American-Eurasian J. Agric. & Environ. Sci., 8 (6): 722-727, 2010
ISSN 1818-6769

Germination of *Terminalia sericea* Buch ex Dc. Seeds: Effects of Temperature Regime, Photoperiod, Gibberellic Acid and Potassium Nitrate

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Abstract: In an effort for improving and promoting the propagation of *Terminalia sericea*, the effects of temperature, photoperiod and growth regulators on seed germination were investigated. Seeds were tested with different temperature regime (10, 15, 20, 25, 30, 35 and 40°C) and in photoperiod (4/20, 8/16, 12/12, 16/8 light/dark hrs and 24 hours continuous dark). Pre-treatments with growth regulators were done with solutions of gibberellic acid (GA_3) at (50, 100, 200, 400 ppm) and potassium nitrate (KNO_3) at (2000, 4000, 6000, 8000 ppm). The effects of temperature regime, photoperiod and gibberellic acid were significant ($p < 0.001$). Optimum temperature regime was found at 25°C with germination 35% while photoperiod of 12/12 light/dark hr had relatively high germination 33%. The highest germination 67% was obtained with pre treatment of GA_3 at 400 ppm. Pre treatments with KNO_3 had insignificant effect and generally had the lowest percentage of seed germination. These results have significant implication on the best methods to be used in improving seed germination of *T. sericea.*

Key words: *Terminalia sericea* · Germination · Temperature regime · Photoperiod · Gibberellic acid · Potassium nitrate

INTRODUCTION

Terminalia sericea Burch. ex DC is a common shrub or tree of 6 to 9 m, but individual trees may reach 23 m in height, the species belongs to the family Combretaceae [1]. *T. sericea* is scattered in open woodlands, or as a dominant or co-dominant in mixed deciduous forests. It thrives in a range of soil types, moisture conditions and drainage conditions as long as light is not a limiting factor [2]. As a multipurpose species, uses of *T. sericea* ranges from land improvements to medicinal plant. The tree improves sites by draining waterlogged soils, shading out weeds, enriching impoverished soils and also used for erosion control [3]. For medicinal uses, roots of *T. sericea* are used to treat bilharzia, colic, pneumonia and diarrhea while leaves are used for stomach disorders [1]. The species is also used for carvings, fencing posts, charcoal, fuel wood, building material and tool handles [3].

Because of its importance in providing many uses and services, efforts aimed at planting this miombo tree species have been unsuccessful due to the low germination rate under natural conditions [4]. Besides, there is an urgent need for domestication of the species in order to reduce pressure from the natural forests [5]. Artificial regeneration and domestication of miombo tree species requires knowledge on their seed biology [6]. Seed germination of tropical species is influenced by several biological factors such species, seed viability, seed size [7-9] and plant growth regulators through actions as germination stimulator [10, 11]. Environmental factors like temperature, relative humidity, light intensity and duration also have influence on seed germination [12, 13].

Though few studies have been conducted on different aspects of seed germination of *T. sericea* [14-16], no information is available on the effect of temperature regime, photoperiod and presoaking treatments of plant growth regulators. The aim of the present study was therefore to investigate the effects of temperature regime, photoperiod and plant growth regulators such as gibberellic acid (GA_3) and potassium nitrate (KNO_3) on seed germination of *T. sericea*.

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MATERIALS AND METHODS

Seed Collection and Processing: Seeds of *T. sericea* were collected from Mkundi (6°40" S; 37°39"E) at an altitude of 475 m a.s.l. Seed samples were collected from randomly selected fruiting branches from as many plants as possible in healthy looking populations. Seeds were mechanically nicked using secateur then surface sterilized with 1% sodium hypochlorite prior to any experimental usage.

