INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 20, No. 6, p. 50-64, 2022
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Macropropagation using cuttings from yakal (*Shorea astylosa* Foxw) wildlings under various rooting hormones and level of concentrations

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Article published on June 15, 2022

Key words: Yakal, Wildlings, Cuttings, Hormone, Macro-propagation

Abstract

Shorea astylosa Foxw is a species of Dipterocarpaceae family. Productions of planting stock of dipterocarp species using seeds confront various problems. Flowering occurs at intervals of 3–10 yr. Propagation of wildlings cuttings was used in this study with levels of hormone, IBA, NAA, and Hormex. It was laid in 2 × 2 × 5 factorial experiment in CRD. Two segments were collected, topmost and middle parts. Hormones were used in levels; 0 ppm, control, 500 ppm, 1000 ppm, 1500 ppm, Hormex, 10mL per gallon of water, replicated three times. The study conducted from May 22 to October 4, 2019, in clonal nursery of Ecosystem Research, Development Bureau, DENR, Maharlika, Bislig City, Surigao del Sur. The results revealed that using IBA in the topmost segment produces more leaves than the middle segment, 1000 ppm of IBA has higher average survival rate of 93%. The average survival of topmost and middle segments has a significant difference with 78% and 61%, respectively. Significant differences observed between topmost and the middle segments, the highest average survival of topmost for IBA was in treatment 3 with 93% survival. For NAA, the highest was in treatment 1 with 96% average survival. For middle, highest survival for IBA was in treatment 1 with 90% survival and, for NAA, it was in treatment 1 with 73% average survival. These results implied that even without applying rooting hormone, cutting segments of yakal wildlings produces higher survival rate than other treatment levels with hormone application.

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Introduction

Dipterocarpaceae is a family of 17 genera and approximately composed of 500 species worldwide. The largest genera are *Shorea* (196 species), *Hopea* (104 species), *Dipterocarpus* (70 species), and *Vatica* (65 species) (Ashton, 2005; Kettle, 2010). *Shorea astylosa* Foxw is a species of plant in the Dipterocarpaceae family. It is endemic in the Philippines, which is known as yakal in Filipino language. A major portion of our dipterocarp forest has been devastated and transformed into grassland and brush land.

It has reported that the forest destruction is mainly caused by land conversion for the settlement, agricultural development, shifting cultivation, logging, forest fire, and to some extent mining, energy projects, and pest and disease treatment (Fernando 2001). The tree is threatened by destruction of its habitat. The plant is classified as 'Critically Endangered' in the IUCN Red List of Threatened Species (2013).

Sakai *et al.* (2006) mentioned that the productions of planting stock of dipterocarp species using seeds confront various problems. Flowering occurs at intervals of 3–10 yr. and flowering evolved to satiate seed predators and/or to facilitate pollination. Flowering is thought to be triggered by droughts that occur during periods from La Niña to El Niño.

This results to the irregularity in the supply of seeds due to irregular flowering and fruiting, short viability period of the collected seeds, low quality of the seeds and the lack of seed storage and handling facilities (FDPM, 1998). Due to these problems, efforts in the reforestation of natural forests have been hindered. The scaling up of the domestication of native timber trees is constrained by the limited availability of planting materials and low-quality germplasm (Tolentino *et al.,* 2002; Gregorio *et al.,* 2005).

Vegetative propagation of *S. astylosa* and other dipterocarp species by stem cuttings is an important alternative for production of high quality and uniform planting stock for reforestation programs. Stem cuttings offer several advantages over seeds. It is also inexpensive and easier to practice than other vegetative propagation methods, such as tissue culture (FDPM, 1998).

As an alternative production strategy, the objective of this study is to determine the potentials of propagating wildling stem cuttings of *S. astylosa* when applied with different levels of IBA, NAA and commercially available rooting hormone, HORMEX, on the recommended application on the rooting and survival of macro propagated *S. astylosa*.

The irregularity in the supply of seeds due to irregular flowering and fruiting of *S. astylosa* justifies the use of wildlings as alternative source of vegetative propagation. The collection of wildling cuttings must be viewed within the wider context of sourcing high quality germplasm for reforestation efforts and species conservation since it is classified as critically endangered. However, protocol for vegetative propagation of *S. astylosa* using cuttings from wildlings is not yet establish hence this study.

Materials and methods

Study Site

The study was conducted at the clonal nursery of Ecosystem Research and Development Bureau, Department of Environment and Natural Resources, barangay Maharlika , Bislig City, Surigao del Sur with geographical coordinates of 9°23' 3.92" N, 125°58' 41,72" E (Fig. 1).

