Vegetative Propagation of *Balanites aegyptiaca* (L.) Del

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SUMMARY

Balanites aegyptiaca is a promising economic plant for both the arid and semi-arid regions of tropical Africa, the Middle East and India. Two experiments were carried out in a heated glasshouse at the University of Wales, Bangor, to evaluate the effects of stock plant and source position on the capacity of cuttings of *B. aegyptiaca* to strike. Scope for clonal propagation by rooting stem cuttings under mist conditions was demonstrated. Stem cuttings taken from different positions on the stock plant did not differ significantly in rooting percentage, but cuttings from distal positions gave better quality rooting than those from medial and basal sources. Treatment with a range of Indole-3-Butyric Acid (IBA) concentrations did not improve the incidence of rooting or the quality of rooting.

RÉSUMÉ

Balanites aegyptiaca est une plante qui a beaucoup de possibilités économiques pour les régions arides et semi-arides de l'Afrique tropicale, du Moyen-Orient et de l'Inde. On a réalisé deux expériences dans une serre chaude à l'Université du Pays de Galles, à Bangor, afin d'évaluer les effets de la plante-mère et de la position de la source sur la capacité de prendre racine des boutures de *Balanites aegyptiaca*. On a démontré la possibilité de réaliser la propagation clonale en enracinant des boutures de tige sous des conditions de brumisation. Il n'y avait pas de différence importante de pourcentage d'enracinement entre les boutures de tige prélevées sur différentes positions sur la plante-mère, mais les boutures prélevées sur des positions distales offraient une meilleure qualité d'enracinement que celles prélevées sur des sources médianes ou basales. Le traitement avec de différentes concentrations d'acide-indole-3-butyrique (AIB) n'a amélioré ni la fréquence ni la qualité d'enracinement.

RESUMEN

Balanites aegyptiaca es una planta con un prometedor valor económico en las regiones áridas y semi-áridas de Africa tropical, Oriente Medio y la India. En la Universidad de Gales, Bangor, se han llevado a cabo, en un invernadero con calefacción, dos ensayos para evaluar la capacidad de enraizamiento de esquejes de *B. aegyptiaca* provenientes de distintas zonas del tallo y de diferentes plantas madres. Se ha demostrado la capacidad de propagación vegetativa de esquejes del tallo en condiciones de neblina. Esquejes cortados de distintas posiciones no diferían significativamente en cuanto al porcentaje do enraizamiento, aunque los esquejes de posiciones apicales mostraron una calidad de enraizamiento superior a la de los que se cortaron de posiciones medias o basales. El tratamiento con distintas concentraciones de ácido 3-indol-butírico no mejoraba el porcentaje ni la calidad de enraizamiento.

INTRODUCTION

Balanites aegyptiaca (L.) Del. (Balanitaceae) is a tough, drought-resistant multipurpose tree species ideally suited to the land-masses of northern tropical Africa, the Middle East and India, which have suffered extensive loss of germplasm (Ladipo, 1989). As a multipurpose tree *B. aegyptiaca* offers food, medicinal products and fuel-wood valued for subsistence living in arid and semi-arid areas where other options are few. The potential of *B. aegyptiaca* under management remains unexplored and it is a priority to construct a picture of variation within the natural range and to generate the capacity to raise plants with desirable features.

The tree naturally regenerates by seed, root suckering and coppicing (Maydell, 1986). Air-layering has been successful with a very closely related Indian species *B. roxburghii* (recently regarded for a time as conspecific with *B. aegyptiaca*) but this technique is expensive, time consuming and limited in productivity compared with the rooting of stem cuttings.

The efforts described in this report to propagate *B. aegyptiaca* vegetatively are a contribution towards meeting immediate needs. Two experiments were carried out – the first examining the potential of stem cuttings to root and the second to look at variation in rooting between cuttings from three positions (basal, medial and distal) on a *B. aegyptiaca* stock plant.

