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Effects of Coconut Liquid Endosperm and indole-3-butyric acid on the Rooting Performance of *Ricinus communis* Stem Cuttings

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ABSTRACT

This study evaluated the effects of coconut liquid endosperm and indole-3-butyric acid (IBA) at different concentrations on rooting and survival of *Ricinus communis* stem cuttings. A 2 × 5 factorial arrangements in a completely randomized design with five replications was used. The treatments consisted of two hormone types (coconut liquid endosperm and indole-3-butyric acid) and five concentrations (0%, 25%, 50%, 75% and 100%). Data were collected on days to root initiation, rooting percentage, number of roots, root length and survival rate. Results showed that no rooting occurred at 0% and 25% concentrations for both treatments. Coconut liquid endosperm induced rooting only at 100% concentration, with root initiation after 18.00 days, 60% rooting, 6.80 roots and 3.82 cm root length. Indole-3-butyric acid produced rooting at 50%, 75% and 100% concentrations. The highest number of roots (10.60) and root length (7.84 cm) were recorded at 100% indole-3-butyric acid. Survival rates were highest (80%) at 75% and 100% indole-3-butyric acid, while 100% coconut liquid endosperm gave 60% survival. Indole-3-butyric acid generally performed better than coconut liquid endosperm. However, coconut liquid endosperm at full concentration could serve as a natural, low-cost alternative for vegetative propagation of *Ricinus communis*. It is recommended that 75% indole-3-butyric acid be used where reduced concentration was desired, as it gave survival comparable to 100%.

Keywords: Adventitious rooting, coconut liquid endosperm, indole-3-butyric acid, *Ricinus communis*, stem cuttings

INTRODUCTION

Ricinus communis L., commonly known as castor bean or castor oil plant, is an economically important species belonging to the family Euphorbiaceae. Although native to the southeastern Mediterranean, Eastern Africa, and parts of India, it is now widely cultivated throughout

tropical and subtropical regions due to its adaptability and economic utility [1]. The plant is a robust, fast-growing shrub or small tree that can attain heights of 10–13 m in tropical climates, though in temperate regions it is often grown as an annual reaching 1.5–2.5 m. Its large, palmate leaves and monoecious floral spikes make it both an ornamental and an agricultural crop [2]. The seeds contain 40–60% oil rich in ricinoleic acid, a compound valued in the production of lubricants, paints, pharmaceuticals, and biodiesel. Beyond industrial uses, various parts of *R. communis* are employed in traditional medicine for treating inflammation and microbial infections, although scientific validation is ongoing [3].

Propagation of *R. communis* is predominantly by seed, which is reliable and easy. Seeds germinate readily in warm, well-drained soils, and pre-sowing treatments such as soaking for 24 hours can improve germination rates [4]. However, seed propagation results in genetic variability, which is undesirable when uniform planting material of elite genotypes is required. Vegetative propagation via stem cuttings offers a means of cloning superior genotypes, but it is less commonly practiced in *R. communis*. Adventitious root formation is a critical step in vegetative propagation and is regulated by endogenous and exogenous factors, particularly auxins [5]. Synthetic auxins such as indole-3-butyric acid (IBA) are widely used to enhance rooting in stem cuttings [6]. However, the high cost and limited availability of synthetic hormones in developing countries have prompted interest in natural alternatives.

Coconut liquid endosperm (CLE), commonly known as coconut water, is a rich source of naturally occurring growth regulators, including cytokinins, auxins, minerals, and organic compounds [7]. Its use as a rooting agent has been explored in some species, but information on its effectiveness for *R. communis* is scarce. In particular, it is not known whether CLE can match the rooting performance of IBA in stem cuttings of this species, or at what concentration it becomes effective, which limits its adoption as a low-cost alternative.

The present study was therefore conducted to evaluate the comparative effects of CLE and IBA at different concentrations on rooting and survival of *R. communis* stem cuttings. The specific objectives were to: (i) determine the effect of hormone type and concentration on days to root initiation, rooting percentage, number of roots, and root length of *R. communis* stem cuttings; (ii) assess the survival rate of rooted cuttings under different treatments; and (iii) identify the most effective and economically viable hormone treatment for vegetative propagation of *R. communis*.

MATERIALS AND METHODS

Experimental site

The study was conducted at the screen house of the Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria, located at latitude 5°48′06″N and longitude 7°54′56″E. Stem cuttings were planted in polypots and mechanically irrigated, instead of using mist drip irrigation or bottom heat technique.

