aril dibuang keseluruhannya dan paling panjang (31 hari) pada biji benih yang tidak dilelas. Penggunaan KNO_3 memberi sedikit kesan tidak baik kepada percambahan. Punca utama kurang percambahan disebabkan oleh ketaktertelapan aril kepada air. Adalah disyorkan hanya aril dibuang keseluruhannya sebelum menyemai biji benih *T. emetica*.

Introduction

Woodland mahogany (*Trichilia emetica*, synonym *Trichilia roka*) is a large, much branched evergreen reaching 8-25 *m* high with a dense rounded crown. It grows naturally throughout sub-Saharan Africa, from Senegal to the Red Sea, throughout East and Central Africa to the Congo, Natal and Transvaal (Palmer & Pitman 1972). This species is in great demand in rural areas of Africa because it provides edible oil, medicine, timber, fuelwood and is used in agroforestry systems.

The cultivation of *T. emetica* in farms has been difficult because of limited knowledge about the germination of its seed. To date, there is only one paper on how to germinate seed of this species (Maghembe & Msanga 1988), although scanty information is available in publications dealing with general aspects of its silviculture (Watkins 1960, Forest Division 1984). This report presents results of the effect of manual seed coat scarification with or without application of potassium nitrate (KNO_3) solution on seed germination and early growth of the seedlings.

Material and methods

Seed collection and processing

Ripe fruits of *T. emetica* were picked from 15 trees growing naturally at Korogwe (38°17'E; 4°53'S at 400 *m* a.s.l.) in Tanga region, Tanzania. The seeds were extracted from the fruits by hand, immersed in water to discard those which floated and then dried in the shade for five days. Dry seeds were packed in cotton cloth bags and immediately transported to the National Seed Testing Laboratory, Morogoro for testing.

Experimental design

The study involved two experiments of a 3 × 5 factorial model arranged in a randomised block design with four replications. The first experiment was conducted in the laboratory and the second in the nursery. The first factor involved three levels of manual seed coat scarification: (1) unscarified seeds, (2) seeds with complete removal of aril alone, and (3) seeds with complete removal of aril plus partial removal of seed coat. In the treatment involving partial removal of seed coat, approximately one-third of the seed coat was removed at the radicular end. The seed coat in the rest of the seed remained tightly attached to the cotyledons. In the treatment involving complete removal of the aril, the aril was peeled manually by using a scalpel. Seeds that appeared to have damaged embryos were discarded.

The second factor involved soaking the seeds in KNO_3 solution at five concentration levels: 0.0, 0.2, 0.4, 0.6 and 0.8 %. These treatments involved

separate immersion of five lots of each scarification treatment in the different concentration levels of KNO_3 for a period of 12 *h*. At the end of this period, seeds were removed and immediately sown.

Seed germination in the laboratory

Blotter paper substratum (three layers of Whatman No. 41) was laid inside transparent plastic dishes (size 18 × 12 × 6 *cm*). Then 25 treated seeds were evenly distributed on top of the substratum without touching each other.

The substratum in each dish was moistened with 10 *ml* of distilled water and kept sufficiently but not excessively moist at all times to supply the necessary moisture to the seeds.

The dishes were covered and placed in a germination incubator. Each dish represented an observation plot and the shelves inside the incubator represented blocks. A constant temperature of $25 \pm 1^{\circ}C$ and relative humidity of approximately 90 % were maintained inside the incubator. Seeds were illuminated at all times by four 20W, cool, white fluorescent tubes.

Seed germination in the nursery

Timber frames with internal dimensions of 20 × 20 *cm* and a depth of 15 *cm* were used as observation plots. The frames were laid on the ground and filled with sifted sand. Seeds were distributed on top of the sand without touching each other and then covered with the sand to a uniform depth of 10 *mm*. Water was applied manually so that the medium was kept moist all the time without getting waterlogged.

Data collection

Germination

In the laboratory experiment, the seeds were scored as having germinated when the protruding epicotyl had reached at least 10 *mm*. In the nursery the criterion for germination was a visible protrusion of the shoot apex or epicotyl on the surface of the sand.

