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Research Paper

Seed germination, seedling growth and biomass prediction on pre treated seeds of *Acacia senegal*

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ABSTRACT

Acacia species are characterized by a very hard and impermeable seed coat resulting to temporary dormancy and influences germination process. Therefore, the application of severe treatments of seeds is needed to break the dormancy and also speed up the process of germination. The study was achieved through germination trial experiment using different treatment methods in a nursery. The experiment was conducted on 1st Dec 2019, during dry season at Kenya Forestry Research Institute Lodwar Nursery. Seeds were collected from different part of Turkana County and provided by KEFRI to be planted in nursery for the study. An experiment was carried out to study the effect of seed pretreated on emergence of *Acacia senegal,* to determine seedling germination growth rate and biomass prediction. The pretreatments were; lukewarm water (water at room temperature of 20°C plus hot water of 15°C) and cold water (at room temperature). The seed soaked in lukewarm water for 12 h had the shortest time to germinate (2 days after sowing). Shortest time to 50% emergence (5 days after sowing) and shortest time to last observed emergence (8 days after sowing). The seed soaked in lukewarm water also produced the highest percentage emergence of 70%. This can be compared to the seed soaked with cold water. For seed soaked in cold water for 12 h of germination was moderate. It took moderate time to germinate (4 days after sowing) and also took moderate time to last observed (10 days after sowing). It took moderate time to attain 50% emergence (10 days after sowing). The seed soaked in cold water produced average of 50%. The study shows that seed without any pretreatment took longer time to germinate (6 days after sowing), longest time to last observed emergence (15 days after sowing). Seed without pretreatment did not attain 50% emergence. The study findings presented in biomass Table showed that the lowest root collar diameter of *A. senegal* seedling is 1 mm, and highest root collar diameter is 4.5 mm. Regression equation for seeds soaked in lukewarm water is 0.9818; cold water is 0.9412 and control 0.9158. The best regression equation was given by seeds soaked in lukewarm water. Based on the result of the study, pretreatment of *A. senegal* seeds with lukewarm water for 12 h before sowing in the nursery is encouraged.

Keywords: Seed dormancy, pre- germination treatments, growth, *Acacia senegal*, biomass prediction.

INTRODUCTION

Acacia senegal is widely spread in tropical and sub-tropical Africa from South Africa Northward to Sudan (Raddad, 2005). In Kenya, the *A. senegal* tree grows on Homa hills in the Rift Valley, Lokitaung and Mutha hills. The dry Acacia commiphora bush stands of this species have been found in parts of Turkana and Baringo District (Maundu, 1999). It is a shrub species characteristic of arid zones with 200 to 500 mm rainfall (Pascal, 1992). The easiest way to identify this tree is by thorns, one is curved and faces backwards and the other one is curved and faces forward, or the central one may be hooked downwards and the lateral one curved upwards occasionally solitary (Anthony, 1996). Deforestation and forest degradation in the tropics and have continued unabated and are posing serious threats to forests and livelihoods of those who depend on forests and forest resources (Lalisa, 2019). Soil erosion, deforestation, loss of soil fertility, loss of biodiversity and regular drought/floods are now common occurrences particularly in arid and semi-arid (ASAL) areas (Foundation, Desertlands, 2018). Globally, *A. senegal* is known to be a multifunctional tree, wood products that have become major international commodity in modern times. Non-timber tree produce often referred as non-wood forest is ranked among the oldest traded commodity (Eisa, 2008). In Sudan, gum from the *A. senegal* tree has played a large economic role for smallholders for generations, but there are signs of a declining production which is detrimental if people have no alternative means (Olsson, 2006). Apart from harvesting gum Arabic from the trees and selling it to earn cash, the local communities obtain fodder, fuel wood, traditional medicine, fencing materials and fibre from the trees (Wekesa, 2010) . Acacia species are characterized by a very hard and impermeable seed coat resulting to temporary dormancy and influences germination process (Aref, 2000). Therefore, the application of severe treatments of seeds is needed to break the dormancy and also speed up the process of germination. Having this information helps in understanding the species germination rate, its habitat and critical life history stages in the development of *A. senegal* which guide in conservation of the species as well as increasing availability of the tree (Baskin, 2017). This study therefore, seeks to find the best treatment time for seeds of gum Arabic for both cold and hot water so that farmers can use the identified times for any of the two treatments cold or hot water for plantation establishment (Usman, 2010). In germination trial, seeds are given the needed resources (air water warmth and light) to germinate and grow into the seedling (Abram, 2011). Measuring seedling numbers helps to determine soil condition at sowing, non-wetting, sowing operation, seed rate and quality (Department of Primary Industries and Regional Development, 2019). Biomass yield is necessary as it is regarded as an important indicator of ecological and management processes in the vegetation, species that dominate a site in terms of biomass are a reflection of the species that are controlling the nutrient, water and solar resources on the site (Hatim, 2015). The greatest challenge affecting *A. senegal* availability is climate change which is likely to further increase the vulnerability of the species through disturbances of natural habitat (Boko, 2007). The study's objectives is to determine the germination trend in partly controlled arid environment, to determine seedling growth for *A. senegal* in high watering regime and to predict yield for pretreated seeds of *A. senegal* with the growth data.

