

BULLETIN OF ENVIRONMENTAL SCIENCE & SUSTAINABLE MANAGEMENT

Website: <http://journal.hibiscuspublisher.com/index.php/BESSM/index>



Studies on the Comparative Effects of Three Auxins and Seasons on the Rooting of Stem Cuttings of *Moringa oleifera* Lam (Moringaceae)

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HISTORY

Received: 4th June 2022
Received in revised form: 13th July 2022
Accepted: 25th July 2022

KEYWORDS

M. oleifera
Vegetative propagation
Plant hormones
Plant tissue culture
Auxin

ABSTRACT

Rooting on mature stem cuttings of the Drumstick tree, *Moringa oleifera*, Lam. Moringaceae, was studied using three auxins (indole-3-acetic acid (IAA), indole-3-butyric acid (IBA) and naphthalene acetic acid (NAA) at two seasons. The experiments were carried out at random using a 342 factorial design. The growth of stem cuttings prior to rooting was influenced by auxin concentrations and the seasons. Stem cuttings taken during the wet season and treated with 500 mg/L of IBA, NAA, and IAA sprouted 18-27 days sooner than dry season cuttings (24-30 days after planting or DAP). Wet-season bud development into leaves was found to be more affected by auxin application and seasons than dry-season bud development (2.0%-83.4% wet season and 10%-56.08% dry season). The results also demonstrated that the stem cuttings did not callus, but instead formed nodules at the base of the stem regardless of the treatment or time of year. Sizes ranging from small (S) to medium (M) to large (B) nodules were spotted. Larger concentrations of auxins (500 mg/L of IBA, NAA, and IAA) influenced the production of smaller nodules during the dry season, while in the wet season, 500 mg/L of the three auxins influenced the production of larger nodules (B), and 300 mg/L of the auxins influenced the production of smaller nodules (M). Auxin concentration and control affected the production of small (S) nodules. The results also showed that large nodules were associated with the tap, lateral, and feeding roots. High auxin concentration (500 mg/L) affected these. The wet season stem cuttings produced more tap roots than the dry season cuttings. The study showed that vegetative propagation of *M. oleifera* by rooting stem cuttings is best done in the wet season. Wet season cuttings produced proto-type seedlings of the parent stock.

INTRODUCTION

In Nigeria, the main source of generating national revenue is the exploration and exportation of petroleum products. Since this single source of nation's wealth has not adequately solved the nation's socio-economic problems e.g. increase in population, unemployment, poverty, diseases, various types of crime waves, and social unrest, it becomes necessary that intensive revival of the agricultural sector be revisited [1]. One of the ways of achieving the revival of the agricultural sector is mass production of a large quantity of uniform, vigorously growing planting materials that can sustain large farm (Plantation) establishment. At maturity and reproduction, the resources of these plants can be exploited biotechnologically [2]. This can drastically reduce unemployment and at the same time generate significant revenue.

Of all the plant species that can be relied upon for sustainable biotechnological exploitation, *M. oleifera*, quickly strikes the mind. Hence, the species, *Moringa oleifera*, a multipotential plant that yields industrial raw materials from all its component parts (leaves, seed, pod, flower, bark and root) was selected for this study [3]. The *M. oleifera* plant, specifically its leaves, has been found to contain cytokinin, a plant growth hormone. According to Price [4], the yield of several crops was greatly improved after Moringa hormone was sprayed on the seedlings. These crops included maize, bell peppers, onions, sorghum, coffee, and chilli melons. Additional research by the same author found that feeding cattle a formula made up of 40-50% Moringa leaves increased milk yield by 30% and increased daily weight gain by 10%.

Price [4] described in detail how Moringa leaves, pods, and seed powder can be used to disinfect and purify water (After oil extraction). The author reports that polyelectrolytes, isolated from Moringa leaves, pods, and seed powder, are the active ingredient responsible for water treatment in the species. An antibiotic (Pterygospermina) with potent antibacterial and antifungal activities was discovered, as reported by Rajangam et al. [5]. This substance was extracted from the *M. oleifera* plant's flower and bark. The widespread demand for *M. oleifera* can be attributed to the species' high multipotential. Cash is made by selling raw or canned pods, leaves, and seeds, and the product is widely distributed and used [5].

