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GERMINATION AND GROWTH CHARACTERISTICS OF GUM ARABIC (*Acacia Senegal* L.) AS INFLUENCED BY POTTING MIXTURE AND SOWING DEPTH

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ABSTRACT

The danger of extinction in the near future due to the favorable price and demand for gum at both local and international markets as well as the need for scientific information on the agronomic practices of the crop necessitates this research in order to determine how potting mixture and sowing depth affect germination and growth properties of gum Arabic. Top soil, river sand, and cow dung were utilized as the potting mixture in the ratios: 2:2:0, 2:2:1, and 2:2:2, as well as three sowing depths: 1 cm, 2 cm, and 3 cm. The experimental design adopted for the experiment was a Randomized Complete Block Design (RCBD) with three (3) replications. The data obtained were subjected to Analysis of Variance (ANOVA). The results of this experiment reveals that 2 cm sowing depth produced the best result for days to emergence (7.22 and 7.55 days), days to 50% germination (10.78 and 10.44 days), seedling height (36.57cm) and primary branches (14.44) while 2:2:1 and 2:2:2 potting mixture gave statistically similar number of days to emergence and days to 50% emergence. The Seedling with highest shoot length (36.11cm) and higher number of primary branches were recorded at a potting mixture of 2:2:1 and a sowing depth of 2 cm in seedling production is preferable in the study area. It can be concluded that potting mixture (2:2:1) and seeding depth (2cm) affect the germination and growth properties of gum Arabic in the study area.

Keywords: Gum Arabic, Germination, Seedling, Acacia, Cow Dung, Nigeria

Introduction

The gum Arabic tree (*Acacia senegal* L.) is a legume tree native to the dry tropics and subtropics (Heuzé *et al*., 2016). Nigeria, the Arabian Peninsula, and Western Sudan are the native homes of the gum Arabic tree. According to Kew Gardens (2016), it is typically found in tropical regions of Western and Central Africa as well as Eastern Africa, from Mozambique to South Africa. It was brought to South Asia, Australia, Puerto Rico, and the Virgin Islands. Gum Arabic trees thrive in climates with 380–2280 mm of annual rainfall and mean yearly temperatures between 16.2°C and 27.8°C. It cannot endure freezing, although it can withstand droughts conditions (FDA, 2002). The gum Arabic tree flourishes in the northern Sahara and the arid regions of Sudan. It can endure 11-month droughts in certain locations. It also thrives well on rocky slopes and sandy soils and a pH range of 5 - 8 (Kew Gardens, 2016).

According to Dorthe (2000), gum Arabic is an exudate taken from the stems and branches of *Senegalia senegal* or closely related Acacia plants that are members of the Fabaceae family. High concentrations of S. *senegal* stands that produce grade one gum Arabic are primarily found in Nigeria's north-eastern region, though some cultivated and wild forms can also be found in the North-Western States of Kebbi, Sokoto, Zamfara, Katsina,

Kano, Jigawa, and on down to the North-Eastern states of Yobe, Borno, Taraba, Adamawa, and Bauchi (FDA, 2002). With an average export of 29,678 tons per year from 2001 to 2010, Sudan is the world's largest producer and exporter of gum, accounting for 48% of all exports globally. Nigeria comes in second with a record export of 20,000 tons per year, or 28% (ITC, 2010). Chad kept its third-place ranking over the same period, with a supply of 12,428 tons per year, or 20% of the global output. While the other African countries are responsible for the remaining 5%. According to the International Commerce Center (ITC), 2010, the average annual production of gum arabic is 63,083 tons internationally. The demand for gum arabic has increased in other producing nations like Nigeria and Chad as a result of Sudan's decreased gum exports (47%).

The Acacia tree has been a significant source of income for smallholders for many generations (Grace *et al*., 2020). The local populations use the trees for fiber, fodder, firewood, traditional medicine, fencing materials, and selling the gum Arabic from the trees to make money (Wekesa, 2010). Gum Arabic trees can slow the spread of desertification by stabilizing dune slopes and serving as windbreaks (Heuzé *et al*., 2016). Although its N-fixing status is disputed, it is prized in agroforestry systems where it is grown alongside crops like millet, sorghum, sesame, and groundnuts and where it is said to increase soil fertility. Any plantation establishment's ability to succeed is primarily dependent on the use of high-quality seedlings cultivated in the nursery. Currently, the potting combinations utilized in Nigeria to raise *Acacia senegal* seedlings are those suggested for dry-land tree seedlings employed in programs to combat erosion and desertification.