MATERIALS AND METHODS

Experimental site

Seed germination tests were carried out in Nursery Department, Kenya Forestry Research Institute Turkana Lodwar (3.112550'N, 35.599170'E). The nursery was established by Kenya Forestry Research Institute for raising different tree species for research purposes as well as conserving trees species and other allied resources. Lodwar has a hot desert climate with very high temperature and very little rainfall throughout the year. The average annual temperature is one of the highest in the world with nearly 29°C and average annual rainfall is about 186 mm, with very sunny climate year-round (weatheronline.co.uk, 2018).

The site selected was suitable for nursery bed preparation with adequate water supply, protected from direct supply of sunshine. The nursery was well located under the shade of different trees which includes *Azadirachta indica, Diosyphorus scabra, Cordia sinensis, Jatropha curcus, Senna seamea* and *Moringa stenopatela.* These trees are all aligned in a way that it provides easy access to routine monitoring and evaluation.

The materials used for the *A. senegal* germination were seed obtained from KEFRI, polyethylene tubes (18 × 12 cm), scooping metal, soil mixture 5:3:2 (Estimated by use of wheelbarrow), hose pipe and seedlings, Jembe and spade, soil survey instrument (pH) and each half glass of water at room temperature of 20°C plus hot water of 15°C (lukewarm water), water at room temperature of 20°C. The method used to analyze data was Microsoft excels and data was presented in graphs. Weed control was carried out by hand pulling throughout the period of the experiment so that the seedlings could be free from weed as weeds compete with plants for air, light, nutrients, space and water. Gum Arabic is very sensitive to weeds particularly at the early stages after planting. This is considered as first observed germination time for that seed. This process was done through close monitoring both morning and evenings during the time of the experiment.

Seed germination and seedling growth for *Acacia senegal*

The experiment was conducted on 1st Dec 2019, during dry season at Kenya Forestry Research Institute Lodwar Nursery. Seeds were collected from different part of Turkana County and provided by KEFRI to be planted in nursery for the study and for the improvement of environment conservation for future reference. The type of pretreatments used were lukewarm (mixture of half glass of 200 ml hot water at temperature of 15°C and half glass 200 ml of water at room temperature of 20°C) and cold water (water at room temperature of 20°C) to soak the seeds. The supply of adequate water was essential because the experiment was conducted in the dry season. Gum Arabic seeds may not need any irrigation in the rainy season. Potting was done and were arranged in 3 sections of 100 tubes and supplied with water a day before planting

