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Full Length Research Paper

The rooting performance of shea (*Vitellaria paradoxa* gaertn) stem cuttings as influenced by wood type, sucrose and rooting hormone

J. Yeboah*, S. T. Lowor and F. M. Amoah

Cocoa Research Institute of Ghana, P. O. Box 8, Tafo-Akim, Ghana.

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Vegetative propagation of stem cuttings of different physiological woodtypes of *Vitellaria paradoxa* was studied in a polythene propagator. The treatments included combinations of wood type (soft, semi-hard and rejuvenated (coppiced) shoots), sucrose application at 0, 15 and 25%, and Seradix '3' powder hormone (active ingredient- indolebutyricacid) at 0 and 8000 ppm. Cuttings of rejuvenated shoots dipped in 15% sucrose solution gave significantly higher rooting and longer roots than both softwood and semi-hardwood. High levels ($P < 0.05$) of soluble sugars and total free phenols were recorded for coppiced cuttings which resulted in better rooting performance than the other wood types. Cuttings dipped in Seradix '3' powder hormone significantly recorded higher rooting than the control (no hormone).

Key words: Cuttings, rooting, rooting hormone, sucrose, *Vitellaria paradoxa* gaertn.

INTRODUCTION

The shea tree (*Vitellaria paradoxa* Gaertn) is indigenous to the savanna zone of Ghana and stretches from Senegal to Sudan in the Guinea savanna belt (Burkill, 1985). Edible fruits produced by the tree are eaten throughout the Guinea Savanna, especially during the lean season (Irvine, 1961) and nuts from which the marketable product, shea butter is extracted. Globally, the butter is used in the cosmetic, pharmaceutical and confectionery industries (Hall et al., 1996), while locally, it is used as cooking oil, body cream, and fuel in rural lamps and in medical preparations. The shea tree grows in the wild despite its importance in the life of the people of the savannah zone and has remained largely undomesticated due to its long gestation period of 12 - 15 years. The shea tree has low genetic and physiological capacity for adventitious root formation, which limit its commercial production. The current focus of research on the shea tree in Ghana has been the development of effective propagation methods to facilitate the rapid multiplication of shea trees for plantation establishment. However, this development has been hampered by the tree's slow growth and long juvenile phase (Yidana, 1994). Work done by Opoku-Ameyaw et al. (2000) using different wood type of shea stem cuttings treated with hormones and setting in different media showed that rooting is variable and inconsistent.

Many advantages, including rapid dissemination of selected clones and retaining the heterotic nature of bred seedlings without fear of segregation are derived from vegetative propagation (Nanda and Tandon, 1967).

Stem cuttings, based on the physiological age of the tree from which they are taken are known to have different rooting potentials. Root initiation and shoot development in stem cuttings are also influenced by internal factors such as carbohydrates, nitrogen levels, rooting cofactors and auxins in the rooting stock (Hartmann et al., 1997).

This paper reports on studies conducted at the Cocoa Research Institute of Ghana's substation, Bole, in Northern Ghana to develop a suitable vegetative propagation technique that will facilitate the rooting of cuttings for the establishment of shea tree plantations.

MATERIALS AND METHODS

The experiment was carried out in June 2004 at the CRIG substation at Bole, 9^0 01'N, 2^0.29'W, 309m above sea level. Wood types of the shea tree were harvested and set up to give a 3 x 3 x 2 factorial

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*Corresponding author. E-mail: juliusyeboah@ymail.com.

Table 1. Effects of wood type on rooting performance of shea stem cuttings in a polythene propagator set under a shading net in Ghana.

Wood type	% of cuttings alive after 120 days			Number of roots per cutting	Average root length (cm)
	Dormant Cuttings	Callused cuttings	Rooted cuttings		
Softwood	20 (26.1)	30 (28.9)	20 (25.7)	3	5.0
Semi-hardwood	20 (25.8)	10 (11.1)	10 (16.7)	2	2.5
Coppiced shoots	30 (32.6)	20 (23.6)	40 (38.6)	5	8.5
LSD (P=0.05)	(14.6)	(13.7)	(10.7)	3.5	0.7

Figures in parenthesis are angular transformed.

Table 2. Influence of sucrose levels on the rooting performance of shea cuttings.

