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Analysis of Nursery Techniques with Various Propagules of Jatropha Curcas (L), a Biofuel Plant Species

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Abstract:
Nursery experiments were conducted on the various identified propagative parts of Jatropha curcas during the wet season. The aim was to affirm the rightful propagules for propagation and multiplication purpose most suitable for the plant species. Two major propagules were used in the experiments, consisting 4 treatments. These are seeds in the sexual propagation process as Treatment A; and the vegetative parts which comprised the upper stem/tip stem-cuttings (Treatment B), the middle stem/cane stem-cuttings (Treatment C), and the lower stem/the caudex (pluralized as caudices/caudexes-Treatment D) in the asexual propagation process. Ten filled polypots were used for each treatment, with ordinary top soil as potting mixture, having 5 replicates. It was laid in a Complete Randomized Design (CRD). At the end of the experimental period, results indicated 90% germination on treatments A, while B had nil sprouting, but C and D 10% each. Significant difference exists between Treatment A and other treatments, and at 0.05 level of significance, 3DF for treatment and 16DF for error/residual; F calculated was 23.46, while F tabulated was 3.24. Mean separation with LSD also showed highly significant difference between Treatments A, B, C, and D, but no significant difference between Treatments B, C, and D with each other. It was however established that Jatropha propagation through seeds is best over cuttings economically.

Keywords: *Nursery, Jatropha, propagules, multiplication, economically*

1. Introduction

Several types of plant parts could be used as propagating materials for multiplication purpose. These ranges from root, sucker, stem, leaf to seeds among others. However, every plant has specific propagules that are suitable to its propagation and multiplication (Salami, 2005). This may however be through the open nursery propagation, engineering or mechanical propagators; and incubator devices, or through bio-technological approach. Specifically, the leaf, root, stem, and seeds are good and active propagules for *Jatropha curcas*, which could be modified to suit the objects of plantation establishments as applicable to other economic plant species. Unfortunately, the commercial propagation of Jatropha is not taken seriously globally, and especially in Nigeria towards addressing the universal quest for alternatives to the conventional fossil fuel utilization, against the acclaimed global climate change scenario.

Jatropha curcas (L) commonly called the Physic Nut or Purging Nut is a drought resistant perennial with vigorous growth and development (Brook and Baghat, 2004). It is a drupe in the family euphorbiaceae (Adio, *et al,* 2008). It grows fast with minimal inputs, producing seeds for over 40 years (Jatropha Africa, 2006; USDA-ARS, 2015). The plant is said to have been introduced to Africa and Asia from Mexico and Central America; and is now cultivated and adopted to wetlands, arid and semi-arid conditions (Umar, 2007; PROTA, 2015).

Jatropha curcas grows 6-8m high with straight stems and thick branches, containing white latex. Leaves are green, 6-18cm long and wide, but deciduous. Fruits are oval, green, turning yellowish when ripe. It is approximately 40mm long, containing 2-3 seeds, black, with an average length of 18mm and 10mm width. A thousand seeds are approximately 1kg, and oil content of seeds is more than 30%. Germination commences within 4-7 days, which is usually affected by storage time (Jepsen, *et al,* 2003; Salami, *et al,* 2009_1). Germinated seeds normally have 5 roots, with 1 central and 4 lateral roots, while stocks produced vegetatively has no tap-root (Dela Vega Lozano, 2007; Heller, 1996).

In Nigeria, 2 broad varieties of Jatropha are presently available; the green, which are most common, and the red, commonly used in Southern Nigeria as amenity plants in cemeteries (probably because of the bright and attractive coloration of the leaves). The two varieties are equally used as live fence (hedges) around farmlands, or along grazing routes to minimize crop destruction by browsers (Salami, 2008). The toxin, known as curcin, contained in the plants also deters animals ((Lin, *et al,* 2010; Goel, *et al,* 2016); thereby maintaining intact hedges on farmlands, and reducing clashes between farmers and rearers (Umar, 2007; Salami, *et al,* 2009_2).