Experimental Design

This experiment was laid-out in a 2 × 2 × 5 factorial experiment in Complete Randomized Design (CRD). Two segments of the wildlings were collected as cutting materials, the topmost part and the middle part. IBA, NAA rooting hormones were used in varying levels; 0 ppm, as control, 500 ppm, 1000 ppm, and 1500 ppm, and the commercially recommended application of Hormex, 10mL per gallon of water, and replicated three times. A total of 600 cuttings were observed in the clonal nursery with 10 cuttings per experimental unit (Fig. 2).

Fig. 1. Map of the Study Area.

C2 H1 L3	C2 H1 L4	C1 H2 L3	C1 H2 L2	C1 H1 L5	C2 H1 L5	C1 H1 L1	C2 H1 L3	C1 H1 L3	C1 H1 L4	C2 H2 L5	C2 H1 L4	C2 H1 L1	C2 H2 L2	C2 H1 L2
C1 H2 L5	C2 H2 L1	C1 H2 L2	C1 H2 L4	C2 H2 L3	C2 H1 L5	C2 H1 L1	C2 H2 L3	C1 H1 L2	C2 H2 L4	C1 H1 L3	C1 H1 L1	C2 H1 L2	C2 H2 L5	C2 H2 L4
C1 H2 L3	C2 H2 L2	C2 H2 L5	C2 H2 L3	C2 H2 L4	C1 H1 L5	C1 H2 L5	C1 H1 L4	C1 H2 L1	C2 H1 L3	C1 H2 L1	C2 H2 L2	C2 H2 L1	C1 H1 L2	C2 H1 L5
C1 H2 L3	C2 H2 L1	C1 H2 L2	C1 H2 L1	C1 H1 L5	C1 H1 L3	C1 H2 L4	C1 H2 L5	C2 H1 L2	C1 H1 L2	C2 H1 L1	C1 H1 L4	C2 H1 L4	C1 H2 L4	C1 H1 L1

Fig. 2. Experimental lay-out of a 2 x 2 x 5 factorial experiment involving two cuttings (Top most segment and Middle segment).

Experimental Procedure

Preparation of Rooting Hormone

Rooting hormone preparation was conducted in the College of Forestry & Environmental Science, Central Mindanao University – Bukidnon. The preparation of rooting hormone in varying levels of concentration per treatment of IBA, NAA and hormex.

Cuttings Collection and treatment

The source of cuttings was coming from the wildlings of *S. astylosa* and collected in their natural habitat at the laboratory area of ERDB, DENR, Maharlika, Bislig City, Surigao del Sur. The wildlings were not uprooted in the field, only the portion serves as the cutting materials were cut and collected leaving the basal area and root system intact in the ground. The average length of cuttings was 8-10cm and the basal part of cuttings were cut in slant.

Only three to four leaves were retained from cuttings and cut to half of their original size to reduce transpiration. Cuttings were planted in the closed mist rooting chamber vertically with the depth of 2 – 3cm and distance of 5cm × 5cm between cuttings, 10cm between treatments. The area for the study was .5 meters × 5.2 meters (Fig. 3).

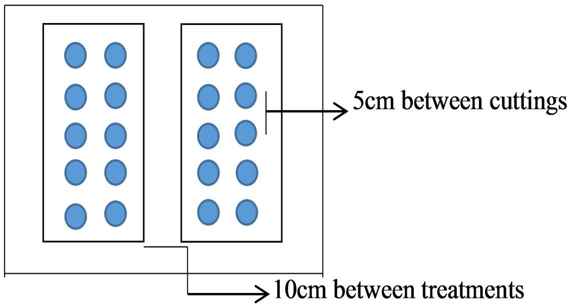

Fig. 3. Schematic Diagram of cutting set-up in the clonal nursery.

Data collection

Data collection were done at the 160th day of the study. The average number of leaves and roots, length of roots and average survival rate were measured after the termination of the study.

Average number of leaves was determined using the formula: $ANL = \frac{TNL}{TNCT}$

Where, ANL – Average Number of Leaves
TNL – Total Number of Leaves
TNCT – Total Number of Cuttings/Treatment

Average number of roots was determined using the formula: $ANR = \frac{TNR}{TNCS}$

Where, ANR – Average Number of Roots
TNR – Total Number of Roots
TNCS – Total Number of Cuttings Survive

The average root length was determined using the formula: $ALR = \frac{TRL}{TNR}$

Where, ARL – Average Root Length
TRL – Total Root Length
TNR – Total Number of Roots

Survival rate was determine using the equation below: $SR\ (\%) = \frac{NSC}{TNCP} X\ 100$

Where, SR– Survival Rate
NSC – Number of Survived Cuttings
TNCP – Total Number of Cuttings Planted

Data analysis

The data were analyzed using analysis of variance (ANOVA) and the significant effect of each factor were separated by Tukey's pairwise comparison post hoc (Least Significance Difference) test at a 5% level of significance (Moreira *et al.*, 2009).