MATERIALS AND METHODS

Stock plant preparation and tending

Stock plants of two age groups (14 months and 23 months) had been grown in a glasshouse at the Treborth Botanical Garden of the University of Wales, Bangor (UWB). The original seed source was wild trees at Kitui (1° 22'S, 38° 01'E; 1090 m), Kenya. The older stock plants were raised from seeds pretreated by soaking in warm water (30°C) and subsequently incubated for 8 days in a growth cabinet under a cycle of 30°C (12 hours light) and 20°C (12 hours dark). Germinated seedlings were transferred to pots containing a 2:1 (by volume) vermiculite, Levington Multipurpose Compost, and grown-on in a heated glasshouse in a temperature regime of 30°C day and 20°C night. After two months the plants were re-potted into John Innes No. 1 Compost. By the time the younger stock plants were raised,

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procedures had been refined: the growth cabinet phase was reduced to 7 days during which light period temperature was maintained at 28°C. After germination, transfer was directly to John Innes No. 1 Compost.

A liquid fertilizer was applied weekly to all stock plants (elemental concentration g l^{-1}: 0.26 N, 0.11 P, 0.22 K plus trace elements – boron, copper, iron, magnesium, manganese, molybdenum and zinc). For a month prior to the taking of cuttings a higher nitrogen feed was given (g l^{-1}: 0.33 N, 0.09 P, 0.16 K plus trace elements as above). The fertilizer solutions were administered as required to restore field capacity in the pots.

The growth model of *B. aegyptiaca* follows that of Champagnat (Hallé *et al*). More familiar temperate examples of this model are roses, brambles and elder (*Sambucus nigra*). A trunk is eventually formed by superposition of renewal shoots which are generated by lateral buds after the apical shoot bends and becomes pendulous under its own weight. In the first few years many renewal shoots arise from the basal region forming a multi-stemmed bush. It was in this condition that the stock plants were used.

Five younger stock plants (C1–C5) and one older stock plant (C6) were selected for Experiment 1 (potential of stem cuttings to root). Another older stock plant (C7) was used for Experiment 2 (significance of within-shoot position of cuttings).

The experimental environment

The experiments were carried out at the UWB Pen-y-Ffridd Field Station and commenced on 12 May, 1989. Two mist propagation benches enclosed in a polythene tent were used for the experiments. Misting was controlled by the electronic leaf method (Hartmann and Kester, 1983). Bottom heat was provided by thermostatically controlled warming cables situated in the bench sand. The rate of misting was set to ensure a film of water was maintained on the leaves. Bench temperature was monitored by a thermocouple having its sensor element inserted into the rooting medium and connected to a chart recorder. Compartmented trays filled with the rooting medium (1:1 moss peat and perlite mixture) were left on the mist benches for one and a half weeks to stabilize. At the start of the experiments the bases of the trays were sunk 3cm deep into the mist benches. The temperature in the rooting medium ranged from 31°C to 37°C with the latter frequently attained during hot sunny weather. A minimum night temperature of the mist unit was maintained at 22°C. Day temperatures, however, were difficult to control and ranged from 22°C to 39°C. Ventilation was provided automatically on the numerous hot days experienced during the course of the experiments. There was no supplementary lighting: the experiments relied on natural day length (about 16 hours).

Experimental design

A two-factor randomized design with three blocks was adopted for each experiment. The randomized block design was based on replicates of clones × treatment combinations. Individual cuttings were allocated to 4.5cm × 4cm compartments in plastic trays (5cm deep) in each experiment.

Experiment 1 – potential of stem cuttings to root

Comparisons were made between material from six ortets (seed derived mother plants) subjected to five different hormone treatments (including a control). One hundred and fifty cuttings were incorporated in each of three replicate blocks. Within each block there was complete randomization of five replicate cuttings of each clone × hormone treatment combination.

Provision was made for reserve replicate cuttings (under every clone × treatment combination) so that the progress of rooting could be monitored without disturbing the experiment.

