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Agroforestry Potential of *Dacryodes edulis* (G. Don) HJ Lam: A Tool for Agro Industry Innovation in South West Nigeria

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Abstract

Dacroydes edulis (G. Don) HJ Lam is a multipurpose tree that provides a dual function of strengthening food security and carbon sequestration in rural environments. The aim of the study was to investigate the agroforestry potential of *D. edulis* in south western Nigeria and the objective was to access the phytosociology and determine the vegetative propagation strength of *D. edulis* with the view to provide baseline information of its suitability for multi species agroforestry innovation and improve the sustainability of human livelihood in Nigeria.

This study was carried out in the Akinyele and North West local government areas in Ibadan. An extensive field survey was carried out in the study areas, all compound farms, home gardens and forests were visited in the area.

The data were collected on *D. edulis* by enumerating all the species and by identifying and enumerating the plant species associated with the subject tree (*D. edulis).* Statistical analysis was done using percentages and charts. For the propagation study, two growth hormones, Indole-3-Butyric Acid (IBA) and Gibberellic Acid (GA), were administered at three concentration levels (0 ppm, 1000 ppm, and 2000 ppm), to marcots positioned at three crown levels (upper, middle and lower) on five matured trees. The effects of hormonal treatment and marcotting position on rooting were monitored. The variables assessed include root number, root length, root collar diameter and root biomass. Data collected were analyzed using descriptive and inferential statistics at $p<0.05$ level of significance.

Results show that a total of 66 plant species were found associated with *D. edulis*, the species were of different structures and classes ranging from woody tree, shrub, climbers and herb species belonging to 40 families were encountered in the study area. Many of the species are of high economic and medicinal values, cultivated species were found to be closely associated with *D. edulis*. The study shows that *D. edulis* has the potential coexist with many other species which include the cultivated agricultural crop such as *Zea mays*, *Ipomoea*, *Manihot esculenta* and *Occimum gratissimum*, it can also coexist freely with many woody tree species. The finding from propagation study reveals that there was no significant impacts of hormone type and concentration on the rooting of *D. edulis* marcots, however, there was significant difference in the marcotting position on the mature tree. The mean root biomass accumulation was 3.85 g, 6.83 g and 10.37 g for the lower, middle and upper levels respectively along the main bole. The mean number of roots for lower, middle and upper were 11.17, 15.48 and 17.49 respectively. The root length of upper layer marcots was highest (9.56 cm) while lower layers produced the lowest (6.15 cm). The upper section of the main stem produced the best response to rooting, while the application of hormones may not be necessary for marcotting in *D. edulis*.

Based on the obtained results of this research it may be concluded that *D. edulis* can be compatible with other tree species for agroforestry purpose and can easily be introduced to the farmers that could contribute to regional and local income generation, strengthens food security, improves health care and sequestrate carbon to fight climate change.

Keywords: Agroforestry; Phytosociology; *Dacryodes edulis*; Hormone; Marcotting; Multipurpose

Introduction

Agroforestry practices embarked upon by rural farmers and agroforestry experts have been dominated by mono-specific tree components. The population of people who depend on agroforestry output for livelihood is geometrically increasing. This has led to the depletion and disappearance of many valuable trees through deforestation and has also aggravated food insecurity, especially in rural areas. Multi-purpose agroforestry improves the sustainability of biodiversity, the production of good quality timber and non-timber species, the control of pest and diseases and climate change amelioration. To identify the tree species that can be compatible with other species for agroforestry practices, the phytosociology needs to be studied. Due to lack of pre-assessment of the phytosociology of some so-called agroforestry trees, lots of agroforestry practices have been neglected. This is because some trees inhibit the growth of other trees and agricultural crops growing around them [1].

Dacryodes edulis (G. Don) HJ Lam is an evergreen humid tropical forest species from Africa and has been introduced in numerous farm settings in Africa particularly where they are planted in association with cash crops like cocoa and coffee, in home-gardens and other agroforestry practices [2]. Its belongs to the family *Burseraceae*, Common name is African pear and it's also called bush butter tree in some places. It is highly valued for its fruits in the Central and West Africa [3]. Vegetative propagation are increasingly becoming more attractive to people because of the added advantage of capturing desirable traits, quicker fruit yields and their potential to resolve problems of seasonality in *D. edulis* fruit production [4]. Many edible fruits are collected mainly from the wild and their habitats are currently threatened. A proper understanding of the propagations of these species will help the communities and industries on few known arable crops for fruits. Also, knowledge of their propagation methods will help us to understand the appropriate methods to conserves the fruits.

Vegetative propagation is significant because there is too much pressure on the seeds of *D. edulis*, which is the only alternative to achieve inexpensive domestication. Grafting *D. edulis* trees with scions from adult trees has not produced encouraging results. Some variants of grafting (approach grafting) have produced up to 50% success but need greater skill just like in rooting of cuttings and marcots [5]. In vegetative propagation various factors have been reported to influence the rooting of cuttings in tree crops out of which hormone type and concentration are the most significant [6].