Results and discussions

A. Comparison of cutting segments (topmost segment and Middle Segment).

IBA hormone

Average Number of Leaves

The highest average number of leaves of the topmost segment was in treatment 3 with a mean of (1.0), followed by treatment 4 (.92), treatment 2 (.79), treatment 5 (.77) and the lowest was in treatment 1 (.70). For the middle segment, the highest mean was observed in treatment 1 (.63) followed by treatment 3 (.45), treatment 4, (.34) treatment 2 (.32), and the lowest was in treatment 4 (.19) (Table 1). No significant result was observed per treatment on the topmost segment, the same with the middle segment in terms of the average number of leaves.

However, the mean comparison on the average number of leaves between the topmost segment and middle segment had a significant difference with a mean of .84 for the topmost segment and .39 for the middle segment (Table 2). These results shown that the topmost segment treated with IBA significantly produces more leaves than the middle segment. Likewise, these results corroborate to the study of Kassahun and Mekonnen (2011) on the effect of cutting position on the propagation ability of stevia through its effect on leaf number and survival rate varies from top and middle cutting position of a plant.

They further added that this difference in propagation ability of apical and middle cuttings of stevia could be due to high concentration of endogenous root promoting substances in the apical cuttings which arise from the terminal buds and also "more cells" which are capable of becoming meristematic (Hartman and Kester 1983).

Table 1. IBA: Comparison on the means of the cutting segments on the Average Number of Leaves of cuttings from Yakal wildlings160 DAP.

Treatment Levels	Replicate	Top most segment	Middle segment
		Ave. no of leaves	Ave. no of leaves
1	3	.71	.63
2	3	.80	.32
3	3	1.0	.45
4	3	.91	.35
5	3	.77	.19

CV: 40.65 Mean: .6140

Table 2. IBA: Mean comparison on the cutting segments on average number of leaves of Cutting from Yakal Wildling 160 DAP.

Cuttings	Average	N Group
Top most segment	.84	15 a
Middle segment	.39	15 b

Means with the same letter are not significantly different.

Average Number of Roots

Analysis of variance shows no significant difference was observed per treatment on the topmost segment and middle segment on the Average number of roots. These results mean that both topmost and middle segments produce almost the same performance in terms of producing the number of roots. However, the present findings contrast with the study of Deen and Mohamoud (1996) as cited by Kassahun and Mekonnen (2011), they mentioned that apical cuttings exerted a greater number of roots for rosemary (*Rosemarinus officinalis* L.). Similar results were also reported by Palanisamy and Kumar (1997) in rooting of neem (*Azadirachta indica* A. Juss), where cutting from the upper part of the branches is rooted better than the lower ones (Wassner and Ravetta 2000). Leakey (1983) also added that with the propagation of *Triplochiton scleroxylon* a gradual reduction in rooting percentage was recorded with distance from the apex. In comparison to the present study, many authors (Leakey 1983; Hansen 1986, 1988; Hartman *et al.*, 1990; Jawanda *et al.*, 1991; Al-Saqri and Alderson 1996) reported that the best rooting of cuttings is usually found from the basal portions of shoots. This variation comes due to the variation in accumulation of photosynthetic products, mostly carbohydrates or it could be due to juvenility factors (Jawanda *et al.* 1991), species, environmental conditions, the season of propagation, degree of maturity, rate of growth (Hansen 1986; Leakey and Coutts 1989).

Average Root Length

Analysis of variance also reveals that no significant difference was observed per treatment on the topmost segment and in the middle segment for the Average root length. These results were different from the results mentioned by Araya (2005) that the difference in rooting due to cutting position can be related to the difference in the chemical composition of the shoots. Hartman *et al.* (1990) also indicated middle cuttings could be a more mature and low meristematic activity to develop roots than the apical cuttings.

Average Survival Rate

The highest average survival rate for the topmost segment was in treatment 3 with (93%), followed by treatment 4 and treatment 5 with the same mean of (80%), followed by treatment 1 (56%). For the middle segment, the highest average survival rate was observed in treatment 1 (90%) followed by treatment 4 (80%), treatment 5 (73%), and the lowest average survival rate was in treatment 2 (60%) (Table 3).