Moringa leaves, leaf powder, and seed powder (obtained after the seed oil has been extracted) are used in herbal medicine, and Rajangam et al. [5] and [6] provide an in-depth account of their applications. In summary, many reports have shown that *M. oleifera* has innumerable economic values ranging from the source of food/food condiment, water purification, feed, hormonal effects, [through herbal medicine production to revenue generation. In Europe and the United States of America, intensive research is currently ongoing for the production of *Moringa* tablets for use as a nutritional supplement. However, detailed reports on how best large quantity of the species seedlings can be produced, especially when the seeds are out of season appear lacking, thus justifying the objectives of the present study [7]. Successful vegetative propagation of *M. oleifera* using stem cuttings with hormonal treatment or without hormonal treatment in South Africa indicates that vegetative propagation of *M. oleifera* is possible and may yield a high quantity of planting materials. In this study, the vegetative propagation of this plant using selected auxins is carried out [8].

MATERIALS AND METHODS

Experimental Site, Collection, Identification and Confirmation of Materials

The research took place in the Botanic Garden of the University of Nigeria, Nsukka (UNN Department)'s of Plant Science and Biotechnology, in the shade [9]. The experiments spanned two full years, from December 2020 through September 2021. The trial will take place during the wet season from May to September 2021, and the dry season from December 2020 to April 2021. During the first week of each season, branches (current year's growth) of the species were harvested from trees in staff premises on Dan Fodio Street, UNN. By following the procedure outlined by Hutchinson and Dalziel, the plant materials were identified and confirmed in the herbarium of the Department of Plant Science and Biotechnology, UNN.

Preparation of Plant Materials for Planting

As a result of defoliating the tree's branches, we were able to collect 600 cuttings of the stem (26-28 cm in length) that each had 4-5 buds. Stem cuttings were divided into four groups. Sixty seeds were planted without adding any auxin (the control). The remaining three lots (180 in total) were split between the three tested concentrations of auxins: IBA, NAA, and IAA. After determining the appropriate auxin concentration for each batch of stem cuttings, we further divided each batch into three lots of sixty cuttings, and then we tied each lot of cuttings with a piece of twine before introducing them to the auxin solution (soaking).

Preparation of Growth Hormone Concentrations and Soaking of Stem Cuttings

The three auxins (rooting hormones) used were indole-3-butyric acid (IBA), naphthalene acetic acid (NAA) and indole-3-acetic acid (IAA) at three levels/concentrations of 100 mg/L, 300 mg/L

and 500 mg/L. The concentrations were prepared by dissolving 1g of each auxin in one liter of sterile water, this is the stock solution. To prepare 100 mg/L of each of the auxins, 100 mL of the stock solution was withdrawn and diluted with 1 liter of water. In a similar process, 300 mg/L and 500 mg/L of each of the auxins were prepared. The three concentrations of auxins were poured into labeled, transparent, medium-size plastic buckets (thus, each auxin had three plastic buckets), after which the bundles of stem cuttings were introduced into their appropriate auxin concentration; the soaking period lasted for 24hrs in an airy laboratory room [10]. The soaking period of 24 hours is "to allow the woody stem cutting to sufficiently absorb the auxins [10].

Planting of the Stem Cuttings

The rooting medium used was a mixture of sawdust (SD), rivers sand (RS) composted poultry manure (PM) i.e., SD + RS + PM medium in the ratio of 2:1:1 respectively. A total of two hundred (200) medium-sized poly pots were filled with the rooting medium. Twenty poly pots filled with the medium were allotted for the control, while sixty poly pots of the rooting medium were assigned to each of the auxins and concentrations (IBA, NAA and IAA). Each treatment was replicated four times and each replication had fifteen stem cuttings. The stem cuttings were planted in a slanting position [11] at the rate of three stem cuttings per poly pot. Hence, five poly pots gathered together constituted a replication.

Experimental Design

This study used a 3 x 4 x 2 factorial, completely randomized design with "four main treatments (auxins) and no auxin (control)," "three sub-effects/auxin concentrations (100 mg/L, 300 mg/L, 500 mg/L)," and "two seasons" (wet and dry). As far as possible, the experimental setup was arranged randomly (CRD). Every day, a watering can be used to keep the arrangement of exquisite roses hydrated.

