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Effect of Growth Promoter Indole Acetic Acid (IAA) on Leaves Sprout and Rooting of Acacia Senegal Cuttings

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Abstract-* Some studies have revealed the effectiveness of growth promoters in enhancing root formation in cuttings. However, using these growth promoters in trials, reproducible result is not easily achieved. Examples are presented from the literature; these relate to the effects of hormone concentration, application methods, comparative effectiveness of different synthetic growth hormones and their applications at different times of the year. The effect of growth promoter indole acetic acid (IAA) on leaves sprout and rooting of Acacia senegal cuttings was investigated in a practical experiment involving the use of different doses of IAA i.e. 1, 2, 3, 4 and 5ppm. The different doses were compared with separate control experiment which did not received any treatment. Growth protagonist such as number of leaves were observed at weekly interval for a period of six weeks, after that data obtained were subjected to analysis of variance of which the statistical difference between the leaf numbers were determined. The result shows that, number of leaves sprout increases with increase dose of IAA on cuttings which shows that IAA has enhance sprouting in Acacia senegal cuttings. However, rooting was not established possibly due to low dose of IAA used.

***Indexed Terms-* Acacia Senegal, Indole Acetic Acid (IAA), Gum Arabic Tree, Stem Cuttings, Rooting.**

I. INTRODUCTION

Acacia senegal (L) Wild commonly called gum arabic is a leguminous tree mostly found in the Sahel region of Africa including northern Nigeria, where four different commercial grades of the gum are produced (Osagie, 2002). It is a 2-3 stemmed shrub of the family Mimosaceae. The gum arabic tree grows to a height of 7-15m with a width of about 1.3m. It is a low branching, small, and spiny tree (Gardens K, 2016).

The tree is deciduous that is, dropping its leaves during the dry season. Under dry conditions, the taproot develops to a great depth allowing the tree to become larger than usual. The trunk is about 30cm in diameter and is covered by a greyish-white bark that becomes dark, scaly and thin in old trees (Bekele-Tesemma, 2007; Orwa et al., 2009; Gardens K, 2016).

The tree bears prickly branches, armed with three hooked thorns, up to 7mm long, just below the nodes. The leaves are pinnate compound, 3.5-8cm long. Their axis may be spiny. The leaflets are linear to oblong, 1-9mm long and 0.5-3mm wide. They may be sparsely hairy and a pale opaque green in colour (Bekele-Tesemma, 2007; Gardens K, 2016). The yellowish-white and fragrant flowers are borne on cylindrical spikes, 5-10cm long. The fruits are straight, hairy, flat, dehiscent papery pods, about 7cm long x 2cm wide. Green and pubescent when young, they become a shiny bronze with maturity. They contain 3-6 smooth, flat shiny seeds (Pareek et al., 2017). The tree grows where annual rainfall is in the range of 380mm to 2280mm, and annual mean temperatures between 16.2°C and 27.8°C (Abdellah, 2019) It cannot survive frost but is particularly tolerant of drought. It can survive in places where drought lasts for 11 months. It thrives on rocky slopes and sandy soils, but also on clay plains and cotton soils with a pH ranging from 5 to 8 (Gardens K, 2016). In west Africa and Nigeria in particular it grows wild in contiguous states of Adamawa, Borno, Yobe, Kano, Jigawa and Sokoto in the northern parts (Haliru, 2014; Gyimah-Brempong et al., 2016).

The most significant use of the gum arabic tree is the harvest of gum arabic, an exudate from the bark that is tapped for this purpose during the dry season (Ahmed, 2021). Several thousand tons of gum arabic are globally traded every year, mainly in Europe and the USA (Gardens, 2016; Abdellah, 2019). Gum arabic has many commercial uses: food (flavour fixative, emulsifier, stabilizer of dairy products), pharmaceutics (these two sectors representing 60-75% of the use of gum arabic), and industrial products (inks, pigments, polishes) (Sahari et al., 2014; Bashir and Haripriya, 2016; Singh et al., 2021).

Gum arabic was reported to have antidotal effects as it can destroy many alkaloids (Hurr and Hurr, 2021). The wood from gum arabic is valued as firewood and can be used to produce charcoal. The wood is also used to make utensils, poles and fence-posts. The bark and the roots provide fibre and make strong ropes and fishing nets (Orwa et al., 2009;). Gum arabic trees provide valuable fodder to sheep, goats and camels. Leaves and pods are browsed by domestic and wild ruminants. Flowers provide valuable nectar to bees for honey production (Orwa et al., 2009).

Gum Arabic trees can help prevent desertification through dune stabilization and by acting as a wind break. It is valued in agroforestry systems where it is combined with crops such as millet, sorghum, sesame and groundnut, and where it is reported to improve soil fertility, though its Nitrogen fixing status (Orwa et al., 2009; Harrier et al., 2000; Midgley and Bond, 2001).