Jatropha curcas is used for bio-diesel production. It can yield up to 2 tones of bio-diesel fuel per year per hectare. Similarly, it can also yield about 1000 barrels of oil per year per square mile (Brook and Baghat, 2004; PROTA, 2015). Bio-diesel is a renewable eco-friendly fuel obtained through a process of esterification, which involves the reaction with esters and alcohol in the presence of a catalyst (Umar, 2007; USDA-ARS, 2015). It is a diesel equivalent processed fuel consisting of alkyl (methyl or ethyl) esters made by transesterification of vegetable oils or animal fats, which can be used (alone or blended with conventional diesel fuel) in unmodified diesel engine vehicles (Knothe, 2007; Vimal Chandra Pandey, *et al,* 2012). It had been in existence since 1893. Bio-diesel is distinguished from Straight Vegetable Oils (SVO) or Waste Vegetable Oils (WVO) used alone or blended as fuels in some diesel vehicles. It is bio-degradable and non toxic, typically producing about 50% less net-life carbon dioxide via photosynthesis in plants (Brook and Baghat, 2004). It also reduces emission of particulate matter by 40-65%, unburned hydrocarbons by 68%, carbon monoxide by 44-50%, sulphate by 100%; Polycyclic Aromatic Hydrocarbons (PAHs) by 80%, and the carcinogenic nitrated PAHs by 90% on the average (Brook and Baghat, 2004). In essence, the bio-diesel molecules are simple hydrocarbon chains free of aromatic substances and sulphur, which are associated with fossil fuels. Further reports from Buckland (2005) also emphasized that the United States Environmental Protection Agency (USEPA) currently estimated that the use of bio-diesel represents 67% reduction in green house gas emission, in comparison with petroleum-based fuels.

Apart from the above, several other advantages are credited to the use of bio-diesel against the conventional diesel, amongst which are the lower engine wear, a better solvent (as it clears the engine by removing deposits in the fuel lines); blendability/mixability with other diesel types towards a good formulation to increase the lubricity of pure Ultra Low Sulphur Diesel (ULSD) fuel, and for virtually no sulphur content (McCormic, 2006).

Additionally, *Jatropha curcas* is good in desertification control, soil protection and conservation, afforestation and reforestation, as well as in agro-forestry programmes (Salami, 2008; Salami, *et al,* 2009_1**)**. It is also beneficial through its leaves, latex, roots, pods, bark and cake as pharmaceutical raw materials, and in local herbs preparation (Makkar, *et al,* 2008; Igbinosa, *et al,* 2009). Same time, Jatropha is useful in the promotion of organic crop enrichment components in the soil (Valdes-Rodríguez, *et al,* (2013); Becker, K., *et al,* 2013). A by-product of bio-diesel production known as glycerin is also a more profitable product in the world market. These and other benefits had made the plant species to be acknowledged as unique and currently rated as the first choice for bio-diesel production (Brook and Baghat, 2004; Salami, *et al,* 2009_2).

The objectives of the study are: - [1] Plant and sow appropriately the various selected propagules of *Jatropha curcas* in the nursery [2] Enumerate the germination and sprouting models of the various selected propagules [3] Put the experiment under intensive care to substantial maturity level [4] Collect data from the experiments within specified periods [5] Analyze the data collected for drawing conclusion, and [6] make appropriate recommendations based on the results of the experiments for public consumption.

2. Derivable Propagules from Jatropha Curcas

Within the context of theoretical and practical prowess, the propagules suitable to a sustainable propagation of *Jatropha curcas* are through its seeds and vegetative parts, particularly its cuttings.

2.1. Seeds

In propagative terms, plant seeds are that part of the plant that is sown in the nursery to produce seedlings, or directly sown out onto the field to develop into a full-grown plant. Seeds may be sown directly in open beds or inside polypots containing the potting mixture, or inside germination trays, otherwise it may as well be sown by broadcast in any related germination medium. Jatropha seeds are however dark brown in colour with an average length of 18mm and 10mm width, fig. 1.

2.2. Cuttings

Cutting is a vegetative plant part which is severed from the parent plant in order to regenerate itself, thereby forming a whole new plant. Nonetheless, many types of plants either woody or herbaceous are frequently propagated by cuttings. Practically, a piece of twig or branch is cut from the plants part, and the lower end is inserted or placed into the soil or other planting/rooting media; which later develop roots to become an independent plant, the prototype of the mother tree. Moreover, these cuttings may either be from stem, leaves or roots.