Observations and Data Collection

Observations were made daily for the following parameters: a period of bud break/sprouting, the number of buds that sprouted per stem cutting, and the period expended for sprouted buds to develop into photosynthesizing leaves. Meteorological data for the periods of this study; (rainfall, temperature, and relative humidity of Nsukka meteorological zone were obtained from the Centre for Basic Space Science (CBSS, UNN). At the termination of the experiment in each season, the following data were obtained: number of buds that sprouted on stem cuttings, number of buds that developed into leaves, number of cuttings that rooted, types of roots produced, number and length of roots. In each treatment, the mean of the four longest roots was determined. Root numbers were counted while root lengths were measured with the aid of a meter rule.

Data Analysis Method

The data obtained on bud break, and root parameters (number, mean root length) were subjected to the analysis of variance (ANOVA) and the means were separated using New Duncan Multiple Range Test (NDMRT). Other relevant information was presented in plates and tables.

RESULTS

Meteorological Data

Meteorological data for the periods of study (dry and wet seasons) which stretched for five months each, showed variations. Rainfall in the dry season, December 2020 to April 2021 ranged between 3 mm to 5.2 mm with a peak in April (5.2

mm), while the least monthly rainfall (3.0 mm) was observed in February and March. In the wet seasons, from May to September 2021, mean rainfall ranged between 150 mm to 450 mm. The highest rainfall mean (450 mm), occurred in September, while the least occurred in August, (mean, 150 mm). Comparatively, mean monthly rainfall was higher in the wet than in the dry season. Mean monthly relative humidity for the periods of the study showed a pattern similar to that of mean monthly rainfall. In the dry season, from December 2020 to April 2021, the mean relative humidity ranged from 20% to 25%. The most humid month was December; 25% and the least, February 20%. In the wet season, mean relative humidity ranged between 50% to 75%. The most humid month was September (75%) and the least August (50%). Comparatively, the wet season was more humid than the dry season.

Mean monthly temperature for the two seasons of the study, dry and wet seasons showed variations. The mean monthly temperature for the dry season (December 2020 to April 2021) ranged from 29 °C to 32.5 °C. The highest temperature was observed in March 2021 (32.5 °C) and the least, 29 °C in December 2020. In the wet season (May to September 2021) the mean temperature ranged from 28.5 °C to 29.5 °C. The highest temperature 29.5 °C was observed in August and the last at 28.5 °C in June. Comparatively, the dry season had a higher temperature than the wet season.

Irrespective of treatments and season, buds sprouted on all the stem cuttings (Fig. 1). The number of sprouted buds ranged from 2 to 4. Periods of initial and final bud sprouting on the stem cuttings in both seasons (dry and wet) showed variations (Table 1). In the dry season study, the period of initial bud sprouting was 24 to 35, days after planting. The results showed that stem cuttings treated with the highest concentration of the auxins (500 mg/L) IBA, NAA, and IAA, respectively sprouted buds within 24 to 30 DAP, earlier than cuttings treated with lower concentrations (100 mg/L, 300 mg/L) of the same auxins (28 to 33 DAP). Stem cuttings that were planted without any auxin treatment (control), took the longest time to sprout buds and ranged from 34 to 35 DAP.

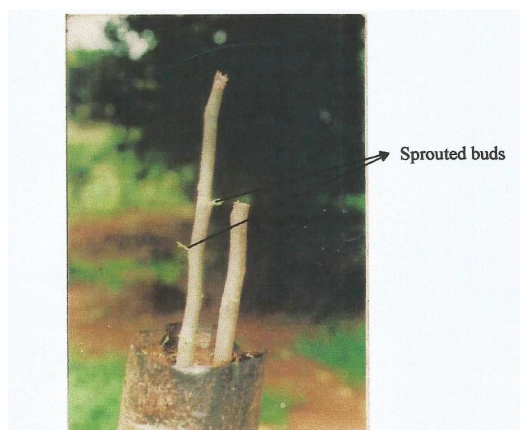


Fig. 1. Bud sprouting/bud break on the stem cuttings of *M. oleifera*.