Nigeria was second largest country after Sudan in Africa with Gum arabic export value of 34780tons in 2010 (NGARA, 2017; Tadesse et al., 2020). Similarly, according to Tridge, (2022) the new global sourcing and market intelligence hub for the food industry, the export value of gum arabic from Nigeria in 2020 stood at USD 908, 29k, and the export volume was 1.05 million metric tons. which shows an increase over the years. Economically, no waste as far as the gum arabic Tree is concern. Therefore, cultivation of Acacia senegal should be promoted especially for high yield and drought resistant species to make a sustained production. Propagation practices of Acacia senegal tree is done by direct seeding of pretreated seeds or grow seedlings in nurseries however, the propagation by seeds is not recommended for production of true-to-type species of high quality and yield (Warag, et al., 2012), Furthermore, there are chances that seeds exhibit dormancy or they have poor viability and long generation time before attaining maturity (Somashekar and Sharma 2002) Therefore, propagation by vegetative propagation methods such as stem cuttings could demonstrate a great potentiality in shoot regeneration and rooting (Kesari et al., 2009: Aseesh et al., 2011). Similarly, among the plant propagation techniques, stem cutting is considered one of the most important since it is economically viable, simple and fast (Zuffellato-Ribas and Rodrigues, 2001; Hartmann et al., 2011; Stuepp et al., 2018).

This study was undertaken to investigate the sprouting and rooting ability of mature stem cuttings of Acacia senegal. Sprouting and rooting was evaluated on stem cuttings treated with varying concentrations of synthetic auxins (indole-3-acetic acid).

II. MATERIALS AND METHODS

Study Location

The experiments were carried out at the botanical garden University of Maiduguri Nigeria, located at latitude 11° 48' 33.971" N and longitude 13° 11' 37.728" E. from June to July 2022 for a period of 6 weeks (4^{th} June to 16 July, 2022).

Data Collection

Cuttings of 1.2cm in diametre were taken from stems and branches of 2 to 3 years old trees of Acacia senegal at gate one of the University of Maiduguri Nigeria. The cuttings were taken early in the morning to keep drying out to a minimum level. The cuttings were then placed in a big polyethene bags and tied before taken to the propagated site. A shape sterilized knife was used to re-cut the cuttings into equal length of 10cm each.

Top soil mixture of pH 5.6 was taken from the botanical garden of the University of Maiduguri which comprised of sandy-loam soil. The soil was sterilized using a mini sterilizer at temperature 80ºC for 30 minutes. The soil was then filled into 750cm^3 black polyethene bags of perforated ends and arranged under an open shaded area with an average air temperature of 26°C and average relative humidity of 87% into six different experimental blocks (group of 1,2,3,4, 5 and 6) where the 6th block served as the control. Each group replicate 5 times i.e, 6x5 which makes up 30 pots each.

Treatment

Indole-3-acetic acid (IAA) solution was then prepared which served as the growth promoting hormone. 0.1g of IAA was dissolved in 2cm^3 of absolute alcohol using 100mL beaker, 900cm^3 of distilled water was added using 100mL beaker then heated to 80ºC for 5mins. 100mL of distilled water was again added to the solution to make up 1000mL of the solution hence, 100ppm concentration was obtained. Therefore, to get 1ppm, 2ppm, 3ppm, 4ppm and 5ppm concentration, 0.001g, 0.002g, 0.003g, 0.004g, and 0.005g of IAA were used respectively.

The first group was treated with 1ppm dose, the second group was treated with 2ppm, dose respectively. The cuttings were dipped into the solution for 5mins before planting. The stocks were then watered daily while observation and reading were taken at weekly interval for 6 weeks duration. The cuttings was said to be rooted or sprouted when they had one root or bud exceeding 0.5 cm in length.

Statistical Analysis

The data were analyzed for single factor variance (completely randomized design) using Microsoft Excel package (2016) the mean number of sprouted leaves, were subjected to analysis of variance (ANOVA) to determine the statistical difference among the treatments

Results Presentation

Table 1 shows the effect of different doses of IAA on mean number of leaves produced by Acacia senegal at weekly interval.

At week one after planting, mean number of leaves ranges from 0.75 to 1.28 for the controlled experiment. The highest number of leaves were recorded from cuttings treated with the highest concentration (5ppm of IAA) while cuttings treated with the lowest concentration (1ppm of IAA) produced lesser number of leaves however, the leaves number produced by cuttings treated with 1ppm IAA were significantly higher than cuttings treated with 0ppm of IAA.