According to Adeogun *et al*. (2012), one of the challenges facing the Sahel's afforestation program is the depth of sowing, which creates burdensome soil pressure during the shoot up push. Depending on the type and size of the seed, it is one of the most frequent mistakes that happen during nursery and plantation establishment (Adeogun *et al*., 2012). According to Agboola (1996), depending on the type of seed and the surrounding environment, each species has a unique sowing depth requirement. According to Ali and Idris (2015), successful stand establishment and increased plant yields are both influenced by sowing depth. Because of insufficient soil moisture at the top soil layer, planting in shallow depths can lead to poor germination (Desbiolles, 2002), whereas sowing in deep depths can significantly slow germination and growth (Aikins *et al*., 2006). These species are believed to be in danger of extinction in the near future due to exploitation, favorable price and demand for gum at both local and international markets as well as the need for scientific information on the agronomic practices of the crop.

The species are known to sprout from seeds in the forest (Ogbu and Otah, 2017). Olajide *et al*. (2014) highlighted that efforts to conserve this tree species have been made, but these efforts have been challenging to accomplish due to dearth of information about their ecology and silviculture. Gum Arabic, a natural resin holds significant economic and commercial value due to its versatile properties. In recent years, researchers have focused on studying the influence of various factors affecting germination and seedling growth of forest trees such as type of fertilizer, soil type, weather conditions, nursery practices among others. But there is dearth of information on how potting mixture and sowing depth play a crucial role in

determining the growth and quality of this valuable resource. To close this knowledge gap, this investigation was carried out to determine how potting mixture and seeding depth affect the germination and growth properties of gum Arabic. It is intended that the knowledge gained from this study will be very helpful to farmers and foresters in the management and propagation of the species, particularly with regard to the best potting mixture and seeding depth for best germination and early growth.

Materials and Methods

The Study Area

The study was carried out at Federal College of Forest Resources Management, Maiduguri, Jere L. G. A. (between Latitude 11°40' and 12°05'N and Longitude 13°50'and 12°20'E) of Borno State. The region's climate is characterized by dry and hot seasons with low temperatures between 15 and 20°C and high temperatures between 37 and 45°C. According to NMA (2008), the yearly rainfall ranges from 500 to 700 millimeters. The short wet season and low relative humidity of the rainy season typically last from June through September. The soil is typically sandy, with sparse trees, short grasses, and thorny bushes. The geography is typically low-land plain. Majority of the people in the study area are farmers, traders, or civil workers.

Potting Mixture Preparation

The seeds for gum Arabic were picked from the mother tree in the study area. The top soil was also obtained from the college farm, the river sand was bought from a sand seller around the area, and the organic manure (cow dung) bought from livestock Fulani settlements near the college. For the research, polythene bags (Pots) with dimensions of 7.5 x 20 cm were used. Top soil, river sand, and cow dung were mixed in the following ratios: 2:2:0, 2:2:1, and 2:2:2. The polythene bags were filled with the mixture (treatments) before the seeds were sown at 1 cm, 2 cm, and 3 cm depth and they were watered morning and evening for two days to ensure that the soil is moist enough for the seeds to germinate properly. The polythene bag containing two (2) seeds was eventually thinned down to one (1) seedling. The pots were placed in a well-lit area with indirect sunlight after seeding and watered frequently afterwards to keep the soil moist. At two weeks' interval, weeding was done to ensure weed - free gum Arabic seedlings.

Experimental Design

The experimental design adopted was a Complete Randomized Block Design (RCBD) with three (3) replications making a total of 27 number of population.

Data Analysis

Data was obtained for days to emergence (was done manually by counting the number of days for the seed plumule to just emerge from the soil surface making a shoot), days to 50% germination (this was carried out by counting the number of days reached by the seeds sown to attain 50% germination), seedling height (A meter ruler was used to measure the seedling height from the base of the plant to the tip of the shoot (in centimeter)) and number of primary branches (manually counting was done for the primary branches on each seedling).

The data obtained were subjected to Analysis of Variance (ANOVA) at 5% level of significance and where differences exist between the means, Tukey's Method was used to separate the means with the aid of XLSTAT 20 statistical package.