There have been few studies to critically evaluate appropriate agroforestry species and the factors of importance in marcotting, the technique produces clonal propagules possessing the same characteristics as those of parent plants and are early fruiting [5,7]. Vegetative propagation should be used to capture and replicate the phenotype of a superior individual mother tree of *D. edulis* with desirable fruit characteristics.

It is necessary to initiate this study aimed at getting information on the phytosociology and vegetative propagation of *D. edulis* and their below ground growth attributes. Knowledge on an individual tree below ground growth attributes is very important in ensuring successful establishment of the plantation and their inherent agro-ecosystems services.

Materials and Methods

Study one: Phytosociology study of *D. edulis* (G. Don) HJ Lam

This study was carried out in the Akinyele and Ibadan North West local government areas in Ibadan. An extensive field survey was carried out in the study area, all compound farms, home gardens and forests were visited in the area, the forests are located around the school's administrative and residential area. Akinyele is a Local Government Area in Oyo State, Nigeria. It is one of the eleven local governments that make up Ibadan metropolis (latitude 7°28'N, longitude 30°52'N, altitude 277 m above sea level). The climate is the West Africa monsoon with dry and wet seasons. The dry season lasts usually from November through March and is characterized by dry cold wind of harmattan. The wet season usually lasts from April to October with occasional strong winds and thunderstorms. The annual rainfall in the area is 1258 mm-1437 mm with mean daily temperature ranging from 22°C-31°C. Soil type is ferric luvisols. The collection of data was accomplished through identification, enumeration and measurement of distances between the subject tree (*D. edulis*) and its associates' species. The closer a species is to *D. edulis*, the more associated is the species with the subject tree. To identify the species associated with the subject tree, a search radius method according to Sabiiti and Cobbina was used. Crown diameter of the subject tree was measured using 50 m tape for the estimation of the search radius. An associate species is a single or multi-stemmed individual located within the search radius of the subject tree. Search radius (SR) is the distance from the subject tree within which all other species are considered associate species. It can be calculated as: $SR=7/4 \times CD$, where CD is a crown diameter of the subject tree. Data were analyzed using Frequency, percentages and graphs. Past statistical software used for the data analysis [8].

Study two: Macropropagation of *D. edulis*

The study was carried out at Central Nursery Forestry Research Institute of Nigeria (FRIN).

Study area

Forestry Research Institute of Nigeria (FRIN): Forestry Research Institute of Nigeria (FRIN), Ibadan, Oyo State. FRIN is located on the longitude 07°23'18''N to 07°23'43''N and latitude 03°51'20''E to 03°51'43''E. The climate of the study area is the West African monsoon with dry and wet seasons. The dry season is usually from November through March and is characterized by dry cold wind of harmattan. The wet season usually starts from April to October with occasional strong winds and thunderstorms. Mean annual rainfall is about 1548.9 mm, falling within approximately 90 days. The mean maximum temperature is 31.9°C, minimum 24.2°C while the mean daily relative humidity is about 71.9% (FRIN 2015).

Hypotheses

The Collected data was stored into Microsoft excel spreadsheet and analyzed using SPSS version 20. Descriptive statistics were used for describing management practices in each intensive farm. Differences in productive performances (egg) were compared using means generated from two-sided t-test and one-way analysis variance (ANOVA).

Methodology

To determine the response of *D. edulis* marcots to hormone type, hormonal concentrations and marcotting position.

Air layering (Marcotting)

This study involved three factors, which include hormone types and marcotting positions (lower, middle and upper levels). Equal diameter horizontal branches with thick bark were used for air layering (or marcotting) of *Dacryodes edulis*. Growth hormones (IBA, GA) were applied at three concentrations each (0 ppm, 1000 ppm and 2000 ppm). The marcotting were set at three positions on the crown (lower, middle and upper levels), the rooting medium used was sawdust.

Data collection

The variables collected for the experiments include the roots count, roots length, roots diameter and roots biomass.

The experiment design and data analysis

A 2 × 3 factorial experiment in completely randomized design (CRD) were used to set up the experiment.

Factor 'H' is Hormone type in two levels (Indole-3-butyric acid (IBA), Gebreliline (GA)

Factor 'M' Marcotting Position which is in three levels (upper, middle and lower)

The statistical model is Y_{ijk}=μ+H_i+G_j+Ck+HM_{ij}+HMik+MC_{jk} +HMC_{ijk}+E_{ijk}

Where,

Y_{ijk}= observation made in the ith Hormonal type, j^{th} Marcotting level and k^{th} Hormonal concentration.

μ=General mean effect common to all effects.

H_i=main effect of Hormonal type.

G_j= main effect of Marcotting position.

Ck=main effects of hormones concentration.

HG_{ij}=Interaction between hormone type and Marcotting position.

HC_{ik}=Interaction between hormone type and hormones concentration.