Experiment 2 – significance of within-shoot position of cuttings

Comparisons were made between material derived from a single 24-month-old stock plant and referable to three shoot positions (basal, medial, distal). Cuttings from each position were subjected to five different hormone treatments (including a control). Seventy-five cuttings were incorporated in each of three replicate blocks. Within each block there was complete randomization of five replicates (cuttings) of each source-position × hormone treatment combination.

Experimental procedure

Preparation of cuttings: Undesirable variability in the material used for the experiments was minimized by use of stock plants which were comparable in terms of vigour, size, health and node number.

Leafy cuttings of four node lengths (or minimum of 7cm) were taken at 9.00 a.m. on 12 May, 1989. The cuttings were immediately stored in clean polythene bags and water sprinkled on them. The polythene bags were then stored briefly on a cold shaded cement floor pending transfer to the mist tent where they were treated with a hormone.

In Experiment 1 cuttings were collected from all over each of the six ortets in turn. Cuttings in Experiment 2 were collected at three positions; basal, medial and distal end along plagiotropic and orthotropic shoots. The total length of each primary orthotropic shoot was measured and divided by three to get the three positions. Cuttings were then collected from each of the sections accordingly. The number of cuttings from various sections of shoots were dependent on the number of four node cuttings (> 7cm) available.

Hormone application and cutting insertion: Hormone treatments were applied by immersing the proximal 2–3cm of each cutting for 5 seconds in the appropriate solution. The solutions were:

1. Control (50% industrial methylated spirit (IMS) in water).
2. 0.5% IBA in 50% IMS.
3. 1.0% IBA in 50% IMS.
4. 1.5% IBA in 50% IMS.
5. 2.0% IBA in 50% IMS.

Immediately following the hormone treatment cuttings were inserted at 2cm depth into the rooting medium and firmed to position.

Final assessment: After four weeks cuttings were assessed for rooting and rooting quality. For the latter, a score on a six point scale was assigned:

0 cutting did not root at all; no shoot growth
1 at least one root was formed; no shoot growth
2 more than one root was formed; detectable but minimal shoot growth
3 fair rooting; fair shoot growth
4 better rooting but more vigorous root growth than shoot growth or vice versa
5 excellent rooting and shoot growth; both shoot and root growth vigorous.

Data for incidence of rooting and root quality were subjected to analysis of variance, angular transformation first being applied to percentage figures. Significant differences were examined at 95% confidence interval. The Tukey Pairwise Test (Alder and Roessler, 1977) was used to determine which pairs of treatments, clones or positions were significantly different.

RESULTS

General

Cuttings rooted profusely under mist conditions but were not enhanced by the range of IBA treatments given. Periodic examination of reserve cuttings indicated rooting commenced after one week. The total incidence of rooting was 70% (Table 1) and 47% (Table 2) for Experiments 1 and 2 respectively. Roots were observed in most cases to develop as finger-like outgrowths from within 2 to 3cm of the basal ends of the stem cuttings.

Experiment 1 – potential of stem cuttings to root

Incidence of rooting: There was no significant difference between treatments with respect to incidence of rooting although a significant difference arose between clones as is commonly observed with other woody species (Table 5). On the basis of Tukey's test, the only significant difference occurred between the older clone (C6) and two younger clones (C1 and C5).

Rooting quality: There were no significant differences between treatments or clones with respect to rooting quality (Table 3 and Table 5).

Experiment 2 – significance of within-shoot position of cuttings

Incidence of rooting: There were no significant differences in the incidence of rooting associated with source positions or treatments (Table 2 and Table 6).

Rooting quality: A significant difference in rooting quality occurred between stem cuttings from difference positions (Table 4). Tukey's test indicated that rooting quality was superior in the distal cuttings compared with those from the more proximal positions (Table 6).