Effects of Temperature Regime and Photoperiod: The effect of the temperature on seed germination was investigated by exposing the seeds to constant temperatures of 10, 15, 20, 25, 30, 35 and 40°C under photoperiod of 12 light/dark hours. To determine the effect of different photoperiod, treatments were conducted in 4/20, 8/16, 12/12, 16/8 light/dark hours photoperiod and 24 hours continuous dark, seeds were incubated at constant temperature of 25±l°C for 30 consecutive days in the seed germinator. Daily photoperiod treatments were regulated by removal and placement of the petri dishes into black carbon paper. Germination trials were conducted in 10 cm diameter Petri dishes lined with filter papers and moistened with sterile distilled water to ensure adequate moisture for the seeds. Seed germinators were equipped with cool-white fluorescent lamps that provided a photosynthetic photon flux of 40 $\mu mol.m^{-2}s^{-1}$.

Pre-Treatment with Plant Growth Regulators: Seeds were first sterilized with 1% sodium hypochlorite, washed thoroughly with double distilled water and dipped in first various pre-treatment solutions of gibberellic acid (GA_3); (50, 100, 200, 400 ppm). The second pre- treatment involved soaking seeds with solution of potassium nitrate (KNO_3) at (2000, 4000, 6000, 8000 ppm) for period of 12 hr at A constant temperature of 25±l°C. Control was maintained using double distilled water. After treatments, seeds were removed and washed with distilled water three times and immediately sown into 10 cm diameter Petri dishes on a single layer of Whatman No. 1 filter paper with about 5 ml of distilled water. The moisture levels of filter paper were maintained by adding distilled water as required.

Experimental Design: Treatments were arranged in a randomized complete block with four replicates of 25 seeds each. Daily observations were-taken for the germination experiment for a period of two months from the date of sowing and seeds were considered germinated when the radicle was about 2 mm long and cotyledons had emerged from the seed coat indicating the seedling was likely to be successfully established. Results were expressed as germination percentage which was the percentage of live seeds that had germinated at the end of test.

Statistical Analysis: Results of the germination studies were subjected to an analysis of variance (ANOVA) using GenStat Discovery Edition 3 Release 7.22 DE computer software package [17]. Prior to statistical analysis daily germination and cumulative percentages data were transformed into arc sine values to bring data to normality. For significant treatments revealed by Analysis of Variance (ANOVA), means were separated by Duncan Multiple Range Test (DMRT).

RESULTS

Effect of Temperature Regime and Photoperiod: Effect of temperature regime on seed germination of *T. sericea* was significant ($p< 0.001$). Seeds of *T. sericea* germinated in a wide range of temperature from 15 to 35°C. However, the highest germination 35% was found at 25°C indicating the optimum temperature was 25°C (Fig. 1). No significant differences for germination percentage were found in the temperature range of 20 to 30°C, but differed significantly from other tested temperatures ($p < 0.05$ by DMRT test). The results indicated that the species has a wide range of temperature requirement for germination. The minimum temperature of germination is between 10 to 15°C and the maximum between 35 to 40°C under photoperiod of 12 light/dark hours (Fig. 1).

Effect of photoperiod on seed germination was significant ($p < 0.001$). Among different photoperiods, 12/12 light/dark hr duration was found optimum for germination with germination percentage of 33% (Fig. 2). No significant difference were observed between photoperiod of 8/16 light/dark and 12/12 hr light/dark duration. Increasing photoperiods from 16/8 light/dark significantly decreased germination and at photoperiod of 24 hours dark no seed germination was recorded (Fig. 2).

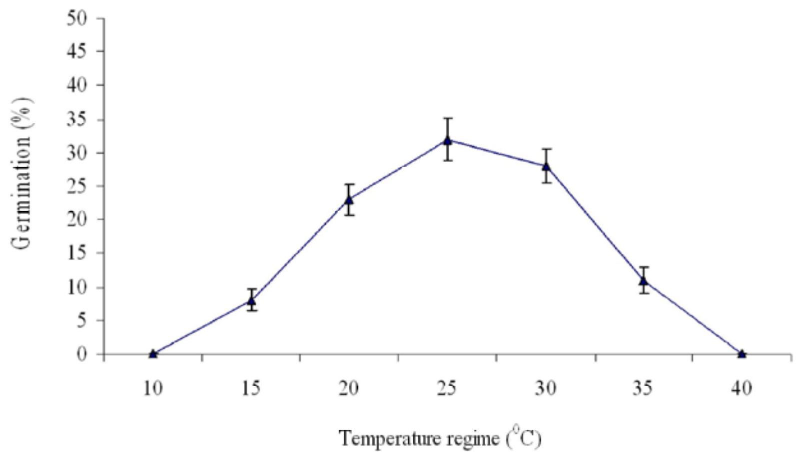

Fig. 1: Effect of temperature regime on cumulative germination of *T. sericea* Bar graph with the same letter indicate no significant difference at $p<0.05$ (DMRT)