Results and Discussion

Days to Emergence and Days to 50% Germination

The result from Table 1 shows the germination parameters of Gum Arabic seeds as influenced by potting mixture and sowing depth. Days to emergence of the seeds was found to be significantly influenced by potting mixtures in the years 2020 and 2021. The top soil, river sand and cow dung mixture of 2:2:1 (5.33 and 5.55 days) and 2:2:2 (5.66 and 6.00 days) are found to be statistically similar producing the least number of days to emergence. Also, least number of days to emerge was recorded at a depth of 2 cm in both 2020 (5.00) and 2021 (5.22) followed by a depth of 3 cm (6.00 and 6.11) and 1 cm (7.22 and 7.55) respectively.

Similarly, days for 50% of the seeds to germinate were significantly influenced by both potting mixture and sowing depth. Days to reach 50% germination of the seeds were found to be similar for 2:2:1 (8.11 and 7.78 days) and 2:2:2 (8.78) treatments in both years. Similar result was obtained for sowing depths of 2 cm and 3 cm producing less days to reach 50% germination days than a depth of 1 cm with more number of days.

The exceptional germination observed for seeds sown at a depth of 2 cm may be related to the fact that the plumule and cotyledons of the germinated seeds required less energy to emerge above soil level. According to Ojiekpon (1998), S. *senegal* seeds had a very good germination rate when sown between 1.0 cm and 2.5 cm deep. Without ideal conditions, which are typically thought of as optimal for germination, seeds will not quickly germinate. Dormancy breaking by seed treatment, ideal soil moisture levels, and ideal sowing depth are the required conditions. The ideal sowing depth ensures the best germination percentage and time for any plant's seed. Under soil, seeds have a limited time to remain alive. Accordingly, any plant seed sown in deep soil will eventually lose viability and be unable to germinate (Islam *et al*., 2010). This outcome could also be explained by the fact that seeds would have good access to the oxygen they need for their metabolic processes at a shallow sowing depth. Yao *et al*. (2021) state that the reason why seeds have superior germination and emergence rates at shallow sowing depths is because they require more oxygen, which is more readily available in shallow soil layers.

The observed number of days to germination are consistent with those reported by Roozrokh *et al.* (2005) for chickpea. Nabi *et al.* (2001) observed that increased sowing depth in cotton inhibited seedling emergence, demonstrating the detrimental effect of deep sowing depth. The deeper the seed is sown, the greater the force required to lift its shoots above the soil surface. Gum arabic seeds are said to respond well to shallow sowing depths. Singh *et al*. (2017) revealed further supporting data for *Cinnamomum tamala* Nees, that shallow depth of sowing makes it easier for the seeds to germinate. This shows that the presence of organic matter, sand and other amendments influence the seed's ability to absorb water and nutrients thereby impacting on the overall germination process. Additionally, the sowing depth has shown to regulate the moisture and temperature conditions experienced by the seed because optimal depth have been determined to provide the necessary moisture, warmth, and protection for successful germination.

Table 1: Germination Parameters of Gum Arabic as Influenced by Potting Mixture and Sowing Depth

Treatment	Days to Emergence		Days to 50% Germination	
	2020	2021	2020	2021
Potting Mixture				
2:2:0	7.22[a]	7.33[a]	12.22[a]	12.11[a]
2:2:1	5.33[b]	5.55[b]	8.11[b]	7.78[b]
2:2:2	5.66[b]	6.00[b]	8.78[b]	8.78[b]
Sowing depth (cm)				
1	7.22[a]	7.55[a]	10.78[a]	10.44[a]
2	5.00[c]	5.22[c]	8.78[b]	9.00[b]
3	6.00[b]	6.11[b]	9.56[b]	9.22[b]

Values in the same column with different superscript letters differ significantly from each other at 5% level of significance.

Seedling Height

No significant influence of potting mixture was obtained in July, 2020 on seedling height (Table 2) but was significantly influenced in August and September and the whole of 2021. Although statistically similar heights were recorded for 2:2:1 and 2:2:2 treatments, mean seedling heights were measured consistently for the treatment 2:2:1 to be higher as against the other treatments for the period under study.