In both laboratory and nursery experiments, germination was recorded daily until no further germination occurred. At this stage, the height (epicotyl + hypocotyl) of all seedlings in the nursery was measured to the nearest *mm*. Ungerminated seeds were tested for viability by the tetrazolium method (ISTA 1985).

Germination phases

The imbibition period (the number of days from sowing to commencement of germination), and the total germination period (the number of days from

sowing to completion of germination) were recorded. These values were used to determine the time between commencement and completion of germination.

Data analysis

At each assessment, the number of germinated seeds was expressed as a percentage of all seeds sown per plot. The germination energy, defined as the germination percentage when the mean daily germination (cumulative germination percentage divided by the time elapsed since sowing date) reached its peak, was also determined. In addition, germination value (GV) which is a composite value which combines both germination speed and total germination and provides an objective means of evaluating the results of germination tests was calculated using the formula of Djavanshir and Pourbeik (1976).

$$GV = (\Sigma \text{ DGs}/N)\ GP/10$$

Where GV = Germination value.
GP = Germination per cent at the end of the test.
DGs = Daily germination speed, obtained by dividing the cumulative germination per cent by the number of days since sowing.
ΣDGs = The total obtained by adding every DGs figure obtained from the daily counts.
N = The number of daily counts, starting from the date of first germination.
10 = Constant.

Before statistical analysis, data from both laboratory and nursery experiments were transformed as follows: cumulative germination and germination energy percentage were transformed into arcsin values; imbibition and total germination period and the time between commencement and completion of germination were transformed into square root values; and the heights of seedlings were transformed into common logarithmic values.

Analysis of variance was performed. Means and standard deviations were calculated for each treatment and Duncan's multiple range test (Gomez & Gomez 1983) was used to separate treatment means that were significantly different.

Results and discussion

Cumulative germination, germination energy and germination value

The applied treatments studied had profound effects on the germination of *T. emetica* seed. Overall, seed scarification treatments produced the highest germination percentage in treatments with complete removal of aril associated with partial removal of seed coat, intermediate results in seeds with aril removal

alone and lowest in unscarified seeds for both laboratory and nursery experiments. Trends in germination energy were similar to cumulative germination (Tables 1 and 2).

Germination values (GV) for all treatments are illustrated in Figure 1. They were highest in treatment where aril removal was associated with partial removal of the seed coat. Unscarified seeds gave significantly lower GV while seeds with aril removal alone were intermediate.

Within scarification treatments, the application of KNO_3 significantly reduced cumulative germination in both laboratory and nursery experiments. The results demonstrate negative effects of applying KNO_3 at concentrations greater than 0.4 percent for scarified seeds. It had no effect on unscarified seeds (Tables 1 and 2).

When tested for viability by the tetrazolium biochemical method, all ungerminated seeds at the termination of the experiment were found to be non-viable. Unscarified seeds were attacked by a saprophytic fungus (*Aspergillus* sp.). The severity of the attack was highest in unscarified seeds sown in the laboratory.

There are some conflicting views of how to obtain the best germination of *T. emetica* seed. Watkins (1960) states that germination is fair when the aril is removed from the base of the seeds. On the other hand *T. emetica* seeds are said