GC_{jk}=Interaction between Marcotting position and hormones concentration.

HGC_{ijk}=Interaction between hormone type, Marcotting position and hormones concentration.

E_{ijk}=error term association with the ijk^{th} experiment.

Results and Discussion

Phytosociology potential of *D. edulis*

A total of 66 plant species were found associated with *D. edulis*, the species were of different structures and classes ranging from woody tree, shrub, climbers and herb species belonging to 40 families (Table 1) were encountered in the study area. Many of the species are of high economic and medicinal values, cultivated species were found to be closely associated with *D. edulis*. The study shows that *D. edulis* has the potential to coexist with many other species which include the cultivated agricultural crop such as *Zea mays*, *Ipomoea*, *Manihot esculenta* and *Occimum gratissimum*, it also coexists freely with many woody tree species. For the herbs and shrubs, *Tridax procumbens* had the first associate with the frequency of 52 and occupy about 5.1% of the area occupied by associate species, *Axonopus compressus*, *Peperomia pellucid*, *Ageratum conyzoides*, *Desmodium adscendens*, *Chromolaena odorata* and *Solenostemon monostachyus* were also highly associated with frequencies of 45, 39, 36, 34, 31 and 29 respectively and they occupied about 4.4%, 3.6%, 3.4%, 3.1% and 2.9% respectively. The herbs and shrubs species that have weakest associated with *D. edulis* are *Sida acuta*, *Phyllanthus nuriri*, *Fluerya aestuans*, *Occimum gratissimum* and *Combretum spp* had frequency and percentage cover of 13 (1.3%), 12 (1.2%), 11(1.1%) 8 (0.8%) and 3 (0.3%). For woody tree species, *Albizia zygia* and *Alchornea cordifolia* had the highest associate with the frequency of 33 each and they also occupy about 3.3% of the area occupied by associate species, *Morinda lucida*, *Newbouldia laevis*, *Citrus sinensis* and *Bridelia micrantha* also associated with *D. edulis* with the proportion of 2.2%, 1.7% and 1.5% respectively. On the other hand, wood tree species that have the weakest association with *D. edulis* are *Milicia excelsa*, *Sterculia tragacantha*, *Anthocleista djalonensis*, *Persea americana*, *Gneliana arborea* and *Terminalia mentalis* with the proportion of 0.9%, 0.7%, 0.6%, 0.3% and 0.2% respectively. Based on the frequency and percentage of occurrence of the species, *Tridax procumbens* had the highest population of individual species 5.2% of the total species population. This is followed by *Axonopus compressus* and *Ageratum conyzoides*, while *Gneliana arboreal* and *Terminalia mentalis* had the lowest population of individual species with 0.3% and 0.2% respectively.

The percentage distribution of species into families (Figure 1) shows that Asteraceae (15.5%) is the highest represented family. This is closely followed by Euphorbiaceae (10.6%). Next to *Euphorbiaceae* are *Rubiaceae*, *Poaceae* and *Moraceae* with (6.4%, 5.9% and 4.6%) representation and the lowest family represented are *Bombaceae* and *Cealsapineaceae* with 0.3%.

Species	Local / Common Name	Family	Frequency	Proportion (%)
Abelmoschus esculentus (L.) Moench	Okra	Malvaceae	12	1.2
Adenia cissampeloides (Planch. ex Hook.) Harms	Adenia	Passifloraceae	10	1.0
Ageratum conyzoides var hirtum (Lam.) DC.	Goat week	Asteraceae	36	3.6
Albizia saman (Jacq.)		Mimosaceae	10	1.0
Albizia zygia J. F. Macbr	Banabana	Mimosaceae	33	3.3
Alchornea cordifolia (Schum. & Thonn.) Müll.	Christmass bush	Euphorbiaceae	25	2.5
Alstonia boonei De Wild	Stool wood	Apocyneceae	11	1.1
Annona muricata L.	Sour sop	Annonaceae	16	1.6