Treatment 1 has significantly lowered average survival rate of (56%) compared to treatment 3 (93%) Treatment 4 (80%) and Treatment 5 (80%) (Table 3).

The findings of Patricio et.al, (2006) in their study on the Macropropagation of *Shorea guiso* using stem cuttings partially corroborate when they mentioned that the application of IBA increased% survival by 16% for cuttings treated with 500 ppm IBA (86%) over untreated (74%). However, it contradicts when they further mentioned that doubling the concentration from 500 ppm of IBA to 1000 ppm did not improve the survival of the cuttings which is not observed in this present study.

This study shows that in treatment 3 (1000 ppm) of IBA with 93% survival rate has a significant difference in terms of survival rate compared to other levels of treatment lowered than 1000 ppm like in treatment 2(500 ppm) with 70% survival rate and the control or no IBA application (treatment 1) with 56% survival rate (Fig. 4).

Table 3. IBA: Comparison of the mean of cutting segments at each level of treatment on the Survival Rate of Yakal wildlings cuttings 160 DAP.

Treatment Levels	Survival (%)	
	Top most segment	Middle segment
1	56 c	90 a
2	70 bc	60 c
3	93 a	70 bc
4	80 ab	80 ab
5	80 ab	73 abc

Means with the same letter are not significantly different.
CV: 15.14 Mean: 75

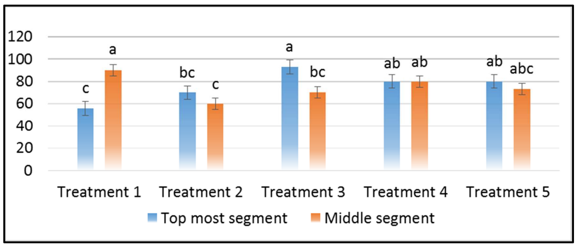

Fig. 4. IBA: Standard of error of the mean of cutting segments at each level of treatment on the Survival Rate of Yakal wildlings cuttings 160 DAP. (Values represent mean ± standard error (SE: 6.58).

Table 4. IBA: Comparison of cutting segments at each level of treatment on the average survival rate of cutting from Yakal wildlings 160 DAP.

Segment	Average Survival Rate				
	1	2	3	4	5
Top most	56 b	70 a	93 a	80 a	80 a
Middle	90 a	60 a	70 b	80 a	73 a

Means with the same letter are not significantly different

No significant difference was observed between treatment 3 and treatment 4 and between treatment 3 and treatment 5 (Fig. 4). This result suggests that using 1000 ppm of IBA is beneficial compared to using 1500 ppm of IBA in terms of the survival rate of cuttings from Yakal wildlings. Likewise, using 10mL/gallon of water of hormex, is more economical than using 500 ppm, 1000 ppm & 1500 ppm of IBA in terms of survival rate for the topmost segment cuttings from Yakal wildlings.

For the middle segment, significant differences in the survival rate were also observed in Treatment 1 with a (90%) survival rate compared to Treatment 2 (60%), and Treatment 3 (70%). A significant difference was also observed between the survival rate of Treatment 2 (60%) and Treatment 4 (80%) survival rate. This result implied that the application of IBA did not affect the survival rate of the middle segment of the cuttings on the basis that Treatment 1 produces a significantly higher survival rate of cuttings compared to treatment 2 and treatment 3. This result supports the findings of Totaan (2019) when he mentioned that it is probable that the application of exogenous auxin to the stem cuttings of *Antidesma bunius* (Linn) has no effect at any level of concentration because of the interference of high level of endogenous auxin present during the period of collection. He further mentioned that there were reports that the cuttings with a larger diameter and longer length result in better survival and growth under normal conditions (Hannerz *et al.*, 1999, Vigl and Rewald 2014, OuYang *et al.*, 2015).

Table 4 shows significant results were observed between means of the topmost segment and middle segment in treatment 1 with 56% and 90%, respectively. This result implies that the middle segment of cuttings produces a higher survival rate compared to the topmost segment when planted without the application of IBA. But, this finding contradicts the finding of Hartman, *et al.* (1997) as cited by Hansel (1986) when they mentioned that the survival rates varied from 62.4% for middle cuttings to 80.11% for top cuttings.

They also added that for many years' propagation ability has been known to vary between cuttings from different parts of the same plant, especially in woody species and this was correlated with the structure of the stem or difference in the chemical composition of the plant along the stem. However, the topmost segment has a significantly higher survival rate compared to the middle segment in treatment 3 with a means of 93% and 70%, respectively (Table 4). Likewise, using of 1000 ppm of IBA significantly higher in the topmost segment compared to the middle segment.