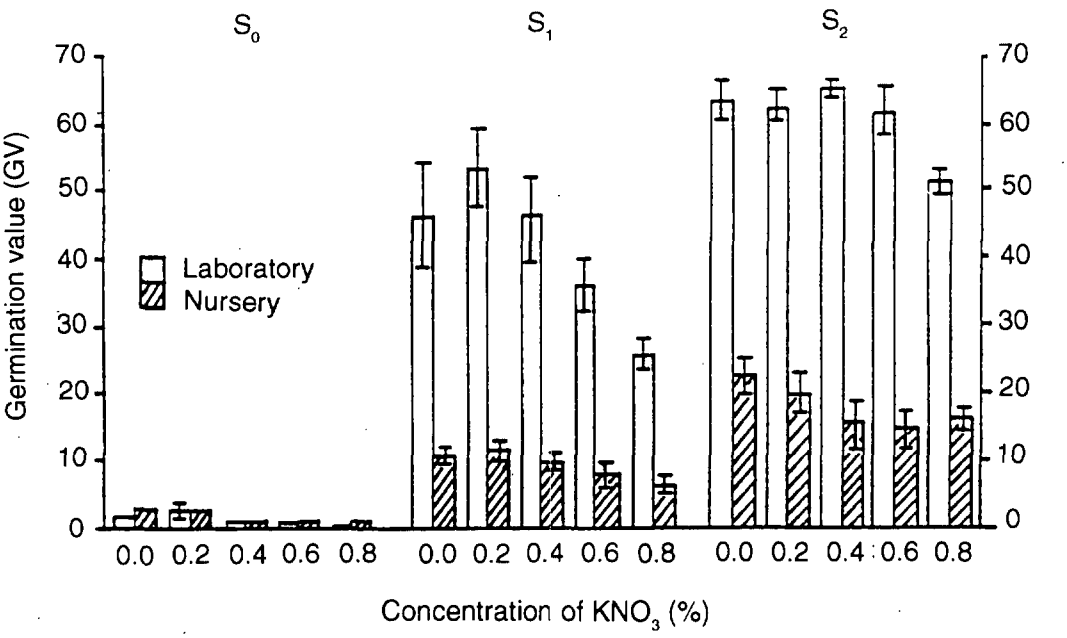

Figure 1. Influence of manual seed coat scarification and KNO_3 concentrations on the germination of *Trichilia emetica* seed in laboratory and nursery experiments. (S_0) unscarified, (S_1) complete removal of aril, (S_2) complete removal of aril + partial removal of seed coat. Each bar is a mean of four replicates. Vertical lines indicate ± standard deviations. A bar without a line denotes that the standard deviation is nearly zero

Table 1. Effect of manual seed coat scarification and KNO_3 concentrations on the germination of *Trichilia emetica* seed 20 days after sowing in the laboratory

Treatments					Germination periods (days)		
Manual scarification	Chemical KNO_3 (%)	Cumulative germination (%)	Germination energy (%)	Germination value (GV)	Imbibition (C)	Total (T)	(T – C)
Unscarified (S_o)	0.0	28 ± 6.5b*	27 ± 8.2b	2.7 ± 1.2a	13 ± 1.5c	19 ± 0.5c	6 ± 1.4c
	0.2	29 ± 7.6b	29 ± 7.6b	2.9 ± 1.8a	14 ± 1.7c	19 ± 0.5c	5 ± 1.5c
	0.4	19 ± 3.8ab	19 ± 3.8ab	1.3 ± 0.6a	14 ± 1.2c	19 ± 0.8c	5 ± 1.8c
	0.6	16 ± 3.3a	16 ± 3.3a	0.8 ± 0.1a	14 ± 1.7c	19 ± 0.5c	5 ± 2.2c
	0.8	5 ± 2.0a	5 ± 2.0a	0.2 ± 0.1a	15 ± 0.5c	19 ± 0.5c	4 ± 0.0c
Complete removal of aril (S_1)	0.0	88 ± 11.3d	84 ± 13.9d	46.1 ± 14.7cd	9 ± 0.0b	14 ± 1.2b	5 ± 1.3b
	0.2	90 ± 6.9d	86 ± 6.9d	52.6 ± 11.2d	9 ± 0.5b	14 ± 1.3b	5 ± 1.3b
	0.4	86 ± 13.7cd	83 ± 15.4d	45.5 ± 13.2cd	9 ± 0.5b	14 ± 0.5b	5 ± 0.8b
	0.6	84 ± 7.3cd	84 ± 7.3d	36.9 ± 7.0c	9 ± 0.5b	14 ± 0.6b	5 ± 0.5b
	0.8	71 ± 5.0c	71 ± 5.0c	26.3 ± 4.5b	9 ± 1.5b	14 ± 3.1b	5 ± 1.7b
Complete removal of aril + partial removal of seed coat (S_2)	0.0	99 ± 2.0e	94 ± 2.3e	62.8 ± 6.5f	8 ± 0.0a	13 ± 0.6a	5 ± 0.6a
	0.2	99 ± 2.0c	94 ± 2.3e	62.0 ± 5.3f	8 ± 0.0a	13 ± 0.5a	5 ± 0.8a
	0.4	100 ± 0.0e	93 ± 3.8e	65.0 ± 2.2f	8 ± 0.0a	14 ± 1.0a	6 ± 0.5a
	0.6	96 ± 5.7e	91 ± 8.2e	61.4 ± 7.0f	8 ± 0.0a	13 ± 0.5a	5 ± 0.5a
	0.8	92 ± 5.7f	86 ± 4.0f	51.5 ± 3.8g	8 ± 0.5a	14 ± 1.5a	6 ± 1.4a