The results further showed that in the wet season, stem cuttings treated with the highest concentration of the auxins (500 mg/L of IBA, NAA and IAA respectively), had a period of bud sprouting ranging from 16 to 23 days after planting. Stem cuttings treated with lower concentrations of the same auxins; 100 mg/L and 300 mg/L of IBA, NAA and IAA respectively took a longer period to initiate bud sprouting, ranging from 20 to 27 days after planting than cuttings treated with 500 mg/L auxin

concentration. The results also showed that the untreated stem cuttings took the longest period to sprout (30 to 31 days after planting) (Table 1). Comparatively, stem cuttings treated with a higher concentration of the three auxins, 500 ppm of IBA, NAA and IAA respectively sprouted earlier in the wet than in the dry season, (range; 18 to 27 days after planting for the wet season and, 28 to 30 days for the dry season). A similar trend in bud sprouting was observed on the stem cuttings treated with lower concentrations of the auxins (100 mg/L, and 300 mg/L) in both seasons, in the wet season stem cuttings sprouted earlier than the dry season stem cuttings. Similarly, the control stem cuttings took a longer time to sprout buds in the dry than in the wet season.

Table 1. Effect of auxin concentrations on bud sprouting of stem cuttings of *M. oleifera* in dry and wet seasons.

Periods of bud sprouting (DAP)				
Dry Season (December 2020 to April 2021)				
Treatment	Initial bud sprouting	Final bud sprouting	Initial bud sprouting	Final bud sprouting
IBA (mg/L)				
0	34a	36ab	28a	30a
100	32ab	35bc	25ab	28a
300	30bc	33b	23bc	27a
500	27d	31b	18cd	21ab
NAA (mg/L)				
0	35a	38a	28a	31a
100	33a	34b	27a	30a
300	32ab	33b	25ab	28a
500	30bc	32b	23bc	27a
IAA (mg/L)				
0	34a	37a	28a	30a
100	30bc	33b	24bc	27a
300	28c	30bc	20 c	24ab
500	24d	28c	16d	18b
	30.07	33.33	23.75	22.28
X				
SE	3.11	2.78	3.82	9.38
CV (%)	0.10	0.08s	0.16	0.02

Figures followed by the same letter (s) along the vertical column are not significantly different (P = 0.05).

Bud Development into Leaves

Development of the buds that sprouted on the stem cuttings of *M. oleifera* into leaves (Fig. 2) was observed within 6 to 7 days after bud break. The percentage of bud development into leaves following auxin application showed variations (Table 2), within and between the two seasons of this study (dry and wet). In the dry season, the percentage of bud that developed into leaves ranged from 10.5% ± 15.62 to 56.08% ± 15.62. The results also showed that in the dry season, the highest percentage of buds that developed into photosynthesizing leaves was obtained when *M. oleifera* stem cuttings were soaked for 24 hr in 500 mg/L of IAA before planting (56.18% ± 15.0%). This was followed by stem cuttings soaked in the same concentration of IBA (50.7% ± 15.62%).

Stem cuttings soaked in 500 mg/L of NAA had the least percentage of sprouted buds that developed into leaves (42.5% ± 15.62%). The results further showed that in the dry season, low concentrations of the auxins 100 mg/L and 300 mg/L resulted in low percentage bud development into leaves (range, 13.5% to 32.2%). Untreated stem cuttings produced the least percentage of buds that developed into leaves (range, 10% to 13.2%). The percentage of bud development into leaves in the wet season's stem cuttings of *M. oleifera* showed variations similar to that of the dry season (Table 2). In the wet season, the percentage of bud development into leaves ranged from 12% ± 24.02 to 83.4% ± 24.02. The Highest concentration of the auxins used (500 mg/L) generally influenced a very high percentage of bud development into leaves (52.6% to 83.4%). The highest percentage of bud development into leaves was obtained when the stem cuttings

were soaked in 500 ppm of IAA ($83.4\% \pm 24.02$), while the least was observed on stem cuttings soaked in the same concentrations of NAA ($52.6\% \pm 24.02$). Within the low concentrations (100 mg/L and 300 mg/L) bud development into leaves ranged from $18.3\% \pm 24.02$ to $62.08\% \pm 24.02$ (Table 2). The results further showed that bud development into leaves as influenced by the applied auxins was higher on cuttings soaked in IAA (100 mg/L, 300 mg/L and 500 mg/L) than in IBA and NAA. Comparatively, bud development into leaves was more prolific in the auxins treated stem cuttings of the wet than the dry season. Similarly, bud development into leaves on the control cuttings was higher in the wet than in the dry season.