NAA hormone

Average Number of Leaves

Table 5 presents the average number of leaves in the topmost segment and middle segment 160 DAP.

The highest average number of leaves for the topmost segment was in treatment 1with a mean of (1.0), followed by treatment 5 (.76), treatment 4 (.72), treatment 3 (.64) and the lowest was in treatment 2 (.61). For the middle segment, the highest mean was observed in treatment 5 (.56) followed by treatment 4 (.46), treatment 2 (.44) treatment 3 (.35) and the lowest was in treatment 1 (.34). No significant result was observed in the comparison between means of levels of treatments in the topmost segment, the same with the means of levels of treatments in the middle segment in terms of a number of leaves (Table 5).

However, the mean comparison on the average number of leaves in the topmost segment and middle segment showed a significant difference with a mean of .75 for the topmost segment and 43 in the middle segment (Table 6).

These results show that the topmost segment of cuttings produces more leaves than the middle segment. Again, this result supports the study of Kassahun and Mekonnen (2011) on the effect of cutting position on the propagation ability of *stevia* through its effect on leaf number varies from top and middle cutting position of a plant.

In their study, they mentioned that the leaf numbers of the seedlings ranged from 5.6 to 8.22 pairs the highest being recorded for top cuttings and the lowest for the middle cutting position.

Table 5. NAA: Comparison on the mean of the cutting segments of cuttings from Yakal wildlings on the Average Number of Leaves 160 DAP

Treatment	Replicate	Cutting (1)	Cutting (2)
		Mean	Mean
1	3	1.0	.34
2	3	.61	.45
3	3	.64	.34
4	3	.72	.46
5	3	.76	.56

CV: 47.01 Mean: .59

Table 6. NAA: Comparison on the mean of cutting segments on ave. number of leaves in of Cuttings from Yakal wildlings 160 DAP.

Cuttings	Average	N Group
1	.75	15 [a]
2	.43	15 [b]

Means with the same letter are not significantly different.

Average Number of Roots

Analysis of variance shows that no significant difference was observed between levels of treatments in the topmost segment and in the middle segment for the Average number of roots of cuttings.

However, the mean comparison on the average number of roots of the topmost segment and middle segment had a significant difference with a mean of 25% for the topmost segment and .00 in the middle segment (Table 7).

These results show that the topmost segment produces more roots than the middle segment cuttings (Fig. 5). These results further supports the statement of Wassner and Ravetta (2000) as cited by Kassahun and Mekonnen (2011) when they reported that in rooting of Neem (*Azadirachta indica* A. Juss), where cutting from the upper part of the branches rooted better than the lower ones. Hartman *et al.* (1990) as cited by Araya (2005).

Also mentioned that the difference in rooting due to cutting position can be related to the difference in the chemical composition of the shoots.

Middle cuttings could be a more mature and low meristematic activity to develop roots than the apical cuttings. Moreover, Hartmann, *et al.* (2002) and Brardwaj and Mishra (2005) stated that the rooting ability of juvenile cuttings may be ascribed to optimum levels of sugars and the total carbohydrate content and low nitrogen levels while the reduction in rooting potential of cuttings from the stem of mature donors might be due to a decrease in the content of endogenous auxins or an accumulation of inhibitory substances.

Table 7. NAA: Comparison of the mean of cutting segments on the average number of roots of Yakal wildlings cuttings160 DAP.

Cuttings	Means	N Group
1	.25	15 [a]
2	.00	15 [b]

Means with the same letter are not significantly

CV: 220.89 Mean: .12

Fig. 5. NAA: Standard Error of the mean of cutting segments on the average number of roots of Yakal wildlings cuttings160 DAP (Values represent mean ± standard error (SE: .16).

Average Root Length

Analysis of variance shows that no significant difference was observed between levels of treatments in the topmost segment and in the middle segment on the average root length of cuttings. However, the mean comparison on the average root length of the topmost segment and middle segment had a significant difference with a mean of .69 for the topmost segment and .00 for the middle segment (Table 8). These results show that the topmost segment produces root length than the middle segment (Fig. 6). This finding could be supported by some studies clarifying that the apical dominance of the apical shoot could affect rooting due to the variation of endogenous auxin or/and cytokinin contents with respect to the axillary shoots (Pandeliev *et al.*, 1990, Torres 2004). In addition, stem cuttings within the juvenile stage have less lignified tissues and lower production of rooting inhibitors as compared to stem cuttings collected from mature plants (Leopold and Kriedemann 1975, Hartmann *et al.*, 1997, Castro and Bonfil, 2013).