DISCUSSION

The experiments revealed that stem cuttings of *Balanites aegyptiaca* are capable of profuse rooting. This is in agreement with that found in Nigeria by Ladipo (1989) but contrasts with total failure in India by Amalraj (1987), and a maximum of 35% rooting in Mali by Gosseye (1980). The conditions under which the cuttings were placed by Amalraj (*op. cit.*) were not reported, and so a comparison with the findings of this study and Ladipo (*op. cit.*) cannot be made. Gosseye (*op. cit.*) carried out cuttings experiments under relatively harsh nursery conditions, i.e. no shading and no atmospheric humidity control – only regular watering.

The overall percentages in rooting for the two experiments differed markedly. The results imply a correlation between the age of a stock plant and the ability to root. The older clone (C6) of Experiment 1 gave an average of 49% rooting of stem cuttings (Table 1). This value was close to the 47% overall results obtained for the clone C7 of the same age used in Experiment 2. In contrast, the lowest mean result obtained from Experiment 1 for the younger stock plants (C1–C5) was 68% rooting of stem cuttings. More formal comparison of stock plants of different ages is clearly desirable.

On completion of the experiments it was evident that cutting diameter was related to root formation. A subjective impression was that the greater the stem cutting diameter the lower its potential to root. The cuttings with the most profuse rooting were generally those only about 2mm diameter – the smallest used. Most of the cuttings that did not root or even showed signs of rotting at their proximal ends were greater than 12mm diameter. For most woody species considered for forestry purposes, greater stem diameter would normally imply increased age of cutting. The growth model of *B. aegyptiaca* is such that this is not always the case, and the youngest material arising vigorously from the base of the plant can be 12mm or more thick. It is, therefore, not possible to say whether or not the observation of better rooting from smaller diameter cutting material is related to age.

The conditions under which the stock plants were grown, the cuttings were taken and the cuttings were rooted, were those known to favour rooting. High temperatures and humidity are essential for rooting in many tropical plants. *Balanites aegyptiaca* is evidently no exception. The low light intensity (relative to the tropics) under which stock plants were raised also could have enhanced rooting of stem cuttings (Leakey, 1985). This possibly explains why the stock plants grown in high light intensity used by Amalraj (1987) did not furnish cuttings which rooted. Similarly, Gosseye (*op. cit.*) apparently used material from unshaded trees.

The restriction of root growth on stock plants has been shown to enhance rooting of cuttings (Hartmann and Kester, 1983). The younger stock plants used in this study were raised in smaller pots in comparison to those used for the older stock plants. There was likely to be more root restriction in the smaller pots, a possible contributing factor to the difference in the rate of rooting between the two.

There were no significant differences between the controls and any of the IBA treatments. These results contrasted with those of Ladipo (1989). The reserve cuttings given no direct pretreatment rooted well. This confirms Ladipo's (1989) view that stem cuttings of this species can root with up to 60% success without any treatment with root promoting hormones.

The clone C7 used in Experiment 2 had vigorous shoots, branches and branchlets most of which exceeded the stem diameter range indirectly suggested by this study for optimal rooting. Accordingly, it is not surprising that cuttings from the distal source did better than those from

TABLE 1. *The effect of IBA concentrations on the percentage incidence of rooting of* Balanites aegyptiaca *stem cuttings*

Clone no./ Treatment	C1	C2	C3	C4	C5	C6	Mean
No IBA (control)	93	67	80	73	53	47	69
0.5% IBA	73	67	73	60	93	47	69
1.0% IBA	73	100	47	60	87	60	71
1.5% IBA	67	87	67	87	67	53	71
2.0% IBA	80	60	73	87	80	40	70
Mean	77	76	68	73	76	49	70

TABLE 2. *The effect of source of cutting and IBA concentration on the percentage incidence of rooting of* Balanites aegyptiaca *stem cuttings (clone C7).*