Fig. 2. Development of leaves on sprouted buds on *M. oleifera* stem cuttings.

Table 2. Effects of auxin concentrations on bud development into leaves on the stem cuttings of *M. oleifera* in dry and wet seasons.

% Leaves Development		
Treatments	Dry season	Wet season
IBA (mg/L)		
0	13.20d	16.50d
100	14.20d	24.50d
300	32.20b	42.70 cd
500 NAA (mg/L)		
0	10.00d	12.00d
100	13.50d	18.30d
300	27.90b	27.80d
500 IAA (mg/L)		
0	10.50 ^d	18.00 ^d
100	16.30 ^{cd}	25.30 ^d
300	23.40 ^{bc}	62.08 ^{bc}
500 X	56.08 ^a 25.90	83.40 ^a 38.53
SE	15.62	24.0

Figures followed by the same letter(s) along the vertical column are not significantly different ($P = 0.05$).

Nodule Formation on the stem cutting of *M. oleifera*

The results of observations on the basal portion of some randomly sampled stem cuttings showed that the stem cuttings nodulated (Fig. 3). The nodules were morphologically similar in appearance but different in size. Three classes of nodules based on the diameter, small (S), medium (M) and big (B) were distinguished. The small nodules (S) measured about 5-6 cm in (at its biggest portions), the medium (M), 7-9 cm and the big (B), 10-12 cm. The results also showed that stem cuttings of the dry season study developed only the small size nodules, while the stem cuttings of the wet season study developed the three observed classes of nodules (S, M and B). Further variations were observed in the effect of auxins and their concentration on the percentage nodule type development on the stem cuttings (Table 3).

In the dry season study, the results showed that untreated stem cuttings and lower concentrations (100 mg/L and 300 mg/L) of IBA, NAA and IAA did not induce nodulation on the stem cuttings. The highest concentrations of the auxins (500 mg/L; IBA, IAA and NAA, respectively) induced the development of 11% to 15.3% modulation. The results further showed that 500 mg/L of IAA induced the development of the highest percentage nodulation on the stem cutting while NAA influenced the least. In the wet season study, the three types/classes of nodules were developed on the stem cuttings irrespective of the treatment the control (0 mg/L) and 100 mg/L of IBA, NAA and IAA resulted in the development of the small-sized nodules. While 300 mg/L of the three auxins (IBA, NAA and IAA) respectively, influenced the production of the medium (M) sized nodules (Table 3). The results further showed that the highest concentration (500 mg/L) of the three auxins (IBA, NAA and IAA), influenced the development of the big-sized nodules (B). The control consistently developed the least percentage nodulation ranging from 5% to 5.5% in the wet season.

The results further showed that percentage nodulation on the stem cuttings as influenced by 100 mg/L of the auxins also varied during the wet season, ranging from 8.5% to 15.5%. The highest percentage nodulation was observed on stem cuttings treated with 500 mg/L of IAA (75%). The results further showed variations in the influence of 300 mg/L of the three auxins on nodule development on the stem cuttings that were almost similar to those of 100 mg/L of the auxins. The highest percentage nodulation on the stem cuttings (40.2%) was observed on stem cuttings treated with 300 mg/L IAA while the least (22.5%) was obtained with NAA (300 mg/L).