Survival Rate

The highest average survival rate in the topmost segment was in treatment 1 with (96%), followed by treatment 3 (83%) treatment 5 (76%), followed by treatment 2 (63%). For the middle segment, the highest average survival rate was in treatment 2 (76%) followed by treatment 1 (control) with (73%), treatment 5 (10mL/gal), with (66%) and the lowest was in treatment 4 (1500 ppm) with (43%) (Table 9).

Table 8. NAA: Comparison on the mean of cutting segments on the average root length of cuttings from Yakal wildlings 160 DAP.

Cuttings	Average root length	N Group
1	.69	15 [a]
2	.00	15 [b]

Means with the same letter are not significantly *CV:* 193.44 Mean: .3492

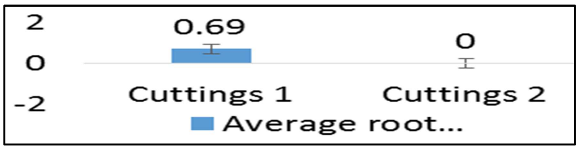

Fig. 6. NAA: Standard Error of the mean of cutting segments on the average root length of cuttings from Yakal wildlings 160 DAP (Values represent mean ± standard error (SE: .39).

No significant result was observed in treatment means in the topmost segment and treatment mean in the middle segment in terms of survival rate. However, the mean comparison on the average survival rate in the topmost segment and the middle segment has a significant difference with (78%) and (61%) respectively (Table 10). These results showed that the topmost segment had a higher survival rate compared to the middle segment of the cuttings.

Table 9. NAA: Comparison on the treatment means of cutting segments on Average Survival rate of Cuttings from Yakal wildlings 160 DAP.

	Treatment				
Cuttings	1	2	3	4	5
1	.96	.63	.83	.70	.76
2	.73	.66	.46	.43	.66

CV: 28.35 Mean: 69

Table 10. NAA: Comparison on the mean of cutting segments on Average Survival rate of cuttings from Yakal wildlings on the survival rate 160 DAP.

Cuttings	Average Survival Rate (%)	N Group
1	78	15 [a]
2	61	15 [b]

Means with the same letter are not significantly

Comparison between Hormones (IBA and NAA) and levels of concentration

Top most segment (cuttings 1)

Average Number of Leaves

The highest average number of leaves in IBA were observed in treatment 3 with a mean of (1.0), followed by treatment 4 (.92), treatment 2 (.79), treatment 5 (.77) and the lowest mean was in treatment 1 (.70). For NAA, the highest mean was observed in treatment 1 (1.0) followed by treatment 5 (.76), treatment 4 (.72) treatment 3 (.64) and the lowest was in treatment 2 (.61). No significant result was observed in the comparison between hormones and levels treatment means for the topmost segment (Table 11).

Average Number of Roots

Analysis of variance shows that no significant difference was observed between means of Hormones (IBA and NAA) and levels of concentration for the topmost segment on the Average number of roots of cuttings.

Average Root Length

Analysis of variance shows that no significant difference was observed between means of Hormones and its levels for the topmost segment on the Average roots length of cuttings.

Average Survival Rate

The highest average survival rate in IBA was in treatment 3 with (93%), followed by treatment 4 and treatment 5 with the same (80%), followed by treatment 2 (70%) and treatment 1 (56%) average survival rate. For NAA, the highest mean survival rate was observed in treatment 1(96%) followed by treatment 3 (83%), treatment 5 (76%), and treatment 2 (63%) (Table 12).

Table 11. Top most segment: Comparison of means between Hormone and levels of treatment on the Average Number of Leaves of cuttings from Yakal wildlings 160 DAP.

Treatment	Replicate	IBA	NAA
		Mean	Mean
1	3	.70	1.0
2	3	.79	.61
3	3	1.0	.64
4	3	.91	.72
5	3	.77	.76

CV: 32.70 Mean: .79

Table 12. Top most segment: Comparison of Hormone at each level of treatment on the Average Survival rate of Yakal wildlings cuttings 160 DAP.