Collection, identification and confirmation of materials

Mature coconut (*Cocos nucifera* L.) fruits (Ghana variety) were purchased from a local market in Ikwuano Local Government Area, Abia State, and the liquid endosperm was extracted. Indole-3-butyric acid (Sigma Chemicals) was obtained from the National Root Crops Research Institute (NRCRI), Umudike, Abia State. Branches of current year's growth of castor bean (*Ricinus communis* L.) were obtained from the College of Natural Resources and Environmental Management (CNREM), Michael Okpara University of Agriculture, Umudike. The stem cuttings were identified and confirmed at CNREM, where the plant was collected. Top soil was collected from uncultivated land in the experimental field of the Department of Plant Science and Biotechnology, MOUAU. Poultry droppings were collected from the Farm Centre Unit, MOUAU.

Preparation of media

The growing medium was prepared from a 2:1 mixture of top soil and poultry manure. The mixture was allowed to cure for 14 days before bagging into polypots of 12 × 25 cm. A total of 270 polypots were filled with 0.25 kg of the medium each. The polypots were perforated at the base and sides to allow drainage of excess water. The amended medium was chosen because mixed media are better aerated and retain sufficient moisture for plant growth [8].

Preparation of rooting substances

A stock solution of IBA at 250 mg L^{-1} was prepared as the 100% concentration. Exactly 250 mg of IBA powder was weighed and dissolved in 5–10 mL of 95% ethanol, then transferred to a 1 L volumetric flask. The beaker was rinsed with distilled water, and the volume was made up to 1000 mL. Working solutions of 25%, 50%, 75% and 100% were prepared by serial dilution using distilled water. For 25%, 25 mL of stock was made up to 100 mL; for 50%, 50 mL to 100 mL; for 75%, 75 mL to 100 mL; and the undiluted stock served as 100%. For CLE, 100% was the undiluted stock, while 75%, 50% and 25% were prepared by diluting 25, 50 and

75 mL of undiluted CLE with 75, 50 and 25 mL of water, respectively. Each solution was mixed thoroughly, labeled, and stored until use.

Preparation of stem cuttings

Branches of current year's growth of *R. communis* were defoliated and cut into 15 cm lengths, each bearing 3–5 buds. A total of 270 cuttings were prepared. Each cutting was tied with twine and dipped into its respective rooting substance for 1 hour before planting. The upper cut ends were sealed with paraffin wax to minimize water loss from the pith [9]. Each treatment was replicated five times. Cuttings were planted in a slanting position, one cutting per polypot. Cuttings not soaked in any rooting substance served as the control.

Experimental design

The experiment was a 2 × 5 factorial laid out in a completely randomized design (CRD), involving two hormone types (CLE and IBA) and five concentrations (0%, 25%, 50%, 75% and 100%), with five replications. The setup was placed under the screen house and irrigated daily with a fine-pore watering can. Weeds were removed during irrigation, and observations were made on bud break.

Data collection

Daily observations were made during watering for resumption of metabolic activities. Stem cuttings were randomly sampled weekly to observe callus and root formation. After each sampling, callused or rooted cuttings were labeled and replanted.

Rooting performance parameters

Rooting percentage: Number of cuttings producing at least one visible root relative to total cuttings per treatment, expressed as a percentage.

Days to root initiation: Number of days from planting to first visible root emergence.

Number of roots per cutting: Adventitious roots counted manually after washing off the medium.

Root length: Length of the longest root per cutting measured with a ruler; mean calculated per treatment.

Seedling development parameters

Shoot length: Measured from the base to the tip of the main shoot.

Number of leaves per seedling: Total fully expanded leaves counted manually.

Leaf area: Determined using a leaf area meter or non-destructive estimation from leaf length and width.

Survival rate: Number of healthy living seedlings after rooting expressed as a percentage.

Data analysis

Data were subjected to analysis of variance (ANOVA), and means were separated using the Least Significant Difference (LSD) test at $P < 0.05$ with SPSS version 23. Pearson correlation and factor analysis were performed using R software.

RESULTS AND DISCUSSION

Rooting performance

The effects of hormone type and concentration on rooting of *Ricinus communis* stem cuttings are presented in Table 1.

Table 1: Main effects of concentration and hormone type on rooting of *Ricinus communis* stem cuttings

Treatment[1]	Days to root initiation (days)	Rooting (%)	Number of roots	Root length (cm)
Concentration (%)				
0	0	0	0	0
25	0	0	0	0
50	11.30	20	3.50	1.90
75	10.30	40	4.30	3.00
100	18.00	70	8.70	5.83
Hormone type				
CLE	3.60	12	1.36	0.76
IBA	12.24	40	5.24	3.53

[1]Zero indicates no rooting recorded. CLE = coconut liquid endosperm; IBA = indole-3-butyric acid.