Data represents a mean of four replicates ± standard deviation.

* Values in the same column and within a scarification treatment followed by the same letter do not differ significantly based on Duncan's Multiple Range test ($p < 0.05$).

Table 2. Effect of manual seed coat scarification and KNO_3 concentrations on the germination of *Trichilia emetica* seed 35 days after sowing in the nursery

Treatments						Germination periods (days)		
Manual scarification	Chemical KNO_3 (%)	Cumulative germination (%)	Germination energy (%)	Germination value (GV)	Seedling height	Imbibition (C) *(mm)*	Total (T)	(T – C)
Unscarified (S_0)	0.0	33 ± 3.8b*	31 ± 3.8ab	2.1 ±0.3a	15 ± 0.5a	24 ± 2.2c	31 ± 2.2c	7 ± 1.0a
	0.2	39 ± 7.6b	37 ± 9.5b	2.6 ±0.8a	21 ± 2.6a	20 ± 1.0c	31 ± 1.5c	11 ± 2.1a
	0.4	33 ± 8.9ab	33 ± 8.9b	1.9 ±0.9a	17 ± 3.7a	21 ± 1.9c	31 ± 2.1c	10 ± 2.5a
	0.6	27 ± 3.8a	27 ± 3.8a	1.4 ±0.6a	16 ± 3.9a	22 ± 3.1c	31 ± 4.4c	9 ± 2.7a
	0.8	27 ±11.0a	25 ±10.5a	1.3 ±1.1a	16 ± 3.7a	23 ± 2.6c	31 ± 2.7c	8 ± 3.0a
Complete removal of aril (S_1)	0.0	71 ± 3.8d	71 ± 3.8d	10 ±1.1c	47 ± 3.2b	14 ± 0.5b	31 ± 1.3b	17 ± 1.7c
	0.2	76 ± 6.5d	73 ± 9.8d	11.9 ±0.9c	59 ± 4.2b	14 ± 0.5b	31 ± 1.3b	17 ± 1.4c
	0.4	69 ± 6.8cd	64 ± 5.7c	10.2 ±3.1c	42 ± 8.4b	16 ± 2.5b	31 ± 0.0b	15 ± 2.6c
	0.6	65 ± 3.8cd	62 ± 2.3c	8.2 ±2.9bc	40 ± 7.1b	15 ± 1.4b	31 ± 1.7b	16 ± 2.6c
	0.8	62 ±10.6c	60 ± 9.8c	6.4 ±3.0b	39 ± 3.3b	15 ± 1.7b	29 ± 4.6b	14 ± 5.2c
Complete removal of aril + partial removalof seed coat (S_2)	0.0	93 ± 6.8f	92 ± 5.7g	23.5 ±5.0e	68 ± 6.2c	13 ± 0.6a	25 ± 1.9a	12 ± 2.4b
	0.2	85 ±14.0f	80 ±13.9ef	19.9 ±6.5e	62 ±10.5c	14 ± 1.8a	27 ± 1.7a	13 ± 0.6b
	0.4	83 ±10.5f	80 ± 7.3ef	16.2 ±7.4d	60 ± 5.9c	13 ± 1.2a	25 ± 1.0a	12 ± 0.5b
	0.6	84 ±12.6f	84 ±12.6fg	15.4 ±4.7d	58 ±14.3c	13 ± 1.3a	26 ± 1.0a	13 ± 1.9b
	0.8	81 ± 7.6e	76 ± 8.6e	16.5 ±2.6d	54 ± 6.3c	14 ± 1.3a	28 ± 1.3a	14 ± 2.2b

Data represents a mean of four replicates ± standard deviation.