Hormone	Average Survival rate per treatment				
	1	2	3	4	5
1 (IBA)	56 [b]	70 [a]	93 [a]	80 [a]	80 [a]
2 (NAA)	96 [a]	63 [a]	83 [a]	70 [a]	76 [a]

Means with the same letter are not significantly different

CV: 14.81 Mean: 77

Significant results were observed in treatment 1 on average survival rates for the topmost segment (Fig. 7). Though both experiment groups of cuttings from the topmost segment were not applied with rooting hormone, these results may be attributed to the report mentioned by Ou Yang *et al.* (2015) as cited by Totaan (2019) that aside from the effect of stem cutting position, the size of stem specifically the length of cuttings probably influenced the percent survival as observed in their study. He added that there are reports that the cuttings with a larger diameter and longer length result in better survival and growth under normal conditions. David (2003) also added that even if the cuttings were taken properly, they would not grow well if the environmental conditions were not correct.

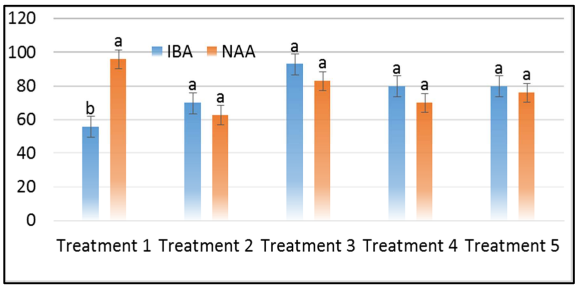

Fig. 7. Top most segment: Standard Error of Hormone mean at each level of Treatment on the Average Survival rate of Yakal wildlings cuttings 160 DAP (Values represent mean ± standard error (SE: .15).

Table 13 shows that IBA, Treatment 1 has a significantly lower average survival rate of (56%) compared to treatment 3 (93%), Treatment 4, and Treatment 5 with the same of (80%). A significant difference was also observed between Treatment 3 (93%) and Treatment 2 (70%). This result suggests that Treatment 3 of IBA has a higher average survival rate for the topmost segment compared to other Treatment levels of IBA. For NAA, Table 13 shows that Treatment 1 has a significantly higher average survival rate of (96%) compared to Treatment 2 (63%), Treatment 4 (70%), and Treatment 5 (76%). A significant difference was also observed between Treatment 3 and Treatment 2. This result suggests that the application of IBA and NAA would not affect on the significant survival rate of the topmost segment of cuttings. This result might be due to the accumulation of photosynthetic products, mostly carbohydrates or it could be due to juvenility factors (Jawanda *et al.*, 1991), environmental conditions, the season of propagation, degree of maturity, rate of growth (Hansen 1986; Leakey and Coutts 1989) that supports for the higher survival rate of cuttings from wildlings of Yakal even without the application of rooting hormone, IBA and NAA.

Table 13. Top most segment: Comparison treatment at each level of Hormone on the Average Survival rate of Yakal wildlings cuttings 160 DAP.

Treatment	IBA	NAA
1	56 c	96 a
2	70 bc	63 c
3	93 a	83 ab
4	80 ab	70 bc
5	80 ab	76 bc

Means with the same letter are not significantly different

Moreover, the application of 1000 ppm of IBA for the topmost segment has no significant difference when using 1500 ppm. No significant difference was also observed using hormex: 10mL/gal of water compared to 1000 ppm and 1500 ppm.

Middle segment

Average Number of Leaves

The highest average number of leaves for IBA were observed in treatment 1 with a mean of (.62), followed by treatment 3 (.45), treatment 4 (.34), treatment 2 (.32), and treatment 5 (.19). For NAA, the highest mean was observed in treatment 5 (.56) followed by treatment 4 (.46), treatment 2 (.44) treatment 3 (.34), and treatment 1 (.34) (Table 14). No significant result was observed in the comparison between treatment means of IBA and NAA (Fig. 8).

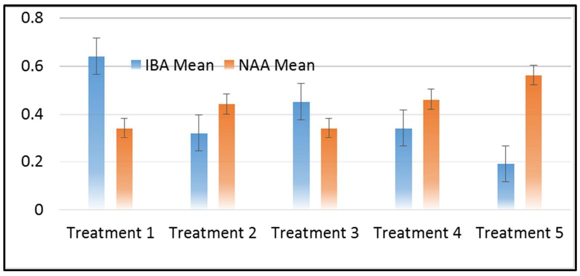

Fig 8. Middle segment: Standard Error between hormone and treatment means on the Average Number of Leaves of Yakal wildlings cuttings 160 DAP. (Values represent mean ± standard error (SE: .15).

Average Number of Roots

Analysis of variance shows that no significant difference was observed between treatment means of IBA and NAA on the Average number of roots. However, the mean comparison on the average number of roots in IBA and NAA showed a significant difference with .19 for IBA and .00 for NAA (Table 15). These results shown that IBA significantly produces more roots compared to NAA. These findings corroborate the findings of Larsen and Guse (1997) and Kester*et al*, (1990) when they reported that the most reliable rooting hormone is indolebutyric acid (IBA) while others such as naphthalene acetic acid (NAA) can also be used. Though there were reports that it may also be toxic to young/ succulent cuttings of certain species, IBA is still probably the best hormone for general use because of being non-toxic to plants over a wide range of concentration levels (Kester *et al.*, 1990).