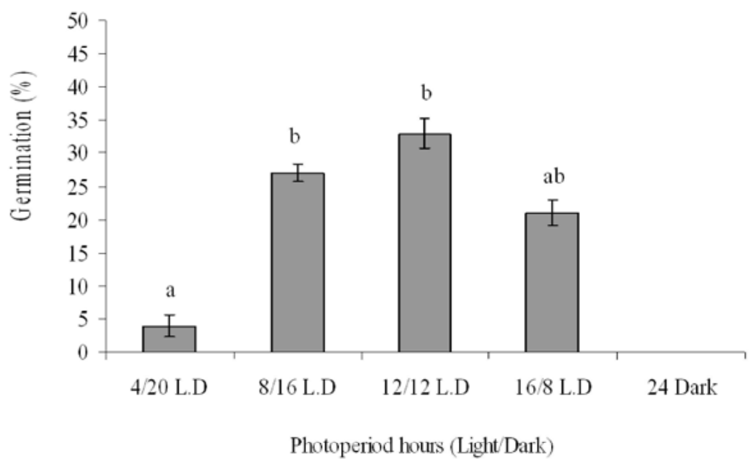

Fig. 2: The effect of photoperiod on cumulative germination of T. sericea Bar graph with the same letter indicate no significant difference at $p<0.05$ (DMRT)

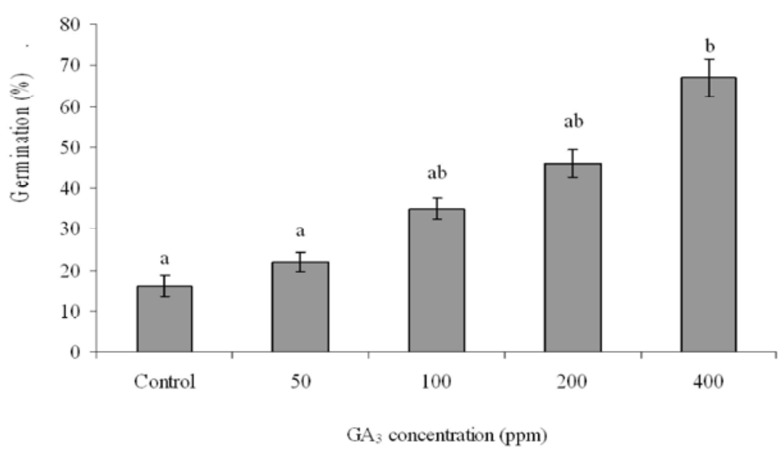

Fig. 3: Effect of gibberellic acid (GA_3) on cumulative germination of *T. sericea* Bar graph with the same letter indicate no significant difference at $p<0.05$ (DMRT)

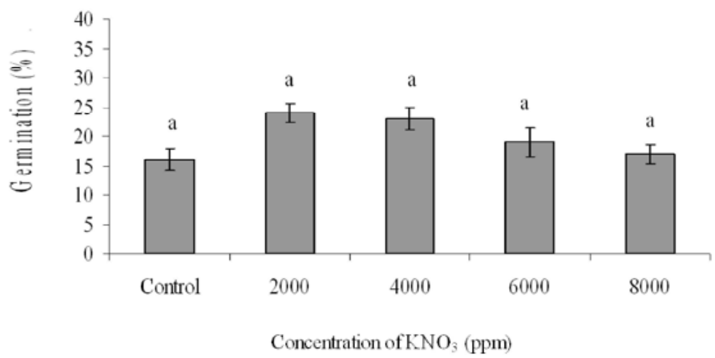

Fig. 4: Effect of potassium nitrate (KNO_3) on cumulative germination of *T. sericea* Bar graph with the same letter indicate no significant difference at $p<0.05$ (DMRT)

Effects of Pre-treatment with Plant Growth Regulators: Effect of pre-treatment with solutions of gibberellic acid (GA_3) on seed germination of *T. sericea* was significant ($p<0.001$). All concentrations of GA_3 had higher germination than control and at highest concentration (400 ppm) was the most effective with seed germination of 67% (Fig. 3). Differences among responses of different GA_3 concentrations were statistically significant ($p<0.05$) and seeds treated with GA_3 began germinating sooner and germination was completed earlier than control treatment.