Sucrose treatment	% of cuttings alive after 120 days			Number of roots per cutting	Average root length (cm)
	Dormant Cuttings	Callused cuttings	Rooted cuttings		
0% (distilled water)	50 (45.1)	40 (35.7)	10 (15.0)	2	3.5
15%	45 (40.9)	30 (24.7)	30 (31.3)	4	6.1
25%	40 (36.7)	30 (31.5)	20 (26.1)	2	3.7
LSD (P=0.05)	(12.5)	(13.6)	(10.5)	1.0	0.7

Figures in parenthesis are angular transformed.

design with 20 cuttings per treatment and replicated three times. The factors investigated were the wood type (softwood, semi-hardwood and coppiced shoots) of mean length 23.0cm and mean diameter of 0.7cm, sucrose concentration (control-water, 15% and 25%) and hormone application (control and 8000ppm Seradix 3 powder). A total of 360 cuttings (made up of softwood-120, semi-hardwood-120 and rejuvenated shoots-120) were used for one replicate the experiment. Each wood type was divided into three sets of 40 cuttings. One set of 40 cuttings was either dipped in distilled water, 15% or 25% sucrose solution. Half of the dipped cuttings (20) from each wood type was set in a polythene propagator without any hormone treatment while the other half (20 cuttings) was dipped in Seradix 3 powder for five minutes and allowed to dry for one minute before setting them in the same polythene propagator for observation. Watering was done regularly as required. Fallen and infected leaves as well as dead cuttings were removed daily to avoid the spread of diseases. The experiment was carried out in a polythene propagator constructed under a black shade net (that provides 50% shade) with an average daily minimum and maximum temperature of 25.0 and 30.5°C respectively and humidity of 88%. The rooted cuttings were gently removed from the medium (rice husk) at the end of 120 days. The parameters studied were: number of cuttings alive (rooted, callused and dormant), number of roots per cutting and root length per using a ruler. Samples of the harvested wood types dipped in different sucrose levels (0, 15 and 25%) were analysed for soluble and insoluble sugars following the procedure of Dubois et al. (1956). Total free phenols were assayed using Folin-Ciocalteu reagent following the procedure reported by Swain and Hills (1959).

Statistical analysis

Angular transformed data from three replications of all treatments and interactions were subjected to analysis of variance using Genstat 5 release (3.2). For all statistical analysis, $P \leq 0.05$ was considered statistically significant.

RESULTS AND DISCUSSIONS

The number of dormant cuttings and number of roots developed per cutting were not significantly influenced ($P > 0.05$) by wood type (Table 1).

Softwood cuttings significantly developed more callus than the semi-hard wood type. Coppiced cuttings had significantly more ($P < 0.05$) rooted cuttings and longer roots compared to the semi-hard and softwood types. This could be due to the juvenility of the coppiced cuttings, which are in their initial period of active growth and have high levels of auxins to enhance rooting as reported by Hartmann et al. (1997). Chevalier (1948) observed that improved rooting on coppiced cuttings of shea may be related to high levels of assimilates.

No significant differences were observed for dormant and callused cuttings in the sucrose treatment (Table 2), but cuttings dipped in 15% sucrose solution recorded significantly higher rooting, more roots and longer roots than both the control and 25% sucrose treatment.

This supports earlier work by Wiegel et al. (1984) that carbohydrate helps in auxin transport as well as growth of shoots and roots. Pallardy and Kozlowski (2007) also observed that cuttings dipped in sucrose solution often improved rooting response by increasing the carbohydrate level and facilitating growth. However, high levels of sugar

Table 3. Effect of hormone application on rooting performance of shea cuttings.

Auxin treatment	% of cuttings alive after 120 days			Number of roots per cutting	Average root length (cm)
	Dormant Cuttings	Callused cuttings	Rooted cuttings		
Control	30 (28.9)	20 (21.7)	10 (18.4)	1	3.2
Seradix 3 powder	25 (24.8)	20 (18.4)	40 (32.7)	4	7.7
LSD (*P*=0.05)	(10.8)	(9.7)	(10.5)	1.0	0.7

Figures in parenthesis are angular transformed.

Table 4. Interaction effects of wood type (WT), hormone application (HA) and sucrose concentration (SC) on rooting of shea stem cuttings.