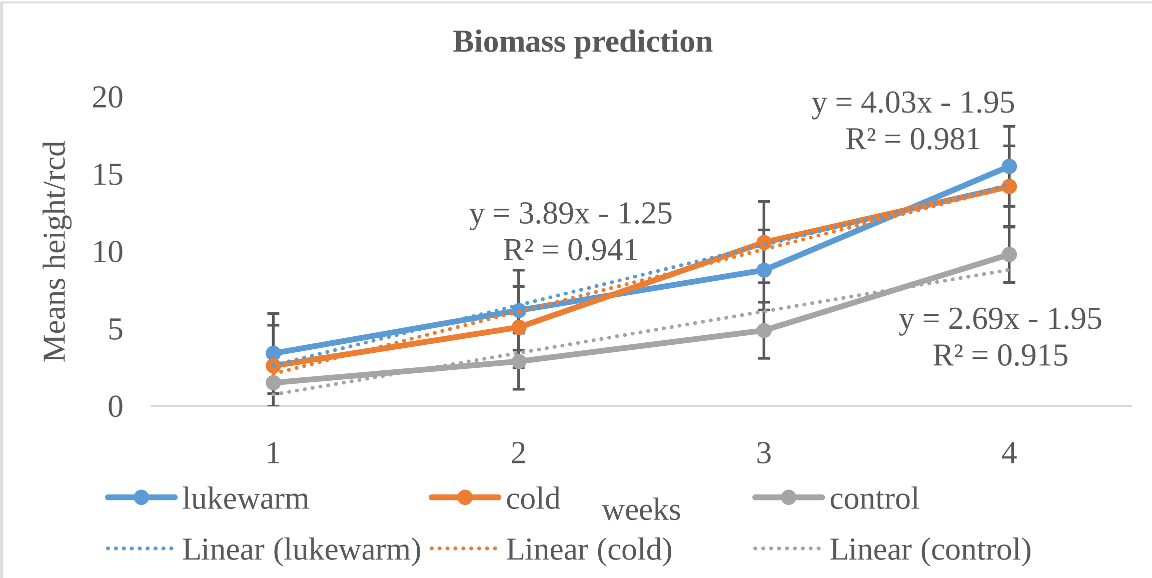

Figure 1: A graph showing biomass prediction using r-squared equation for each experiment.

for it to allow soil to absorb water for moisture upkeep. 600 seeds were used, from which 2 seeds were planted in one polyethylene tube of 18 × 12 cm to increase efficiency of germination, hence 300 polyethylene tubes were prepared to produce a total of 300 seedlings, 200 seedlings for the pretreated seeds and 100 seedlings for seeds without pretreatment. The pre-treatment method was applied in seeds; seeds were directly planted after treatment. Germination was checked daily. Prior to sowing, the poly bags were fully watered in order to keep the moisture content of the soil. The seedlings were supplied with water on a daily basis. The data on seed germination and seedling growth were obtained through count and measurement of height and root collar diameter using meter rule and a caliper. Germination count was recorded daily. Height and root collar diameter was recorded weekly for better results.

Biomass yield prediction for acacia pretreated seeds

Height is a model that characterizes tree growth and it must include some measure of site quality because site quality determines potential site productivity. Biomass assessment has many purposes. Besides it serves as resources used for environmental management. Biomass assessment is also important to determine how fuel wood or timber is available for use. Thus the need arises to know how much biomass is available at specific point in a given time. In environmental management, biomass quantification is of paramount importance to assess both the productivity and sustainability of the forest. As well the biomass is a key indicator in carbon sequestration. For this purpose, there is accumulated over time (days). Statistical method considered here was by use of number count of the seedlings on a daily basis until no emergence growth and taking measurements of both height and root collar diameter of each seedling and recording on weekly basis for a period of four weeks (Figure 1).

RESULTS

Seed germination, seedling growth for *Acacia senegal*

Seed soaked in lukewarm water for 12 h started to emerge 2 days after sowing, while seeds soaked in cold water for 12 h started emerging 4 days after sowing and seeds without pretreatment started emerging 6 days after sowing (Figure 2). Time to last observed for the soaked hot water seeds attained their last emergence 8 days after sowing and soaked cold water seeds attained their last emergence 10 days after sowing. Seeds without pretreatment attained their last emergence 15 days after sowing (Table 1).

Seeds soaked with lukewarm water attained 7% at the time it was first observed and attained a maximum of 70% emergence throughout the period of the experiment. Seeds that were soaked in cold water for 12 h attained 5% at the time it was first observed and attained a maximum of 50% throughout the period of experiment (Table 2). Seeds with no treatment had 1% at the start of emergence, producing a maximum of 3% throughout the period of the experiment. Among the three pretreatment methods, seeds soaked in lukewarm water emerged as the best with the highest number of seeds germinated and grown successfully. Seeds soaked in cold water emerged the second best as compared with seeds without pretreatment which was rated poorest