At two weeks, the mean number of leaves obtained from 0 to 5ppm doses were 1.00 to 1.76 respectively. This shows that cuttings treated with 5ppm doses had a significantly higher mean number of leaves than cuttings treated with 0ppm IAA. There was no significant difference in the number of leaves produced by cuttings treated with 5ppm and 4ppm dose. Similarly, cuttings treated with 4ppm, 3ppm, 2ppm and 1ppm doses of IAA respectively did not show any significant difference.

The result obtained three weeks after planting ranged from 1.56 - 2.45 mean number of leaves. However, cuttings treated with 1ppm to 5ppm doses of IAA respectively did not show any significant difference either. However, irrespective of doses used on cuttings, all treatments stimulated more leaf production significantly than the untreated group.

At weeks four after planting, mean number of leaves ranged from 1.68 - 2.80 on cuttings treated with 0 to 5ppm (IAA) respectively. All the cuttings treated with IAA regardless of doses, produced more leaves significantly than the untreated cuttings. Higher number of leaves were obtained from cuttings treated with 5ppm dose than 4, 3, 2 and 1ppm doses respectively.

At week five after planting the cuttings, the mean number of leaves ranges from 1.96 - 3.28, this shows that the highest leaves production was obtained from group treated with 5ppm of IAA however, the difference was significant when compared with cuttings with 0ppm of IAA. However, there were no significant difference among cuttings treated with 2, 3 and 4ppm doses respectively. Notwithstanding, the result did not indicate any variation between 0 and 1ppm dose of IAA.

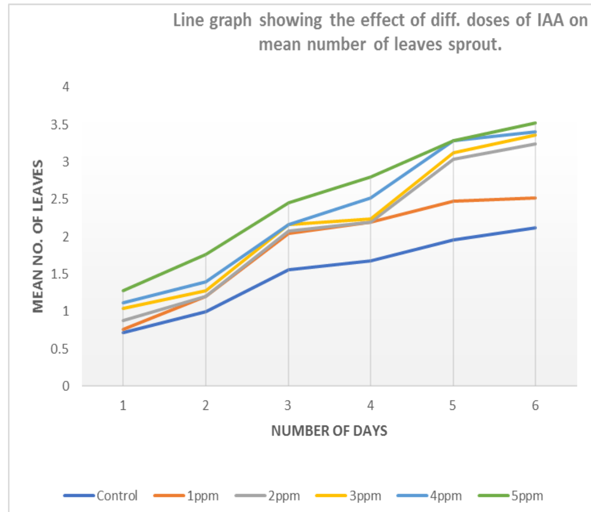
During six weeks after planting, the result shows a range of 2.12 - 2.52 mean number of leaves. Cuttings treated with 2 - 4 ppm doses of IAA show significant number of leaves when compared with those treated with 0 and 1ppm doses respectively.

Table 1: The effect of different doses of Indole-acetic acid (IAA) on mean number of leaves produced by Acacia senegal cuttings

Doses of IAA (ppm)	mean number of leaves at weekly interval						mean
	1	2	3	4	5	6	
0	0.75	1.00	1.56	1.68	1.96	2.12	1.51
1	0.76	1.20	2.04	2.20	2.48	2.52	1.87
2	0.88	1.20	2.08	2.20	3.04	3.24	2.11
3	1.04	1.28	2.16	2.24	3.12	3.36	2.20
4	1.12	1.40	2.16	2.52	3.28	3.40	2.31
5	1.28	1.76	2.45	2.80	3.28	3.52	2.51
Mean	0.97	1.31	2.07	2.27	2.86	3.03	
SE±	0.16	0.13	0.14	0.15	0.21	0.20	
LSD 0.05 N S	0.37	0.40	0.42	0.59	0.55		

Table 2.

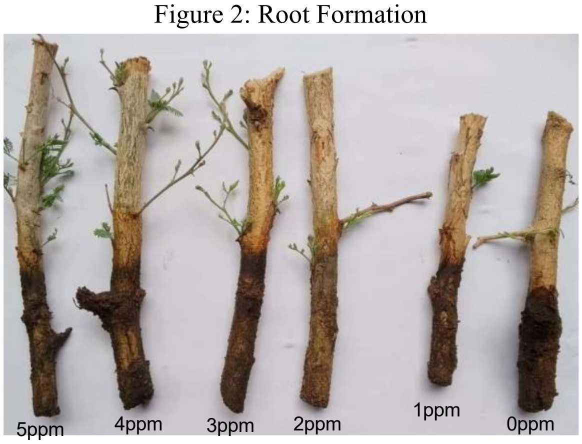
ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	3.797213889	5	0.759442778	1.074780346	0.394016	2.533555
Within Groups	21.19808333	30	0.706602778			
Total	24.99529722	35				



From Table 2 the result of the one-way analysis of variance is presented on the sprouting of Acacia senegal leaves treated with different doses of Indole acetic acid (IAA). The null hypothesis that being tested, is that there is no significant difference in the rooting of Acacia senegal cuttings treated with different doses of IAA. The result of the analysis of variance was conducted at 5% level of significance and degrees of freedom (5 between groups and 30 within groups). The value of the F- calculated was found to be (1.075) which is greater than the critical value of the F being (2.53). Therefore, since the computed value of the F-statistics is lower than the critical value of the F- statistics, we have to accept the null hypothesis and reject the alternate hypothesis. We therefore conclude that there is no significant difference in rooting of Acacia senegal cuttings treated with different doses of IAA. This conclusion suggests that more dose of IAA will probably provide good result on the rooting of Acacia senegal cuttings.