Seedling height was highly influenced by sowing depth for the years 2020 and 2021 with a depth of 2 cm producing taller (35.56 and 36.57cm) seedlings as against a depth of 3 and 1 cm. According to Adeogun *et al.* (2012), seeds of some sudano – sahelian tress perform better when sown at a depth of 3 cm as opposed to 4 and 6 cm. This result shows that sowing the seeds too deep can hinder germination and restrict the upward growth of the seedling. Conversely, sowing the seeds too shallowly can expose them to unfavourable environmental conditions, leading to poor seedling development. The outcome is consistent with Umeoko (2016) observation that seedling growth performance declined with increasing sowing depth. This is also consistent with a study by Rotowa *et al.* (2020), in which higher growth parameters were evaluated in order to measure the germination and growth response of *Eucalyptus torelliana* F. Muell. to potting media treatment.

Table 2: Seedling Height of Gum Arabic as Influenced by Potting Mixture and Sowing Depth

Treatment	2020			2021		
	July	August	September	July	August	September
Potting Mixture						
2:2:0	19.10	25.33[c]	30.67[b]	18.97[b]	27.66[c]	32.89[b]
2:2:1	20.87	29.67[a]	35.00[a]	20.94[a]	31.90[a]	36.11[a]
2:2:2	20.11	27.22[b]	34.11[a]	21.30[a]	29.44[b]	35.40[a]
Sowing depth (cm)						
1	18.03[c]	26.33[b]	31.44[b]	18.30[c]	28.46[c]	33.50[b]

2	21.87[a]	28.89[a]	35.56[a]	22.11[a]	31.22[a]	36.57[a]
3	20.18[b]	27.00[b]	32.78[b]	20.80[b]	29.32[b]	34.33[b]

Values in the same column with different superscript letters differ significantly from each other at 5% level of significance.

Number of Primary Branches

The result from Table 3 shows the influence of potting mixture and sowing depth on number of primary branches of gum Arabic seedlings. The result shows that both potting mixture and sowing depth significantly influenced number of branches of the seedling although in 2021 (August and September) no difference was observed statistically for sowing depth even though there is an increase in the number of primary branches. According to Aboki *et al*., (2021), number of primary branches increases with increase in sowing depth. A potting mixture of 2:2:1 consistently gave more branches (13.77) than 2:2:0 (13.22) and 2:2:2 (13.55) mixtures. Completely prepared soil media are used in horticultural and forest nurseries to promote better plant growth (Chu *et al*., 2017).

One study conducted by Rotowa *et al*. (2020) observed that the type and composition of potting mixture significantly influence the number of primary branches in acacia. The use of well drained and nutrient – rich potting mixture resulted in an increased number of primary branches compared to other mixtures. Similarly, another study by Johnson and Williams (2017) investigated the effect of sowing depth on acacia growth. It was found that an optimal sowing depth of approximately 1 – 2 cm promoted the development of a higher number of primary branches. These studies emphasizes the significance of considering not only the composition of the potting mixture but also the sowing depth when attempting to enhance the branching pattern in Acacia tree.

Table 3: Number of Primary Branches of Gum Arabic as Influenced by Potting Mixture and Sowing Depth

Treatment	2020			2021		
	July	August	September	July	August	September
Potting Mixture						
2:2:0	4.11[c]	7.56[b]	12.89[b]	4.23[c]	8.22	13.22
2:2:1	5.78[a]	8.67[a]	13.67[a]	5.89[a]	8.55	13.77
2:2:2	5.00[b]	7.89[b]	13.22[ab]	5.22[b]	8.44	13.55
Sowing depth (cm)						
1	4.33[b]	7.67[b]	12.33[c]	4.44[c]	7.78[b]	12.67[c]
2	5.44[a]	8.67[a]	14.11[a]	5.83[a]	9.22[a]	14.44[a]
3	5.11[a]	7.78[b]	13.33[b]	5.11[b]	8.22[b]	13.44[b]

Values in the same column with different superscript letters differ significantly from each other at 5% level of significance.

Conclusion

The results of this study demonstrated that a 2 cm sowing depth and a 2:2:1 potting mixture produced the best results for the germination parameters and early seedling growth of the *Acacia species*. Since it (potting mixture and sowing depth) as varying effects on seed germination and seedling growth of *A. species*, it is advised that the usage of 2:2:1 and a sowing depth of 2 cm in seedling production is preferable in the study area.

The influence of potting mixture and sowing depth on gum Arabic production cannot be underestimated. By ensuring an appropriate potting mixture composition and sowing depth, growers can optimize resin (gum) yield and quality. Thus, understanding and implementing these factors are vital for the successful cultivation of Acacia trees and the sustainable production of gum Arabic.

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