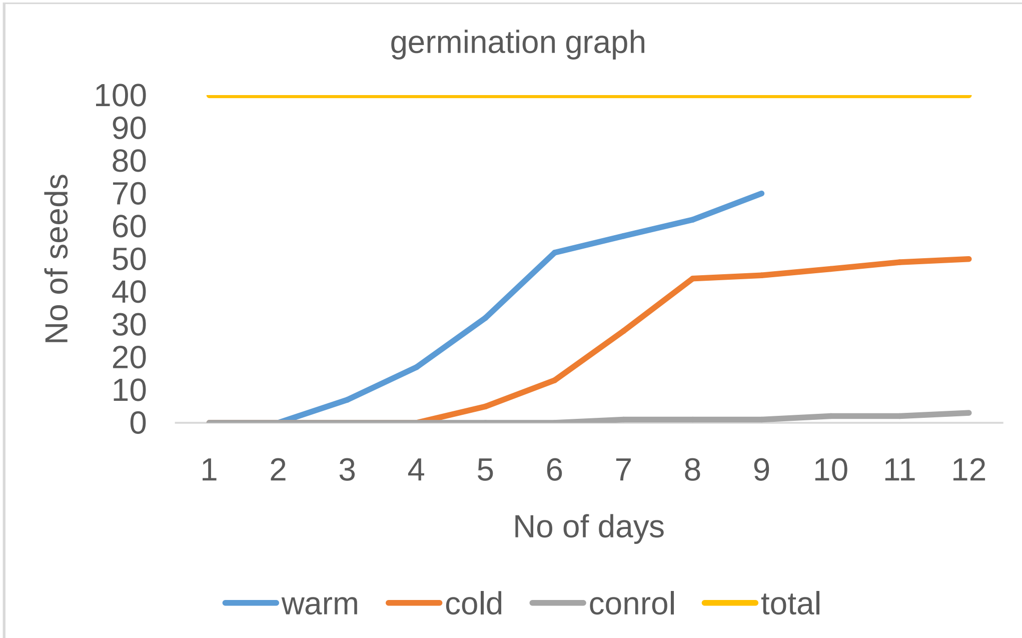

Figure 2: A graph showing seed germinated per each experiment.

Table 1: Number of seed emergence with time (days).

Type of treatments	Average time (days) 1st observed	Average time (days) to last observed	Total final number germinated seeds
lukewarm water	2	8	70/100
Cold water (at room temperature)	4	10	50/100
Control	6	15	3/100

Table 2: Days and seeds germinating after sowing.

Types of treatments	Days after sowing																	
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**14**	**16**	**17**	**18**	**19**	**20**
Lukewarm water	7	10	15	20	5	5	3	5	0	0	0	0	0	0	0	0	0	0
Cold water	0	5	0	8	15	16	0	1	2	2	1	0	0	0	0	0	0	0
Control	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1

of the three and therefore, *A. senegal's* seeds need to be soaked before planting so as to break seed dormancy.

DISCUSSION

Different studies have focused on the effect of bush burning on the germination of various species of the genus acacia (Danthu, 2003). A value of 98% for non-germinated seeds for *A. senegal* shows that this pattern is caused by heavy induced dormancy in the seeds. Germination of *A. senegal* seeds was different depending on the treatments, and also a different pattern of viability of non-germinated seeds was found at the end of the experiment (seeds without any treatment) (Amelework Kassa, 2010). The higher percentage of germination of the species *A. senegal* in comparison with *A. seyal* has been previously reported (Argaw, 1999), but in Amelework study, the difference in viable seeds among the two species of *A. senegal* and *A. seyal* (no viable seeds detected at the end of the experiment in *A. senegal* and a value of 50% for non-germinated seeds for *A. seyal*) indicate that this pattern is caused by a heavy induced dormancy in the latter (Amelework Kassa, 2010). Acacia species are characterized by a very hard and impermeable seed coat resulting to temporary dormancy and influences germination process (Aref, 2000). Therefore,

Table 3: Height and root collar diameter of the seedlings on weekly basis-biomass.

Treatment	Seedling	Height (cm)				Root collar diameter-rcd (mm)			
		Week1	Week2	Week3	Week4	Week1	Week2	Week3	Week4
Lukewarm water	1	5.1	13.4	25.4	30	1	1.5	2.5	3.0
	2	4.5	10.5	15.5	25	1.5	1.5	2.5	3.5
	3	3.5	9.2	12.2	22.5	1.5	2.0	3.0	3.5
	4	5	9.0	15.0	20.5	1.5	2.0	3.5	4.0
	5	6.5	10.2	20.2	25.5	2.0	2.5	3.0	3.5
	6	3	10.6	25.6	34.3	1	2.0	3.5	4.5
	7	5	7.3	15.3	28.5	1.5	2.0	3.5	4.5
	8	4.5	11.2	21.5	21.5	1.5	2.5	3.5	4.0
Cold water	1	4.0	9.0	20.0	25.6	1	1.5	2.5	3.5
	2	3.5	7.5	18.0	24.2	1	1.5	2.5	3.5
	3	2.5	4.6	10.5	20.0	1	1.5	2.5	3.5
	4	3.5	9.5	19.5	24.7	1.5	2.0	3.0	4.0
	5	5	10	22.4	28.5	2.0	2.5	3.0	4.0
	6	4.5	8.0	17.3	26.0	1.5	2.5	3.5	4.5
	7	3	6.5	15.5	23.8	1.5	2.0	2.5	3.5
	8	3.4	5.5	15.0	21.0	1.5	2.5	3.5	4.0
	1	3.5	6.6	12.0	22.6	1	1.5	2.0	3.0
Control	2	2.5	5.8	10.0	25.5	1.5	2.0	2.5	3.5
	3	1.5	4.5	8.9	17.3	1.5	2.5	3.5	4.0
	4	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0

the application of severe treatments of seeds is needed to break the dormancy and also speed up the process of germination.