The results also showed that percentage nodulation on the stem cutting treated with 500 mg/L of the auxins, IBA, NAA and IAA respectively varied. Indole-3-acetic acid influenced the production of the highest percentage nodulation on the stem cuttings, 75%, while the least, 48% was observed on stem cuttings treated with NAA. Indole-butyric acid (IBA), at 500 mg/L influenced the development of 65% nodulation on the stem cuttings. Comparatively, failure of stem cutting to nodulate was more on the stem cuttings of the dry than those of the wet seasons' study. Ostensibly, lower concentrations (100 mg/L and 300 mg/L) of the three auxins induced nodulation on the stem cuttings in the wet seasons, while in the dry season, the stem cuttings did not nodulate. It was also observed that the control stem cuttings of the wet season nodulated while those of the dry season failed to nodulate. It was further observed that 500 mg/L of each of the three auxins (IBA, NAA, and IAA) influenced the highest percentage nodulation on the stem cuttings during the wet season stem cuttings than in the dry season.

At 500 mg/L, IBA influenced 65% nodulation in the wet season as against 13% in the dry season, NAA at the same concentration influenced 48% nodulation in wet season and 11% in the dry season while IAA influenced 75% nodulation in the wet season and 15% in the dry season. (Table 3) Generally, the results showed that the highest percentage of nodulation on the stem cuttings in the two seasons of this study was obtained when stem cuttings were soaked in 500 mg/L of IAA for 24 hours before planting. This was followed by stem cuttings soaked in 500 mg/L of IBA, then NAA at the same concentration and soaking period, all in the wet season (Table 3).

Table 3. Effect of auxin concentration on callusing/nodulation prior to rooting on the stem cuttings of *M. oleifera*.

Treatment	Dry season (Dec. 2020-April, 2021)		Wet Season May-Sept, 2021)	
	Nodulation (%)	Size	Nodulation (%)	Size
IBA (mg/L)				
0	-	-	5.5	S
100	-	-	14.3	S
300	-	-	28.2	M
500	13.0	S	65.0	B
NAA (mg/L)				
0	-	-	5.0	S
100	-	-	8.5	S
300	-	-	22.5	M
500	11.0	S	48.4	B
IAA (mg/L)				
0	-	-	5.4	S
100	-	-	15.5	S
300	15.0	-	40.2	M
500	-	S	75.0	B
X	13.27		28.2	
SE	1.45		22.82	

Key: — = Nil; S = small; M- medium; B = big.

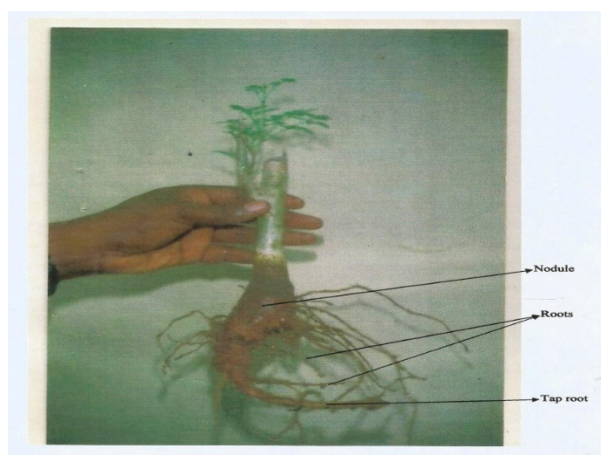


Fig. 4. Nodulation and rooting of *M. oleifera* stem cutting (Big size).

Effect of auxin concentration and seasons (dry and wet) on rooting of stem cuttings of *M. oleifera*

The results of the effect of the three concentrations of the three auxins applied and the two seasons on root formation on the stem cuttings of *M. oleifera* (Plate 4) showed variations. In the dry season, stem cuttings soaked in lower concentrations of the auxins; 100 mg/L and 300 mg/L of IBA, NAA and IAA respectively did not survive and hence did not root. The results also showed that a high concentration of 500 mg/L of the three auxins resulted in a low percentage rooting of the stem cuttings, ranging from; 11% to 15%. The highest percentage of rooting was obtained with stem cuttings soaked for 24 hours in IAA (15%) and the least (11%) with stem cuttings soaked in NAA.