Treatments (WT x HA x SC)	% of cuttings alive after 120 days			No. of roots per cutting	Ave. root length (cm)
	Dormant cuttings	Callused cuttings	Rooted cuttings		
S. wd water only	25 (24.8)	20 (21.8)	20 (24.9)	1	6.0
S. wd x Ctrl x 15% SC	30 (32.5)	50 (45.9)	10 (15.3)	2	11.0
S. wd x Ctrl x 25% SC	20 (19.9)	40 (39.1)	10 (11.1)	1	0.5
S. wd x S3P x Ctrl	20 (21.5)	0 (0.0)	10 (16.7)	4	1.8
S. wd x S3P x 15% SC	20 26.1)	0 (0.0)	20 (21.5)	7	5.7
S. wd x S3P x 25% SC	20 (26.6)	0 (0.0)	40 (38.6)	2	5.2
Shwd water only	10 (15.0)	30 (33.0)	0 (0.0)	0	0.0
Shwd x Ctrl x 15% SC	20 (18.1)	10 (18.4)	0 (0.0)	0	0.0
Shwd x Ctrl x 25% SC	30 (33.0)	0 (0.0)	0 (0.0)	0	0.0
Shwd x S3P x Ctrl	20 (25.2)	70 (61.8)	0 (0.0)	0	0.0
Shwd x S3P x 15% SC	20 (26.1)	40 (35.8)	40 (39.2)	5	5.9
Shwd x S3P x 25% SC	20 (25.9)	50 (42.5)	30 (26.9)	4	6.7
Cshts water only	20 (26.8)	70 (57.9)	20 (18.5)	5	6.1
Cshts x Ctrl x 15% SC	25 (24.9)	50 (44.9)	10 (11.9)	3	2.4
Cshts x Ctrl x 25% SC	20 (24.7)	10 (9.4)	10 (12.9)	4	7.8
Cshts x S3P x Ctrl	20 (21.5)	30 (28.5)	30 (24.8)	5	8.4
Cshts x S3P x 15% SC	25 (26.9)	60 (56.0)	70 (55.7)	8	12.5
Cshts x S3P x 25% SC	20 (25.6)	60 (54.1)	50 (46.4)	6	10.6
LSD (*P*=0.05)	(13.6)	(12.32)	(11.56)	1.6	1.2

Figures in parenthesis are angular transformed.
S3P – seradix 3 powder; Cshts – coppiced shoots; Swd- soft wood; Shwd – semi-hard wood.

affect rooting by reducing the levels of nitrogen, which is essential in the rooting process (Hartmann et al., 1997).

Applying Seradix 3 powder did not significantly influence the number of dormant and callused cuttings but significantly enhanced the number of rooted cuttings; number of roots developed and root length compared to the control (Table 3).

The production of adventitious roots in plants is controlled by growth substances (Davis and Hassig, 1990) and auxins play a key role in this process. Auxin treatment enhances the movement of boron (B), nitrogen (N), Zinc (Zn) and potassium (K) from the leaves and buds of the cuttings to the rooting zone (Blazich et al., 1983). Jarvis et al. (1984) also explained that the nutrients B, N, K, and Zn sustain cell division, auxin biosynthesis and organization leading to root initiation and growth.

Significant interaction was observed for the treatments (Table 4) (except dormant cuttings) with coppiced cuttings dipped in 15% sucrose solution and treated with Seradix 3 powder recorded significantly ($P < 0.05$) higher rooting, developed more and longer roots than the other wood types. This may be due to the high level of assimilates in the coppiced cuttings as observed by Hartmann et al. (1997) and an increase in the carbohydrate levels from the sucrose and auxin treatment which enhanced rooting through cell division (Blazich et al., 1983; Wiegel et al., 1984; Hartmann et al., 1997).

Coppiced cuttings significantly recorded high levels of insoluble sugars compared to the soft and semi-hard-wood cuttings (Table 5). The total free phenols in the

Table 5. Levels of soluble, insoluble, total sugars (mg/g) and total free phenols (µg/g) in wood type and cuttings dipped in various sucrose concentrations.

Treatments	Sugars mg/g			Total free phenols (ug/g)
	Soluble	Insoluble	Total	
WOOD TYPE				
Softwood	8.2	15.8	24.0	92.6
Semi-hardwood	7.6	16.3	23.9	72.8
Coppiced (rejuvenated) shoots	10.0	30.6	40.6	110.2
LSD (P=0.05)	2.0	2.6	5.9	23.1
SUCROSE CONCENTRATION				
Control (distilled water)	2.8	7.3	10.1	110.5
15%	8.6	15.0	23.6	105.6
25%	8.0	15.9	23.9	89.4
LSD (P=0.05)	2.9	2.2	3.4	19.2

Table 6. Levels of soluble, insoluble and total sugars and total free phenols in wood type dipped in various sucrose levels.

Wood type x sucrose levels	Sugars mg/g			Total free phenols (µg/g)
	Soluble	Insoluble	Total	
Softwood x water	7.5	7.9	15.4	90.7
Softwood x 15%	5.4	8.6	14.0	80.4
Softwood x 25%	6.5	9.1	15.6	78.3
Semi-hardwood x water	6.8	5.5	12.3	76.4
Semi-hardwood x 15%	4.6	6.4	11.0	65.4
Semi-hardwood x 25%	5.1	7.8	12.8	63.5
Coppiced x water	8.9	13.8	22.7	121.0
Coppiced x 15%	16.6	20.8	37.4	108.6
Coppiced x 25%	15.8	21.7	37.5	98.5
Interaction LSD (P=0.05)	3.4	11.7	15.6	28.9

coppiced shoots were however not different from that of the softwood, but significantly higher than the semi-hardwood. High level of soluble sugars were observed for cuttings dipped in 15% sucrose solution while the cuttings dipped in 25% sucrose gave high level of insoluble sugars. The phenol levels for cuttings dipped in 15 and 25% sucrose were not significantly different.