Figure 1: Cuttings Treatment at Different Level of Growth Promoter

Figure 2: Root Formation



All treatment did not indicate any root formation

III. DISCUSSION

Since treated cuttings had leaves production in contrast to the controlled experiment, it shows that the growth promoter IAA used had stimulated sprouting of leaves in the treated cuttings. Sprouting of roots and the leaves was dependent on the number of cuttings which produced shoots. Whereas, the survival was based on the number of cuttings that had both roots and shoot. Nordstrom et al., (2004) reported that, root and shoot growth are interrelated as they depend on the photo assimilates from the leaves and hormones especially cytokinin and auxins from the roots and shoot respectively.

Early roots and shoot formation may be due to partitioning of photosynthates and utilization of stored carbohydrates and phenols towards root and shoot development. Faster sprouting and increase in number of sprouts may be attributed to activation of shoot growth due to growth regulators (Poornima et al., 2012). Successful rooting in plants is therefore dependent on a number of co-factors in cuttings, which in combination with auxin enable cuttings to produce shoots (De Klerk et al., 2011; Denaxa et al., 2021; Tsafouros and Roussos, 2022).

Similarly, Auxin is believed to be an effective inducer of root formation (Pacurar et al., 2014; Rasmussen et al., 2015). This observation is in agreement with the findings of Wazir, (2014) with highest number of shoots obtained using 500ppm IBA concentration for the hard wood cutting of Camellia japonica and at 1000ppm IBA for the semi hard cutting of Camellia japonica. Exogenous auxin application stimulates cell differentiation, promotes starch hydrolysis and involve in relocation of nutrients and sugars to the cutting base. All these steps ultimately promote rooting (Atangana et al., 2011). Exogenous and endogenous accumulated auxin concentration, regulates the divisions of very first root initials (Kochhar et al., 2005). Muller et al., (2015) in their work also reported that, after stem decapitation, indole-3-acetic acid (IAA) suppresses the genes involved in synthesis of cytokinin in the node terminates, causing the increased levels of cytokinin. Hence the presence of endogenous cytokinin in the stem tissues (Wroblewska, 2013) with the addition of auxin into the basal ends might have eventually promoted the formation of shoot from the cuttings.

The failure of cuttings gathered from lateral branches of mature trees to root, especially when leafless, is a common phenomenon attributable to several factors like the age-related physiology and morphology of donor plants and their phenology (Stenvall et al. 2006, 2009; Snedden et al. 2010; Teklehaimanot et al. 2004); including factors such as plant carbohydrate and nutrient contents and the content of growth regulators (Maile and Nieuwenhuis 2010; Ky-Dembele et al. 2010; Dick and Leakey 2006). Experience with regeneration from root cuttings is much more limited, and appears to be species specific. The time between the collection of cuttings in field and planting in nursery could induce physiological stresses arising from the loss of water and carbohydrate reserves from the tissues due to transpiration and respiration during this period (Aminah et al. 1997; Sanoussi et al. 2012; Leakey 2014). However, in the present study this is unlikely to explain the poor performance of the cuttings brought in from the field as they were stored in a big black polyethene bags sealed for less than 24 hours.

The result of this research, shows that the cuttings did not yield any root. This was probably due to the doses of auxin (1-5ppm of IAA) used, which might have been too low to initiate rooting in Acacia senegal cuttings. Maggioni et al., (2020) reported that, difficult to root cuttings fail to root because they lack the necessary co-factors. it was also possible that such cuttings contain inhibitory substances in amount high enough to mask the effect of promotive substances present.

CONCLUSION

The rate of sprouting of leaves was excellently achieved on the shoot system, as a result of treatments carried out on Acacia senegal cuttings with 1-5ppm doses of IAA. Poor sprouting was also noticed on the controlled experiment (0ppm of IAA). Cuttings treated with 5ppm dose of IAA gave the highest leaf sprout, this confirmed that the application of growth promoter (IAA) tends to influence the rate of survival when cuttings are used in vegetative propagation. This hypothesis has explained why the controlled experiment (0ppm of IAA) gave lowest number of leaves sprout. More to this, further research is needed to determine the optimal conditions for robust and larger scale propagation of Acacia senegal using higher concentration of IAA or any other plant growth promoter.

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