Anthocleista djalonensis A.Chev	Cabbage tree	Loganiaceae	6	0.6
Antiaris africana Engl.	False iroko	Moraceae	13	1.3
Asystasia gangantica (L.) T.Anderson	Senegal tea tree	Acantheceae	25	2.5
Axonopus compressus (Sw.) P.Beauv.	Tropical carpet grass	Poaceae	45	4.4
Azadirachta indica A. Juss.	Neem	Miliaceae	10	1.0
Blighia sapida (Lovett).	Akeeaple	Sapindaceae	14	1.4
Boerhaavia diffusa Linn	Hogweed	Nyctaginaceae	24	2.4
Bombax buonopozense P.Beauv.	Red cotton tree	Bombaceae	4	0.4
Borreria ocymoides	Irawo ile	Rubiaceae	19	1.9
Bridelia micrantha (Hochst.) Baill	Mitzeeri sweetberry	Euphorbiaceae	15	1.5
Carica papaya L.	Pawpaw	Caricaceae	8	0.8
Chromolaena odorata (L.) R.M.King & H.Rob.	Siam weed	Asteraceae	31	3.1
Chrysophyllum albidum G.Don	African star apple	Sapotaceae	12	1.2
Citrus aurantifolia Christre. & Panzer	Swing	Rutaceae	9	0.9
Citrus sinensis L.	Sweet orange	Rutaceae	17	1.7
Cocos nucifera L.	Agbon/ coconut palm	Palmae	4	0.4
Combretum. spp		Combretaceae	3	0.3
Cyathula prostrata L.	Pasture weed	Amarantheceae	17	1.7
Delonix regia (Boj. ex Hook.) Raf.	Flame of th forest	Leguminosaceae	13	1.3
Desmodium adscendens		Leguminosaceae	34	3.4
Eleais guineensis Jacq.	Oil Palm	Palmae	8	0.8
Ficus capensis hunb	Fig tree	Moraceae	13	1.3
Ficus exasperata Vahl	Sand paper tree	Moraceae	12	1.2
Fluerya aestuans (L.) Chew	African nettle	Urticaceae	11	1.1
Gneliana arborea Roxb. ex Sm	Gniliana	Verbanaceae	3	0.3
Ipomoea involucrata	Morning glory	Convolvulaceae	19	1.9
Irvingia gabonensis (Aubry-Lecomte ex O'Rorke) Baill.	Wild mango	Irvingiaceae	9	0.9
Manihot esculenta Crantz	cassava	Euphorbiaceae	15	1.5
Mangifera indica L.	Mango tree	Anacardaceae	4	0.4
Milicia excelsa (Welw.) C.C. Berg	Iroko	Moraceae	9	0.9
Morinda lucida Benth.	Oruwo	Rubiaceae	22	2.2
Moringa oleifera Lam.	Moringa tree	Moringaceae	10	1.0
Newbouldia laevis (ogilisi)	Dants	Bignoniaceae	20	2.0
Occimum gratissimum (L.)	Balsam	Labiatae	8	0.8
Oldelandia corymbosa Linnaeus.	Oyigi	Rubiaceae	24	2.4
Peperomia pellucida Kunth	Silver bush	Piperaceae	39	3.8

Persea americana Mill	Avocado pear	Lauranceae	5	0.5
Phyllanthus amarus Schumach. & Thonn.	Eyin olobe	Euphorbiaceae	23	2.3
Phyllanthus nuriri L.		Euphorbiaceae	12	1.2
Pinus cariabia Morelet	Pine	Pinaceae	12	1.2
Polyalthia longifolia Sonn.	Police Tress	Annonaceae	5	0.5
Psidium guajava L.	Guava	Myrtaceae	12	1.2
Rauvolfia vomitoria Afzel.	Swizzler stick	Apocyneceae	13	1.3
Securinega virosa omm. ex A.Juss.	Iranje	Euphorbiaceae	17	1.7
Senna siamea (Lam.) Irwin et Barneby		Cealsapineaceae	4	0.4
Sida acuta Burm.f	Hornbeans leaf	Malvaceae	13	1.3
Solenostemon monostachyus (P Beauv.) Briq.	Catnip	Libiatae	29	2.9
Spondias mombin L.	Hog plum	Anacardaceae	8	0.8
Sterculia tragacantha Lindl.	Star chesnut	Steculiaceae	7	0.7
Synedrella nodiflora (L.) Gaertn.	Tanaposo	Asteraceae	21	2.1
Talinium tangulea	Water leaf	Talinaceae	14	1.4
Tectona grandis L.f.	Teak	Verbanaceae	11	1.1
Terminalia catappa L.	Almond tree	Combretaceae	13	1.3
Terminalia Mentalis L.	Terminalia	Combretaceae	7	0.7
Thevetia neriifolia Juss.	Bush milk	Apocyneceae	2	0.2
Tridax procumbens L.	Tridax	Asteraceae	52	5.1
Vernonia amygdalina Delile	Bitter leaf	Asteraceae	17	1.7
Zea mays L.	Maize	Poaceae	15	1.5