There were significant differences ($P < 0.05$) among concentration levels for all rooting parameters measured. No rooting occurred at 0% and 25% concentrations. At 50% concentration, root initiation occurred after 11.30 days, with a rooting percentage of 20%, 3.50 roots per cutting and root length of 1.90 cm. The 75% concentration reduced root initiation time to 10.30 days and increased rooting percentage to 40%, number of roots to 4.30 and root length to 3.00 cm. The 100% concentration recorded the longest time to root initiation (18.00 days) but produced the highest rooting percentage (70%), number of roots (8.70) and root length (5.83 cm).

Hormone type also significantly influenced rooting ($P < 0.05$). Indole-3-butyric acid generally performed better than coconut liquid endosperm. IBA recorded a mean of 12.24 days to root initiation, 40% rooting, 5.24 roots per cutting and 3.53 cm root length, while CLE recorded 3.60 days, 12% rooting, 1.36 roots and 0.76 cm root length, respectively.

The interaction between hormone type and concentration was significant ($P < 0.05$) for all rooting parameters (Table 2).

Table 2: Interaction effect of hormone type and concentration on rooting of *R. communis* stem cuttings (mean ± SE)

Hormone	Concentration (%)[1]	Days to root initiation (days)	Rooting (%)	Number of roots	Root length (cm)
CLE	0	0	0	0	0
CLE	25	0	0	0	0
CLE	50	0	0	0	0
CLE	75	0	0	0	0
CLE	100	18.00 ± 0.5	60 ± 20	6.80 ± 0.4	3.82 ± 0.4
IBA	0	0	0	0	0
IBA	25	0	0	0	0
IBA	50	22.60 ± 0.4	40 ± 20	7.00 ± 0.3	3.80 ± 0.4
IBA	75	20.60 ± 0.4	80 ± 20	8.60 ± 0.5	6.00 ± 0.3
IBA	100	18.00 ± 0.3	80 ± 20	10.60 ± 0.5	7.84 ± 0.3

[1]Zero indicates no rooting recorded. CLE = coconut liquid endosperm; IBA = indole-3-butyric acid.

For CLE, no rooting occurred at 0%, 25%, 50% and 75% concentrations. Rooting occurred only at 100% concentration, with root initiation after 18.00 ± 0.5 days, rooting percentage of 60 ± 20%, 6.80 ± 0.4 roots and root length of 3.82 ± 0.4 cm. For IBA, no rooting occurred at 0% and 25% concentrations. At 50% concentration, root initiation occurred after 22.60 ± 0.4 days, with 40 ± 20% rooting, 7.00 ± 0.3 roots and 3.80 ± 0.4 cm root length. Increasing IBA concentration to 75% reduced root initiation time to 20.60 ± 0.4 days and increased rooting percentage to 80 ± 20%, number of roots to 8.60 ± 0.5 and root length to 6.00 ± 0.3 cm. The highest root number (10.60 ± 0.5) and root length (7.84 ± 0.3 cm) were recorded at 100% IBA, alongside a rooting percentage of 80 ± 20% and root initiation time of 18.00 ± 0.3 days. Overall, 100% IBA produced the best root development, while 75% and 100% IBA recorded equally high rooting percentages.

Survival rate

The survival rates of rooted cuttings under different hormone treatments are presented in Fig. 1. CLE recorded 0% survival at 0%, 25%, 50% and 75% concentrations, while 100% concentration produced

60% survival. IBA recorded 0% survival at 0% and 25% concentrations, increased to 40% at 50% concentration, and reached 80% at both 75% and 100% concentrations. Overall, IBA produced higher survival rates than CLE, with 75% and 100% IBA concentrations recording the highest survival rates.

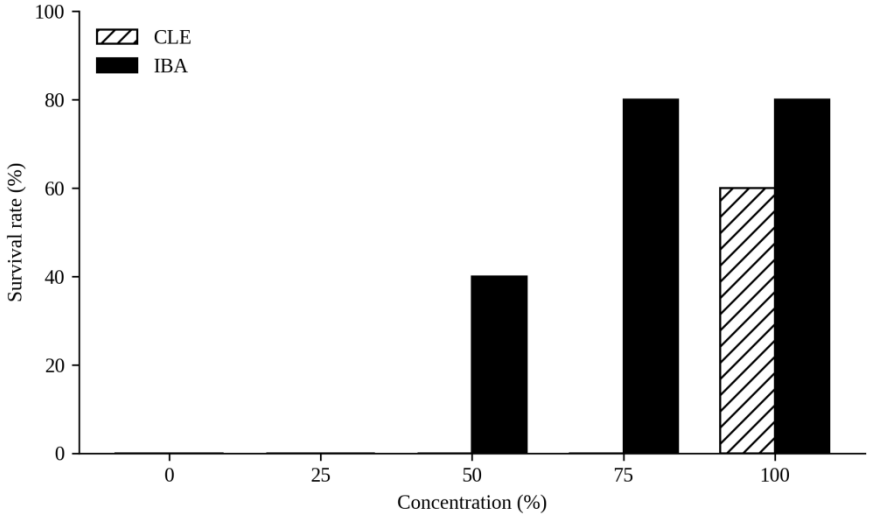


Fig. 1: Survival rate (%) of *Ricinus communis* stem cuttings treated with coconut liquid endosperm (CLE) and indole-3-butyric acid (IBA) at different concentrations