Table 14. Middle segment: Comparison between hormone and treatment means on the Average Number of Leaves of Yakal wildlings cuttings 160 DAP.

Treatment	Replicate	IBA Mean	NAA Mean
1	3	.62	.34
2	3	.32	.44
3	3	.45	.34
4	3	.34	.46
5	3	.19	.56

CV: 65.33 Mean: .41

Average Root Length

Analysis of variance shows that no significant differences were observed in treatment means in IBA and means in NAA for the average roots length of cuttings. However, the mean comparison on the average mean in IBA and NAA had a significant difference in terms of average roots lengths of the middle segment with a mean of .39 for IBA and .00 in NAA (Table 16). This result shows that IBA produces more root length than NAA.

Table 15. Middle segment: Mean comparison on the average number of roots in IBA and NAA on the Yakal wildlings cuttings160 DAP.

	Average	N Group
IBA (H1)	.19	15 [a]
NAA (H2)	.00	15 [b]

Means with the same letter are not significant

CV: 254.13 Means: .098

Table 16. Middle segment: Mean comparison on the average root length in Hormone 1(IBA) and hormone 2 (NAA) of Yakal wildlings cuttings160 DAP.

Hormone	Means	N Group
IBA	.39	15 [a]
NAA	.00	15 [b]

Means with the same letter are not significant

CV: 230.79 Means: .19

Survival Rate of the middle segment

No significant result was observed in comparison to the treatment mean of IBA and treatment means of NAA in terms of the survival rate of Yakal wildling cuttings. This result reveals that the application of IBA and NAA in the Middle segment had no significant impact on the survival rate of Yakal wildlings cuttings.

Conclusions

The highest average survival rate for the topmost segment was in treatment 1 with (96%) survival rate and followed with the IBA hormone application in treatment 3 with (93%) survival rate. While for the middle segment, the highest survival rate was in treatment 1 with (90%) survival rate. Using IBA hormone in the topmost segment produces more leaves compared to the middle segment of cuttings from Yakal wildlings 160 DAP. Application of IBA of various levels did not influence the survival rate of the middle segment for the reason that Treatment 1 produces a significantly higher survival rate compared to other treatments applied with various levels of IBA. Application of NAA hormone significantly produces a higher average number of leaves, average number of roots, average root lengths, and average survival rate for the topmost segment compared to the middle segment. Application of NAA hormone produces a higher survival rate with 78% on the topmost segment compared to 61% for the middle segment.

Recommendations

Increase the duration of the study by at least 1 year to further evaluate the rooting potential and survival rate of cutting segments from Yakal wildlings.

The topmost segment and middle segment of cuttings could be a potential source of good planting materials even without the application of IBA, NAA & hormex. However, a low concentration from 500 ppm below may be tried. Application of another rooting hormone other than IBA, NAA & hormex is recommended. The majority of forest nurseries in the Philippines are non-mist, in order to evaluate the potential of Yakal wildlings cuttings propagation, it is recommended that a similar study should be conducted in a non-mist set-up.

Acknowledgment

The researcher would like to thank the Almighty Father for the strength, knowledge, and continues blessing that He shared throughout the years. He would like to extend his heartfelt gratitude to many people who helped to bring this research to completion: To the Chairperson of the thesis advisory Committee, Dr. Rico A. Marin and members of the thesis advisory committee, Dr. George R. Puno, Dr. Mark Jun A. Rojo, and external evaluator Dr. Adrian M. Tulod. To the College President of Surigao State College of Technology, Dr. Gregorio Z. Gamboa, Jr., for the endorsement to the CHED K to 12 scholarship program. To the CHED Caraga Regional Office XIII, Administration and personnel for the opportunity and financial support given to the K to 12 scholars. To the Administration and staff of ERDB – DENR Clonal Center headed by Center Chief, Forester Conrado B. Marquez, Forester Dennis Gilbero, Forester Rustom A. Aguilos, and Mr. Gil Ladipa. To the Administration, Faculty, and Staff of Central

Mindanao University, College of Forestry and Environmental Science, headed by their dynamic Dean, Dr. Alex S. Olpenda, together with Ms. Lilia S. Paragoso. To Dr. Lowell G. Aribal for his valuable specimen certification.

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