Table 1: Tree species associated with *D. edulis.*

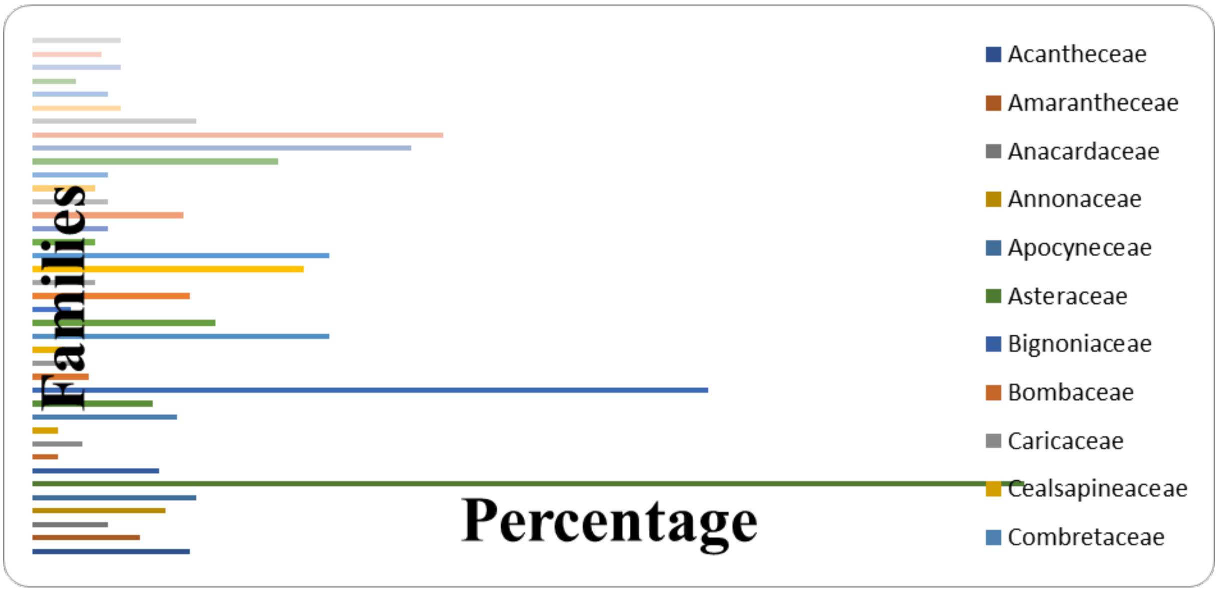

Figure 1: The distribution of the *D. edulis* associates by family.

	Number of marcots	GA 1000 PPM (Germination%)	GA 2000 PPM (Germination%)	GA CONTROL (Germination%)	IBA 1000 PPM (Germination%)	IBA 2000 PPM (Germination%)	IBA CONTROL (Germination%)
Upper	90	94	93	93	92	94	93
Middle	90	82	84	82	83	83	81
Lower	90	76	78	74	77	77	74
Mean	90	84	85	84	84	85	83
Total	370	252	255	249	252	254	248

Table 2: The Rooting percentage of *D. edulis* marcots to hormone type, hormonal concentrations and marcotting position.

The result shows that *D. edulis* have a very good rooting ability when propagated through vegetative propagation means (macortting). The vegetative propagation of *D. edulis* looks very promises, as the rooting percentage is very high in the positions where the marcots were set.

The response of *D. edulis* marcots to hormone type, hormonal concentrations and marcotting position.

Marcots could grow for three months after which variables such as roots number, roots collar diameter, roots length and roots biomass were assessed for another two months. After two months of assessment, roots number at the upper section of the crown gave the highest mean values, marcots tested with IBA at 1000 ppm had 12.53, IBA at 2000, 12.37, GA control had 12.36, GA at 1000 ppm had 12.12, GA at 2000 ppm had 12. 27, the lower section of the crown gave the lowest mean values despite the same hormonal treatment on them, IBA at 2000 ppm had 8.55, IBA at 1000 ppm had 8.33, IBA control had 8.53, GA at 2000 ppm had 8.53, GA at 1000 ppm had 8.40 and GA control 8.35. Result shows that roots length at the upper section of the crown gave the highest mean values IBA at 2000 ppm had 7.71 cm, while IBA at 1000 ppm, 2000 ppm and control had, 7.72 cm each (Table 2).

GA at 1000 ppm and control were 7.72 cm and 7.69 cm respectively. The lower section of the crown also gave the lowest mean values: IBA at 2000 ppm had 5.15 cm, IBA at 1000 ppm had 5.28 cm, IBA control had 5.13 cm, GA at 2000 ppm had 5.12 cm, GA at 1000 ppm had 5.11 cm and GA control had 5.12 cm. Assessment of roots biomass shows that upper section of the crown gave the highest mean values: IBA at 2000 ppm had 4.76 cm, IBA at 1000 ppm had 4.65 cm, IBA control had 4.81 cm, GA at 2000 ppm had 4.72 cm, GA at 1000 ppm had 4.71 cm and GA control had 4.65 cm. The lower section of the crown gave the lowest mean values: IBA 2000 ppm 2.47 cm, IBA 1000 ppm 2.46 cm, IBA control 2.41 cm, GA 2000 ppm 2.41 cm, GA 1000 ppm 2.43 cm and GA control 2.45 cm (Table 3).