Effect of pre-treatment with solutions of potassium nitrate (KNO_3) on seed germination *T. sericea* was not significant. Evidence from the result showed that insignificant differences exist in the effect of the soaking regime of different concentrations of KNO_3 on percentage seed germination of *T. sericea* (Fig. 4). The germination percent was decreased as the concentration increased.

DISCUSSION

The optimum temperature range where seeds of *T. sericea* germinated was the same as for several tropical species [18, 19]. Sensitivity of seeds to the environmental conditions such as temperature results in the high probability of seed germination with high seedling survival [20]. High temperature prevented seed germination in *T. sericea.* High temperature is well known to prevent radicle and shoot elongation by inhibiting synthesis of protein and nucleic acid [21].

Plants have the capacity to monitor light quality and fluency, direction and duration and to adjust their development and reproduction to seasonal and daily changes. That capacity is due to the present phytochrome system as natural process which is responsible for induction of seed germination and seedling developmental processes [12-23]. Light-controlled germination has been associated with phytochrome since the pioneer work of Borthwick [24].

Generally, photoperiod of 8 to 12 hr day light is necessary for maximum germination and growth in forest trees [18], which correspond to the findings of the present study which revealed high seed germination for 8/16 to 12/12 hr (light/dark) photoperiod. Similar photoperiod was found optimum for seed germination and seedling growth. A similar effect has been reported for other species [25, 26]. Seeds of *T. sericea* subjected to 24 hr dark photoperiod did not germinate. In general, absence of light has a negative effect on germination in several species [25, 27].

Application of gibberellic acid (GA_3) enhanced seed germination in *T. sericea.* Several studies from recent years have shown that gibberellin is an effective germination stimulator in several species [10, 11, 28, 29]. Gibberellic acid increased germination significantly depending on doses. Similar results were obtained from the studies carried on other species such as *Sesamum indicum* [30].

Seed dormancy in seeds is closely related to the growth regulators especially gibberellins [31]. Applied exogenous gibberellic acid (GA_3) solution is known to modify the influence of cytokinins on transport across membranes and is thus able to initiate the biochemical processes necessary for germination to occur [11]. The cytokinin probably penetrates the testa and neutralizes the inhibitors present in the embryo, thus enabling the embryo to rupture the seed coats [29]. Gibberellic acid also increases synthesis of hydrolytic enzymes located under aleuron layer. Synthesized enzymes are transported to endosperm and are used for decomposing of stored food to supply energy required for germination [11].

Potassium nitrate (KNO_3), a growth regulating and germination stimulating substance can both stimulate and inhibit seed germination in some species. Several workers have reported that KNO_3 improved the seed germination of many plants [25, 32]. In this study, however, exposure of *T. sericea* seeds to different concentration levels of KNO_3 had adverse results. Similar results have also been reported for many other tree species [33]. The reason might be the sensitivity of *T. sericea* seeds to KNO_3 concentrations which as it has reported that higher concentrations exert decreasing effects on seed germination by causing death of cells and ultimately result in loss of seed viability [34].

CONCLUSION

Seeds of *T. sericea* could be successfully germinated when using appropriate temperature regime, photoperiod and pre soaking treatments of growth substances. The optimum temperature at 25°C and photoperiod of 12/12 hr is required to trigger seed germination in *T. sericea.* The treatment with gibberellic acid (GA_3) with 400 ppm gave the best results with 67% of germination. For the purpose of domestication the use of these treatments is recommended. As a miombo species, this plant has the potential of being a continuous source of supply of raw material for carvings, charcoal industry, building material and phytomedicine industry.

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