* Values in the same column and within a scarification treatment followed by the same letter do not differ significantly based on Duncan's Multiple Range test ($p < 0.05$).

to need no pretreatment for good germination, a claim not substantiated by supportive evidence (Forest Division 1984).

The results of the present study support our previous observation that the poor germination of untreated seeds is attributed mainly to the impermeability of the aril to fluids (Maghembe & Msanga 1988). The exchange of gases through the hilum as in other seeds (Hyde 1954, Ballard *et al.* 1976) is not possible for *T. emetica* seed as the hilum is completely concealed by the aril.

Inhibitory chemicals in the seed coat or aril are not the cause of poor germination in *T. emetica* since seeds which received only partial scarification germinated satisfactorily in the presence of the remaining part of the aril and seed coat (Maghembe & Msanga 1988). Its seed coat is thin and can easily break after water imbibition. As a result, it does not seem to play a significant role in germination.

In many plants KNO_3 is known to promote seed germination (Ogaware & Ono 1961, ISTA 1985). In this study, however, exposure of *T. emetica* seeds to different concentration levels of KNO_3 had adverse results. Similar results have also been reported for many other tree species (AOSA 1955, Msanga & Maghembe 1986, Curran & McCarthy 1986). It is possible that the adverse effects related to concentration levels of KNO_3 higher than 0.4% were due to high osmotic pressure created by the chemical in the substrate. It has been reported that high concentrations of solutes increase osmotic pressure of the germination solutions and make imbibition difficult. Such solutes therefore retard germination in many plant species (Rodger *et al.* 1959, Bonner 1968).

Height of seedlings

The initial height attained by seedlings was also influenced significantly by presowing treatments, especially seed scarification (Tables 1 and 2). Complete removal of aril associated with partial removal of the seed coat induced the highest initial growth and unscarified seed the lowest.

In the present study the concentrations of KNO_3 in the substrate did not affect the average height of seedlings. This may be explained by the fact that both KNO_3 treated and untreated seeds took nearly the same period to start and complete their germination. Consequently the seedlings attained nearly the same average seedling height in both untreated and KNO_3 treated seeds although relatively fewer seedlings emerged form the KNO_3 treated seeds.

Germination phases

Data in imbibition period, total time to germinate and the time between commencement and completion of germination periods are given in Tables 1 and 2. Scarification of seeds had profound effects on these phases. Imbibition and total germination periods were shortest in seeds where aril removal was associated with partial removal of the seed coat, intermediate in seeds with aril

removal alone and longest in unscarified seeds. For seeds sown in the laboratory, scarification had no effect on the time between commencement and completion of germination. For those sown in the nursery, this period was shortest in unscarified seeds, intermediate in seeds where aril removal was associated with partial removal of the seed coat, and longest in seeds with aril removal alone. Application of KNO_3 did not significantly influence germination phases.

The long periods to imbibe and complete germination in unscarified seeds are likely to be due to aril and seed coat impermeability to water and gases as described previously. The non-significant effects of KNO_3 on germination phases in all scarification treatments suggest that KNO_3 does not suppress or promote the speed at which the germination process takes place.

Comparison between laboratory and nursery germination

Unscarified seeds which were sown in the laboratory had lower cumulative germination and germination energy percentage than those sown in the nursery. With scarified seeds, cumulative germination and germination energy percentages were higher in laboratory tests than in the nursery (Tables 1 and 2). In the laboratory, most seeds completed their germination after 19 days compared to 31 days in the nursery. As expected, these findings show that the controlled conditions in the laboratory were more suitable for germination of *T. emetica* seed compared to those in the nursery.

Acknowledgements

We would like to express our sincere gratitude to S. Chamshama, Dean of Faculty of Forestry, Sokoine University of Agriculture, for his professional assistance during planning and implementation of the research work. We greatly acknowledge the technical assistance of J. Malya, Officer-in-Charge of the Tanzania Official Seed Certification Agency and the typing of the paper by M. Gwakinsa.

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