Variables	Marcotting Position	GA 1000 PPM	GA 2000 PPM	GA Control	IBA 1000 PPM	IBA 2000 PPM	IBA Control
Root No	**Lower**	8.4	8.53	8.35	8.33	8.55	8.53
	Middle	11.38	11.23	11.18	11.3	11.59	11.32
	Upper	12.12	12.27	12.36	12.53	12.37	12.31
Roots Length (cm)	**Lower**	5.11	5.12	5.12	5.28	5.15	5.13
	Middle	6	5.99	5.98	5.99	5.98	5.96
	Upper	7.72	7.72	7.69	7.72	7.71	7.72
Roots Collar Diameter (cm)	**Lower**	2.94	2.97	2.95	2.94	2.96	2.94
	Middle	3.23	3.24	3.24	3.28	3.26	3.23
	Upper	3.61	3.36	3.64	3.64	3.69	3.58
Roots Biomass (cm)	**Lower**	2.43	2.41	2.45	2.46	2.47	2.41
	Middle	3.45	3.46	3.43	3.51	3.51	3.41
	Upper	4.71	4.72	4.65	4.65	4.76	4.81

Table 3: Mean roots number, roots collar diameter, roots length, roots biomass, hormone types (GA and IBA), concentration and marcotting position.

Marcotting position	Mean root length	Mean root collar diameter	Mean root number	Mean root biomass
Lower	5.10 a	2.92 a	8.35 a	2.43 a
Middle	5.92 b	3.24 b	11.36 b	3.61 b
Upper	7.70 c	3.59 c	12.28 c	4.72 c
p-value	0.000*	0.000*	0.000*	0.000*

Table 4: Duncan multiple test to compare the different between pair of means on the effects of Marcotting position on mean root length, collar diameter, root number and root biomass of *D. edulis*. Means with the same alphabet are not significantly different at 5% probability level. *=significant ($p<0.05$).

The values from (Table 4) shows that there is significant difference between the marcotting position on the root length, root collar diameter, root number and root biomass of *D. edulis*. The upper section has the highest mean value for all the variables assessed, in root length upper section had 7.70 cm and lower section has the lowest of 5.10 cm.

In root collar diameter of *D. edulis*. The upper section has the highest mean value of 3.59 cm and lower section has the lowest of 2.92 cm. For root number of *D. edulis* the upper section has the highest mean value of 12.28 cm and lower section has the lowest of 8.35 cm. And in root biomass of *D. edulis* the upper section has the highest mean value of 4.72 cm and lower section has the lowest of 2.43 cm.

Roots length

The result shows that there were no significant differences ($p>0.05$) in the hormone types (GA and IBA) and at differences concentrations, but there were significant differences ($p>0.05$) in the marcotting position (upper, middle and lower) (Appendix 1).

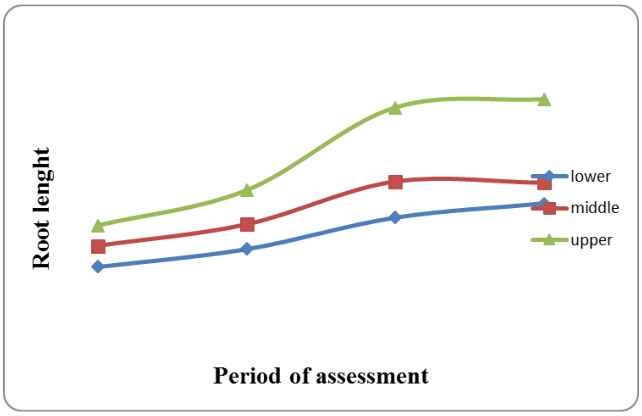

Figure 2: The response of *D. edulis* root length marcots to marcotting position.

Figure 2 shows that the weekly mean increments of root length at different marcotting position (lower, middle and upper) shows a clear distinction.

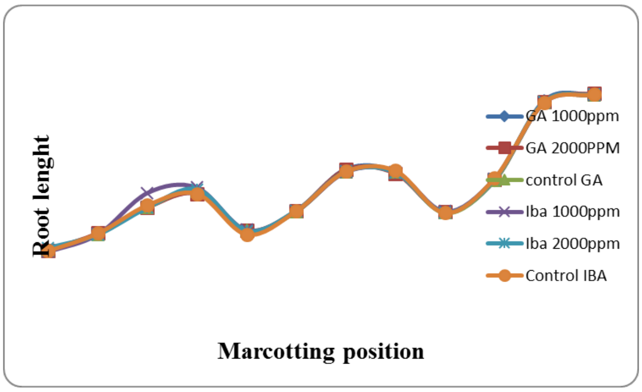

Figure 3: The response of *D. edulis* root length marcots to hormone types (GA and IBA), concentration and marcotting position.

Figure 3 shows the relationship between hormonal type, hormone concentration and marcotting position. It indicates that there is no visible different between the hormonal type and hormone concentration.

The result of the statistical analysis from table above shows that there were no significant differences (p>0.05) in the hormone types (GA and IBA) and at differences concentrations., but there are significant differences (p>0.05) in the marcotting position (upper, middle and lower) (Appendix 2).

The result of statistical analysis from table above shows that there were no significant differences (p>0.05) in the hormone types (GA and IBA) and at different concentrations., but there were significant differences (p>0.05) in the marcotting position (Appendix 3).