Stem position/ Treatment	Basal	Medial	Distal	Mean
No IBA (control)	40	47	67	51
0.5% IBA	40	47	67	51
1.0% IBA	40	33	60	44
1.5% IBA	33	53	33	40
2.0% IBA	33	53	60	46
Mean	37	47	57	47

TABLE 3. *The effect of IBA concentrations on the quality of rooting of* Balanites aegyptiaca *stem cuttings.*

Clone no./ Treatment	C1	C2	C3	C4	C5	C6	Mean
No IBA (control)	2	2	2	2	2	1	2
0.5% IBA	2	2	2	2	2	1	1
1.0% IBA	2	3	1	1	2	2	2
1.5% IBA	2	2	2	2	1	2	2
2.0% IBA	2	2	2	2	2	1	2
Mean	2	2	2	2	2	2	2

TABLE 4. *The effect of source of cutting and IBA concentration on the quality of rooting of* Balanites aegyptiaca *stem cuttings (clone 7).*

Stem position/ Treatment	Basal	Medial	Distal	Mean
No IBA (control)	1	1	2	1
0.5% IBA	1	1	2	2
1.0% IBA	1	1	2	1
1.5% IBA	0	1	1	1
2.0% IBA	1	1	2	1
Mean	1	1	2	1

Key to Rooting Quality Values in Tables 3 & 4.
0 cutting did not root at all; no shoot growth
1 at least one root was formed; no shoot growth
2 more than one root was formed; detectable but minimal shoot growth
3 fair rooting; fair shoot growth
4 better rooting but more vigorous root growth than shoot growth or vice versa
5 excellent rooting and shoot growth; both shoot and root growth vigorous.

TABLE 5. *The effect of clones and IBA treatment on incidence of rooting and rooting quality (Tukey's test).*

Source	DF	Incidence of Rooting		Rooting Quality	
		F	P	F	P
C3 (Blocks)	2	2.25	ns	0.98	ns
C1 (Treatments)	4	0.02	ns	0.93	ns
C2 (Clones)	5	3.07	**	1.07	ns
C1 * C2	20	1.28	ns	0.75	ns
Error	58				
Total	89				

ns, not significant; **, $p < 0.05$

TABLE 6. *The effect of position and IBA treatment on incidence of rooting and rooting quality (Tukey's test).*

Source	DF	Incidence of Rooting		Rooting Quality	
		F	P	F	P
C3 (Blocks)	2	2.50	ns	1.42	ns
C1 (Treatments)	4	0.42	ns	0.80	ns
C2 (Positions)	2	2.54	ns	7.83	**
C1 * C2	8	0.57	ns	0.64	ns
Error	28				
Total	44				

ns, not significant; **, $p < 0.05$

the medial and basal sources. It is, therefore, concluded that cuttings from distal sources will give better rooting success and rooting quality.

In both experiments the analysis of variance showed no significant differences as regards the interactions between treatments and clones; treatment and positions or experimental blocks. The latter was evidence that the environmental conditions were uniform.

The rooting ability of stem cuttings provides the means by which *Balanites aegyptiaca* can be genetically improved and thus its full potential realized. This is another step forward in the race to reduce pressure on the natural forest resources of arid and semi-arid zones, by providing subsistence and urban communities with a broad spectrum multipurpose tree.

ACKNOWLEDGEMENTS

Much appreciation is accorded the Cameroon Government for sponsoring James Mbah to pursue the M.Sc. Rural Resource Management Course under whose umbrella this study was carried out. Beyond this the work was funded by a grant from the Overseas Development Administration held jointly by the School of Agricultural and Forest Sciences and the Centre for Arid Zone Studies at the University of Wales, Bangor, in collaboration with the University of Maiduguri, Nigeria. The project title is 'A Comparative Study in Africa of Agroforestry Trees on Vertisolic Soils Under Low Rainfall (R4181C)'.

Our thanks go to Dr. J. B. Hall who read and commented on a draft of this paper and gave advice on *B. aegyptiaca*.

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