In the wet season, the control and the low concentrations of the three auxins (100 mg/L and 300 mg/L) induced rooting on the stem cuttings, ranging from; 5% to 40%. Within the low concentrations of the auxins, IAA influenced the highest percentage of rooting, while NAA, had the least. Within the highest concentration of the auxins used, 500 mg/L, IAA also induced the highest percentage of rooting (75%), while NAA, the least (48%) while, Indole-3-butyric acid resulted in 65% percent rooting. Comparatively, the results showed that rooting of auxin-treated stem cuttings of *M. oleifera* was better in the wet than in

the dry season; in the wet season, percentage rooting of the stem cuttings was significantly higher than that of the dry season, even at low auxin concentrations and the control.

Root Parameters

The results of the determination of the length of the two major types of roots (lateral and tap root) on the stem cuttings of *M. oleifera* showed variations (Table 4). In the dry season; the control, 100 mg/L and 300 mg/L of the three auxins (IBA, NAA and IAA) respectively did not induce the production of either lateral or tap root system on the stem cuttings. The application of 500 mg/L of the three auxins in the dry season influenced the production of lateral roots only, ranging from, 5 cm to 7 cm. The longest mean lateral root length (7.0 cm) was produced on the stem cuttings treated with 500 mg/L of IAA and the least, 4.5 cm, was obtained with cuttings treated with 500 mg/L of NAA (Table 4).

In the wet season, lateral roots were produced on the stem cuttings irrespective of treatments. The mean lateral root length ranged from 3 cm to 8 cm. The longest mean lateral root length (8.0 cm) was observed on stem cuttings treated with 500 mg/L of IAA while the shortest mean lateral root length (3.0 cm) was observed on the untreated stem cuttings. Within the treatments, the results showed that 500 mg/L of IAA influenced the production of the longest lateral roots (Table 4); while NAA at the same concentration influenced the production of the shortest lateral root length (7.0 cm). The results also showed that in the wet season, no tap root system was produced on the stem cuttings treated with the low concentrations of the three auxins (100 mg/L and 300 mg/L) and the control. Taproot systems produced on the stem cuttings soaked in 500 mg/L of the three auxins (IBA, NAA and IAA), in the wet season had a mean length that ranged from 10 cm to 17 cm. The longest tap root was observed on stem cuttings treated with 500 mg/L of IAA (17.0 cm) and, the shortest on cuttings treated with NAA (10.0 cm) at the same concentration and soaking period.

Table 4. Mean values (cm) of the root types in dry and wet seasons.

Treatments	Dry season		Wet season	
	Tap root (cm)	Lateral root (cm)	Tap root (cm)	Lateral root (cm)
IBA (mg/L)				
0	-	-	-	3.2 ^c
100	-	-	-	4.5 ^{bc}
300	-	-	-	6.7 ^{ab}
500	-	5.2 ^b	15.5 ^a	7.2 ^a
NAA (mg/L)				
0	-	-	-	3.0 ^c
100	-	-	-	4.0 ^c
300	-	-	-	6.0 ^b
500	-	4.5 ^b	10.0 ^b	7.0 ^{ab}
IAA (mg/L)				
0	-	-	-	3.0 ^c
100	-	-	-	5.2 ^{bc}
300	-	-	-	6.8 ^{ab}
500	-	7.0 ^a	17.0 ^a	8.0 ^a
X		5.5	14.17	5.38
SE		1.08	3.00	1.73

Figures followed by the same letter(s) along the vertical column are not significantly different (P = 0.05).

DISCUSSION

The study investigated the effect of seasons (dry and wet), auxins and auxins concentration on rooting, bud sprouting and, development of leaves on the stem cuttings of *M. oleifera*. Meteorological data for the two seasons of the study (dry and wet) showed variation. The observed variations agreed with earlier reports on seasonal and climatic changes [12-16]. The

high temperature, low rainfall and low relative humidity observed in the dry season as against higher rainfall, higher relative humidity and low temperature observed in the wet season have been reported to be distinct features of the two seasons [12]. Earlier reports revealed that bud break/sprouting on stem cuttings is a sign of resumption of metabolic activities/life on the stem cuttings. Several authors have reported that prior to rooting, bud sprouting on the cuttings occurs first before other developmental processes [17-20].