The findings demonstrated that hormone type and concentration significantly influenced adventitious root formation, root development and survival of *Ricinus communis* stem cuttings. The superior rooting performance observed with IBA compared with CLE suggests that the physiological response of *R. communis* cuttings depends on the nature and concentration of the growth-promoting substances applied. This finding agrees with da Costa et al. [5] who explained that auxins play a central role in adventitious root formation by regulating cellular differentiation, root primordium initiation and subsequent root development. IBA is particularly effective in vegetative propagation because it can provide a sustained source of auxin activity within plant tissues, thereby promoting root formation.

The absence of rooting at lower hormone concentrations suggests that the growth-regulating substances available at these levels were insufficient to stimulate adventitious root formation under the experimental conditions. According to Druge et al. [10], successful adventitious rooting depends on interactions among auxin availability, carbohydrate metabolism, physiological condition and environmental factors. Consequently, insufficient hormonal stimulation may limit the activation of cells responsible for root initiation. The improved rooting performance at higher concentrations indicates that increased availability of growth-promoting substances favoured root differentiation and elongation. However, this

response should not be interpreted as evidence that increasing hormone concentration indefinitely would improve rooting, since excessive auxin concentrations may inhibit root development.

The superior performance of IBA at higher concentrations is consistent with the findings of Pacurar et al. [6] who identified auxin signalling as an important regulatory mechanism in adventitious root development. The increased number and length of roots observed following IBA application may be associated with enhanced cell division, root primordium development and subsequent cellular elongation. Furthermore, the reduction in root initiation time with increasing IBA concentration suggests that adequate auxin availability accelerated the physiological processes required for rooting. These findings indicate that IBA provided more effective hormonal stimulation than CLE for the propagation of *R. communis* stem cuttings.

The comparatively limited effectiveness of CLE may be attributed to differences in its composition and concentration of naturally occurring growth regulators. Yong et al. [7] reported that coconut water contains several biologically active compounds, including cytokinins, auxins, minerals and other organic constituents that influence plant growth. However, their concentrations vary with coconut maturity and physiological condition. Such variability may explain why only undiluted CLE promoted rooting in the present study. Although coconut liquid endosperm possesses growth-promoting properties, its hormonal composition may not provide the same rooting stimulus as IBA.

The higher survival rates recorded under IBA treatments may be associated with improved root establishment, which enhances the capacity of cuttings to absorb water and nutrients. Hartmann et al. [11] explained that successful vegetative propagation depends largely on the development of functional root systems capable of sustaining shoot growth. Therefore, the greater root number and length observed under IBA treatments may have contributed to improved cutting survival. Nevertheless, the comparable survival rates at 75% and 100% IBA suggest that maximum survival could be achieved without necessarily applying the highest concentration.

The findings establish IBA as a more effective rooting treatment than CLE for *R. communis* stem cuttings under the experimental conditions. While 100% IBA produced the greatest root development, 75% IBA achieved an equivalent survival rate, suggesting its potential suitability for propagation where reducing treatment concentration is desirable.

CONCLUSION

The study revealed that hormone type and concentration significantly influenced rooting and survival of *Ricinus communis* stem cuttings. Indole-3-butyric acid generally performed better than coconut liquid endosperm (CLE), producing more roots, longer roots and higher survival rates. No rooting occurred at 0% and 25% concentrations for either treatment, while CLE induced rooting only at 100% concentration. The highest root number (10.60) and root length (7.84 cm) were recorded with 100% IBA. However, both 75% and 100% IBA achieved the highest survival rate of 80%. Overall, higher hormone concentrations, particularly IBA, enhanced rooting performance and cutting establishment. Coconut liquid endosperm at full concentration (100%) can serve as a natural, low-cost alternative to synthetic auxins, though with lower efficacy than IBA.

Seventy-five percent IBA is recommended for optimal rooting and survival, as it produced survival comparable to 100% IBA at a lower concentration, thereby reducing cost and potential phytotoxicity. Where synthetic hormones are expensive or unavailable, 100% CLE can be used as a readily available, environmentally friendly alternative for small-scale propagation of *R. communis*, although it may yield lower rooting percentages and root development than IBA. Further studies should explore combinations of CLE and IBA, test additional concentrations, and evaluate the effectiveness of CLE on other indigenous tree species to broaden its application in vegetative propagation.

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