Different methods have been used by scholars in breaking seed dormancy, these methods include hot water (Fao, 2008) and cold water (Doran, 1983). The use of hot water is the most common method of breaking dormancy in Borno state, Nigeria (Oleghe, 1998), although Doran (1983) reported the use of cold water. The present study tries to explain the best treatment method to be applied. *A. senegal* seeds takes a longer period of time to emerge completely due to the problem of seed dormancy (Anon, 2004). Based on the results of the present study, seeds that were not given any treatment took longer time to start emergence and the period was up to 15 days after sowing to finish emergence of which only 3/100 had germinated and there was no germination afterward. This result is comparable with the study of Amelework Kassa (2010) which state that no viable seeds detected in *A. senegal* at the end of the experiment and a value of 50% for non-germinated seeds for *A. seyal*) indicate that this pattern is caused by a heavy induced dormancy in the latter. In the present study seeds given pretreatment took shorter time to first emerge and finish emergence. For seeds soaked in lukewarm water for 12 h, they emerged within 2 days after sowing, reached final emergence 8 days after sowing and gave a high final 50% emergence in 5 days after sowing, as also reported by Usman (2010). There was no much difference for seeds soaked in cold water which took 4 days to first emerge and reach final emergence in 10 days. There was no significance difference in seeds soaked in cold water and lukewarm water for 12 h, but Doran (1983) reported the use of cold water. This study therefore, seeks to find the best treatment time for seeds of gum Arabic for both cold and hot water so that farmers can use the identified times for any of the two treatments (cold or hot water) for plantation establishment (Usman, 2010). In this study, both cold and hot water were used because there was no significant difference in the two treatments. The positive effect of the pretreatment with lukewarm water for 12 h made the seed coat to become adequately softened to absorb water for imbibition. For hot water, pre-treatment exposure for 10 min which gave the highest mean germination is the most desired pre-treatment (Usman, 2010). Seeds that were soaked in cold water showed no much difference in the emergence time and germination numbers. Water play the same role in the seeds but more effective in the seeds soaked in lukewarm water which increased seed coat softening and imbibition process. The treatment of gum Arabic seeds by soaking in lukewarm water for 12 h is often helpful (Biswanger, 1984). The study findings presented in Table 3 showed that the lowest root collar diameter of *A. senegal* seedling is 1 mm, and highest root collar diameter is 4.5 mm. Regression equation for seeds soaked in lukewarm water is 0.9818;

cold water is 0.9412; and control 0.9158. The best regression equation was given by seeds soaked in lukewarm water. Such a model has to be considered by the Forests National Corporation (FNC) and relevant institutions for assessment of the environmental characteristics of the tree (Hatim, 2015). The greatest challenge affecting *A. senegal* availability is climate change which is likely to further increase the vulnerability of the species through disturbances of natural habitat (Boko, 2007). There was a problem in determining viable seeds which cause a delay in experiment.

CONCLUSION AND RECOMMENDATION

The aim of the present study was to assess the germination trend in partly controlled environment, to determine seedling growth for *A. senegal* in high watering regime and to predict yield for pretreated seeds of *A. senegal* with the growth data in KEFRI Lodwar in Turkana County. There is a conclusion that despite germination of *Acacia senegal* seeds in high watering regime, the seeds without pretreatment did not germinate and this is due to seed dormancy. Therefore, it is recommended that the application of severe treatments of seeds is needed to break the dormancy and also speed up the process of germination. Based on the result of the present study, *A. senegal* seeds soaked in lukewarm water for 12 h appeared to be more favorable and promising as compared with the seeds soaked in cold water and seeds with no treatment because it started emergence faster, finish emergence faster and gave the higher final % emergence. This gives the best recommended time of exposure of *A. senegal* seedlings for hot water treatment. The best regression equation is given by seeds soaked in lukewarm water, hence the best model to be used in determining tree characteristics.

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