In this study, a radical change of environment (without mist beds) adopted, suggests that activities of auxins on rooting woody stem cuttings of plant species could be influenced by techniques used. The results of this study showed that rooting of the stem cuttings of *M. oleifera* was more prolific on the wet season stem than on the dry season stem cuttings. The results suggest that the wet season provided a better enabling environment for auxin's influence on rooting the stem cuttings than the dry season, probably due to the availability of sufficient moisture and adequate temperature. In the dry season, rainfall and relative humidity are low and with high temperatures. There is a possibility of water stress due to losses by evaporation and drainage.

The results also showed that the rooting propensity was more on stem cuttings treated with the highest concentrations (500 mg/L) of the three auxins (IBA, NAA, IAA), than the stem cuttings treated with lower concentrations (300 mg/L, 100 mg/L, 0 mg/L) of the same auxins. The results agreed with reports of many authors who reported that stem cuttings of woody plant root when adequate auxin concentration is applied [10; 17; 21; 22; 15; 16]. The findings of this study thus imply that 500 mg/L of three applied auxins was adequate in influencing rooting on the stem cuttings of *M. oleifera*. However, it is recommended other concentrations of the auxins in rooting the species stem cuttings could be assessed in further studies.

When comparing the auxins (IBA, NAA, and IAA), the results showed that a rooting response of 75% was achieved when the stem cuttings were soaked for 24 hours at 500 mg/L of IAA, followed by IBA (65%) and NAA (25%). (48 percent). Among the three, the results suggested that IAA was the most influential on *M. oleifera* stem cutting rooting, followed by IBA and NAA. Few studies have examined the effects of multiple auxins on rooting stem cuttings from the same plant species. There appears to be a discrepancy between the various reports on the sequence of auxin's effect on rooting cuttings of woody stems. Many employees ranked MA higher in efficacy than NAA and IAA [10,15]. Griffith [9] reported that IAA was more effective than IBA and NAA in rooting the stem cuttings of Douglas fir, while Puffy *et al.* [16] reported that IBA was more effective than IAA and NAA in that order. The results of this study agreed with Griffith [9] but disagreed with the reports of other workers [10,23,15,16]. However, Awolaye, [16] pointed out that auxin activities on stem cuttings of the wood plant could be influenced by the techniques adopted. The results of this study the IAA was more effective in rooting stem cuttings of *M. oleifera* could in addition to the techniques adapted (radical change of environment) be influenced by other factors inherent in plants as well as season.

Among the merits of propagating plant species vegetatively by rooting the stem cuttings, the production of seedlings (rooted cuttings) that are the prototype of the parent stock is very important [16,24,10,17]. In this study, the results showed that roots formed on the stem cuttings soaked for 24 hours in 500 mg/L of the auxins had the major components of the root system

(tap, lateral and feeding roots). The results implied the production of seedlings that are the prototype of the parent stock and hence agreed with earlier reports [10,17].

Based on the findings of this study, it can be concluded that: *M. oleifera* can be propagated vegetatively by rooting the stem cuttings. That successful rooting of the stem cuttings can be achieved in the wet season, adapting a radical change of the environment techniques. It is recommended that IAA at 500 mg/L be used in treating the stem cuttings. The production of big-sized nodules on the stem cuttings can be used to predict the rooting and production of quality seedlings. The study has shown that propagating the species by rooting the stem cuttings could spare the seeds for industrial activities. The large quantities of uniform seedlings (rooted cuttings) produced can play an important in the conservation of the species.

CONCLUSION

During the wet season, 500 mg/L of auxins can be used to successfully root auxin-treated stem cuttings for propagating *M. oleifera*. Higher bud development into leaves was observed during the wet season as a result of auxin application and seasons, compared to the dry season (2.0 percent - 83.4 percent wet season and, 10 percent - 56.08 percent dry season). It was also discovered that nodules formed on the cuttings' base regardless of treatment or time of year. Roots that are prototypical of the parent stock can be predicted based on whether or not stem cuttings form large nodules, as was found in the study. Vegetative propagation of the species through rooting of stem cuttings could spare the seeds for industrial exploitation, while also providing a large number of uniform seedlings necessary for the conservation of the species. Therefore, it is suggested that 500 mg/L of LAA be used in the propagation of stem cuttings of *M. oleifera*, based on its overall performance.

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