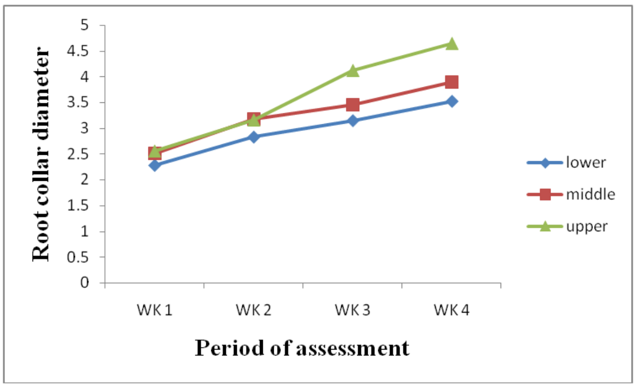

Figure 4: The response of *D. edulis* root collar diameter marcots to marcotting position.

Figure 4 shows graph shows the weekly mean increment of root length and it's the marcotting position (lower, middle and upper).

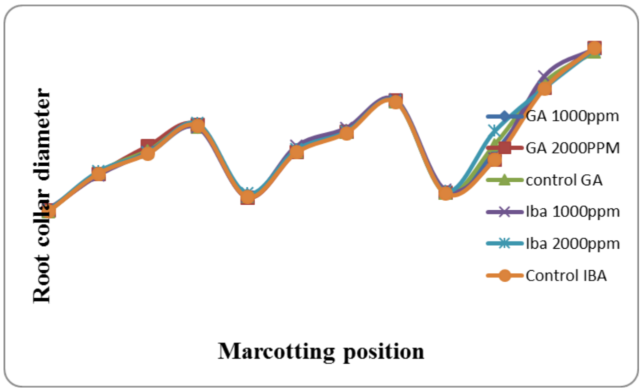

Figure 5: The response of *D. edulis* root collar diameter marcots to hormone types (GA and IBA), concentration and marcotting position.

Figure 5 shows the relationship between hormonal type, hormone concentration and marcotting position. It shows that there is no visible difference between the hormonal type, hormone concentration on root collar diameter.

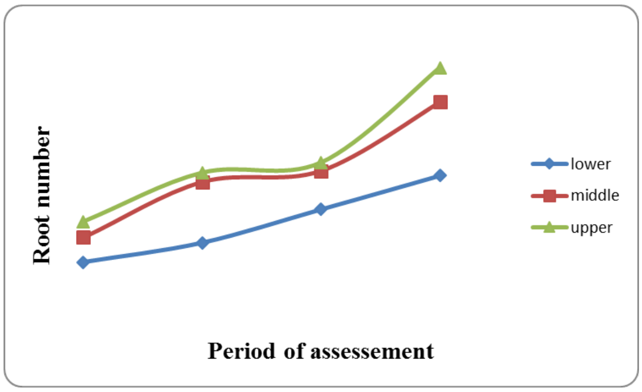

Figure 6: The response of *D. edulis* marcots root number to marcotting position.

Figure 6 shows the graph shows the weekly mean increment of root length and the marcotting position (lower, middle and upper).

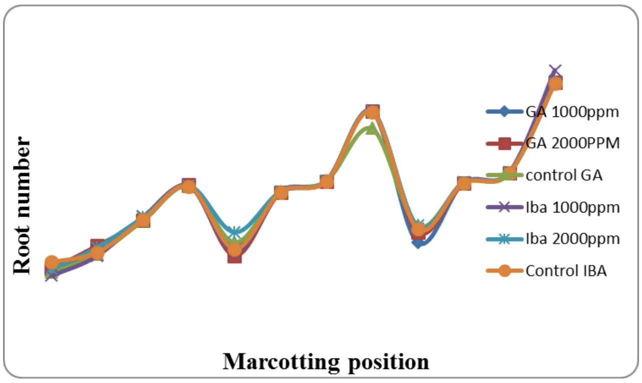

Figure 7: The response of *D. edulis* root number marcots to hormone types (GA and IBA), concentration and marcotting position.

Figure 7 shows the relationship between hormonal type, hormone concentration and marcotting position. It shows that there is no visible difference between the hormonal type, hormone concentration on root number.

The result of statistical analysis from table above shows that there were no significant differences (p>0.05) in the hormone types (GA and IBA) and at differences concentrations., but there was significant difference (p>0.05) in the marcotting position (Appendix 4).

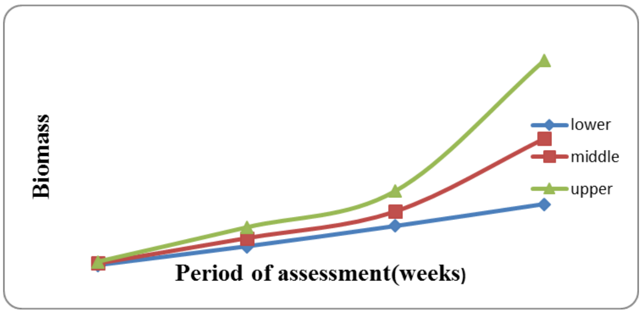

Figure 8: The response of *D. edulis* root biomass marcots to marcotting position.