Application of 15 and 25% sucrose solutions to the coppiced cuttings significantly gave high levels of soluble and insoluble sugars than the other wood types but did not differ from each other (Table 6). This resulted in a better rooting performance of coppiced materials (Table 2) dipped in 15 and 25% sucrose solution than those without sucrose. Also, the wood types dipped in different sucrose levels significantly gave lower phenol levels compared to the control. The phenols play a very important role by modifying Indoleaceticacid (IAA) activity, liberating endogenous auxins and forming covalently bonded auxinphenol conjugates which enhance root formation (Hackett, 1970; Jarvis and Shaheed, 1986; Coll et al., 2002).

The various wood types dipped in water gave higher levels of total free phenols than those dipped in sucrose giving an indication of the interruption of the phenols by the sucrose. Statistically, however, those increases in phenols content over sucrose treatments were not significant. Coppiced cuttings dipped in water significantly gave the highest phenol level than the other wood types.

Conclusion

Coppiced cuttings rooted better than the semi-hard and soft wood types and could be selected over the other wood types in combination with Seradix 3 powder hormone and 15% sucrose application for vegetative propagation of shea cuttings in Ghana.

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REFERENCES

Blazich FA, Wright RD, Schauffer HE (1983). Mineral nutrition status of "Convexa" holly cuttings during intermittent mist propagation as influenced by exogenous auxin application. J. Amer. Soc. Hort. Sci. 109: 350-355.

Burkill HM (1985). The useful plants of West Tropical Africa. Royal Botanic Gardens; 2nd Revised edition.

Chevalier A (1948). Norvelles recherchers sur L'arbre àa beure du Sondan. Revue internationale de Botanique Appliquée et al Aagriculture Tropicale 28: 242-256.

Coll JB, Rodrigo GN, Garcia BS, Tames RS (2002). Acido abscisicoytros inhibidores. In : Coll JB, Rodrigo GN, Garcia BS, Tames RS (eds) *Fisiologia vegetal* Madrid: Piramide pp. 369-379.

Davis TD, Hassig BE (1990). Chemical control of adventitious root formation in cuttings. Bull. of Plant Growth Regul. of Soc. Amer. 18 : 1-17.

Dubois M, Gilles KA, Hamilton JK, Rebers PA, Smith F (1956). Colorimetric method for determination of sugars and related substances. Anal. Chem. 28 : 350-356.

Hartmann HT, Kester DE, Davies FT, Geneve RL (1997). Plant propagation principles and practices. Prentice Hall Eng. Cliffs, New Jersey 07632 pp. 276-391.

Irvine FR (1961). Woody plants of Ghana with special reference to their uses. Oxford University Press. London p. 868.

Jarvis BC, Shaheed AI (1986). Adventitious root formation in relation to the uptake and distribution of supplied auxin. New Phytologist. 103 (1): 23-31.

Hackett WP (1970). The influence of auxins, catechol and methanoic tissue extracts on root initiation in asceptically cultured shoot apices of the juvenile and adult forms of *Hedera helix.* J. Amer. Soc. Hort. Sci. 95 (4): 398-402.

Hall JB, Aebischer DP, Tomlinson, HF, Osei-Amaning, Hindle JR. (1996). *Vitellaria paradoxa,* a Monograph. School of Agricultural and Forest Sciences, University of Bangor. UK. pp. 105.

Jarvis BC, Yasmin S, Ali AHN, Hunt, R (1984). The interaction between auxin and boron in adventitious root development. The New Physiologist. 97 (2): 197-201.

Nanda KK, Tandon R (1967). Mechanism of auxin action rooting of cuttings. Proc. Inter. Symp. Plant Growth substances. Calcutta University, Cuculta pp. 250.

Opoku-Ameyaw K, Amoah FM, Yeboah J. (2000). Studies into the Vegetative Propagation on the sheanut tree. J. Ghana Sci. Assoc. 4 (2): 138-145.

Pallardy SG, Kozlowski TT (2007). Physiology of Woody plants. 3rd Ed. Academic Press, New York. p. 454.

Swain T, Hills WE (1959). The phenolic constituents of *Prunus domestica.* I. The Quantitative Analysis of Phenolic Constituents. J. Sci. Food Agric. 10: 63-68.

Wiegel K, Horn H, Hock B (1984). Endogenous auxin levels in terminal stem cuttings of *Chrysanthemum morifoluim* during adventitious rooting. Physiologia. Plantarum. 61 (3): 422-428.

Yidana, JA (1994). Studies in the shea tree. Reports, Cocoa Research Institute of Ghana. p. 10.