Figure 8 graph shows the weekly mean increment of root length, its shows a clear distinction between the marcotting position (lower, middle and upper).

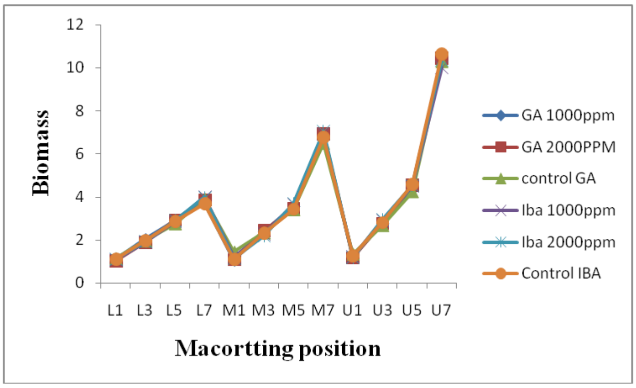

Figure 9: The response of *D. edulis* root biomass marcots to hormone types (GA and IBA), concentration and marcotting position.

Figure 9 shows the relationship between hormonal type, hormone concentration and marcotting position, its shows that there is no visible difference between the hormonal type, hormone concentration.

Figure 10: Marcotting.

Figure 10 showing Marcotting procedure.

Discussion

Phytosociology study of *D. edulis*

The measure of the coexistence and distribution of abundance of species diversity has long been used to characterize the taxonomic structure of communities, this study's findings support the assertion reported by Garrity that a woody tree species is justified to be used for multiple tree agroforestry if it supports that existence of other woody species around its niche. Hence, the observed associates of *D. edulis* in this study indicate great potential for agroforestry uses. In addition, the diversity of the *D. edulis* associates encountered in this study appeared to be appropriate, and the results of the study match with in the findings of White, who found that tree of similar evolutionary history tend to be adapted to a peculiar location and niche [8,9].

Vegetative propagation of *D. edulis*

The results from this study showed that there is no significant difference between the two-hormone type and hormonal concentrations. The results corroborate with earliest reported that hormonal treatment has no significant effects on the cuttings of *D. edulis* [10].

Findings from this study shown that there is significant difference between the marcotting position for all the variables assessed. The upper section has the highest mean values than the lower section of the crown. The finding is like the result of Ansari et al. who reported that in *Dalbergia sissoo*, the cuttings from the apical end of the branch rooted better than the basal end, apical cuttings recorded higher mean percentage of rooted cuttings and root length than the basal cuttings [11]. Upper section of the crown seems to have higher potential for vegetative propagation from this study having recorded mean values as found in *T. heterophylla* [12,13]. The ability of cuttings to form roots is determined by the position of where the cutting is obtained, the juvenility of stock plant can also be an overriding. The results of this study indicated that positions had effects on roots development in *D. edulis* with respects to roots length, root collar diameter, roots number and roots biomass. The results of this study however contrasts with the statement of Hartman and Kester that the best rooting is usually found from the basal portion of shoot. The differences in rooting responses with respect to marcotting position are greatly affected by the extent of lignification's, secondary thickening and chemical composition of plant tissues. Basal marcotted position could be mature and highly lignified to develop roots than the apical position [14,15]. In woody plants, these differences in rooting due to marcotting position can be related to differences in chemical composition of the shoot, the age of the stem, carbohydrate accumulation or due to bud growth.

Conclusion

D. edulis is a multipurpose tree that provides a dual function of strengthening food security and carbon sequestration in rural environments. This research is therefore pertinent to efforts towards indigenous fruit/nut tree domestication and incorporation to a agroforestry system. However, the research was aimed at obtaining insights into the agroforestry potential of *D. edulis* and the possibilities of vegetative propagation of the species. This study showed that *D. edulis* has the potential of being used for multi-species agroforestry system and based on the large number highly economic values of the associated species, they have the potential of improving agroforestry practice in the area.

The results show that marcotting is very possible for *D. edulis* and the marcot should be set at upper section of the main stem because its produces the best response to rooting in all the variables assessed, while the application of hormones may not be necessary for marcotting in *D. edulis.*

The sustainable use of *D. edulis* can contributes to regional and local income generation, strengthens food security, improves health care and sequestrate carbon to fight climate change. Consequently, it is necessary to initiate studies aimed at getting insights on multipurpose tree species such as *D. edulis* on their bellow and above ground growth attributes and their potential ecosystem services to humanity to sustenance of both rural and urban livelihood, thus, an agroforestry innovation with multipurpose species should be advocated and encouraged.

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