Figure 1: Jatropha Seed Propagules

2.3. Stem Cuttings

Stem cuttings are those propagules derived from the stem of a mother tree obtainable from a reasonably matured plants part, but not over-matured or too-tender. The following are therefore some of the known stem cutting types and propagative processes as could be obtained in *Jatropha curcas*:-

2.3.1. Tip Stem-Cuttings

A single 5 to 15cm piece of stem is detached alongside the terminal bud by making the cut just below a node. The lower leaves that would touch the planting medium or that are sighted below it are then removed, and the cuttings are dipped in the rooting hormone if desired. The end of the cuttings is then tapped gently to remove excess hormone picked from the dip, as they are deeply inserted enough into the media to support its firm grip. However, at least one node must be below the surface, while rooting follows subsequently to evolve an independent new plant.

Medial stem-cuttings: The first cut to be made just above a node, and the second cut just above another node 5 to 15cm down the stem. Then the cuttings are prepared and inserted just like the tip cuttings. It should however be ensured that the right side is positioned up as axial buds are always above the leaves. In respect of the jatropha propagule index values, it is known as the caudex, fig. 2. Caudex is a noun word which literarily translates to “tree trunk”, and it is from Latin origin. A caudex (plural: caudices/caudexes) of a plant is a stem, but the term is also used to mean a rootstock, and particularly a basal stem structure from which new growth arises. It is also a form of stem morphology appearing as a thickened, short, perennial stem that is either underground or near ground level (frequently woody, and non-photosynthetic). It may be swollen for the purpose of water storage, especially in xerophytes. These attributes made plants caudex to have various different physiological and morphological features, which are dictated by the type of plant species and their habitat, fig. 2.

2.3.2. Single Eye Stem-Cuttings

The eye refers to the node. This is used for plants with alternate leaves when space or stock materials are limited. To prepare this stem cutting method, the stem should be cut at a little stance after 1cm above, and same below a node. Then the cuttings are placed horizontally or vertically in the medium.

2.3.3. Double Eye Stem-Cuttings

This is used for plants with opposite leaves when space or stock material is limited. Cut the stem about 30cm above and 30cm below the same node. Then insert the cutting vertically in the medium with the node just touching the surface.

2.3.4. Heel Stem-Cuttings

This method uses stock materials with woody stems efficiently. To prepare this a shield-shaped cut is made about halfway through the wood around a leaf and axial bud and, the shield is inserted horizontally into the medium.

Other types of cuttings which may be derived from Jatropha curcas are leaf and root cuttings. They are specifically applicable to the propagation of the plant species if the biotechnological principles are involved.

2.3.5. Cane Stem-Cuttings

Cane-like stems to be cut into sections containing one or two eyes or nodes in the preparation of cane-stem cuttings. Then both ends are dusted with fungicide or activated charcoal. It should be allowed to dry for several hours and then laid horizontally into the planting media with about half of the cutting below the media surface, while the node is facing upward. Cane cuttings are usually potted when roots and new shoots appear.

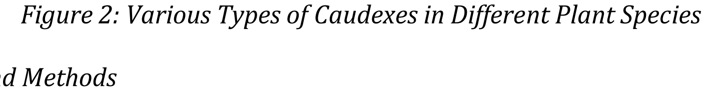

Figure 2: Various Types of Caudexes in Different Plant Species

2.4. Experimental Materials and Methods

Various propagules for these experiments were collected within Kano State of Nigeria. Seeds and vegetative materials consisting of 4 variable propagules were used. These are: (A) which were freshly collected seeds that were dried under shade at room temperature for a couple of weeks, (B) that were top stem parts (tip stem-cuttings), (C) middle stem parts (cane stem-cuttings), and (D) the lower stem parts (the caudex (plural: caudices/caudexes) of the plant species. A total number of 10 stocks each were raised from each of the selected propagules, replicated 5 times. Treatment B, which was top stem parts were green and matured, while Treatments C and D were grey in colour, but more matured than B. Ordinary top soil was used as potting mixture, while the experiment was laid out under the nursery shed in a Complete Randomized Design (CRD).

Records of germination and sprouting were taken in the nursery over a period of twelve days, which were arranged per day's intervals of 3 i.e. 1-3, 4-6, 7-9, and 10-12 (Table I).

3. Results and Discussion

It would be recalled that two main categories of Jatropha propagules were used for this experiment. These were seeds and vegetative parts, which culminated into 4 variables as experimental treatments. Treatments A were freshly collected seeds that were dried under shade at room temperature for a couple of weeks, B were top vegetative stem parts or tip stem-cuttings; while C the middle stem or cane stem-cuttings, and D the lower stem parts of the plant species also known as the caudex.

S/N	Treatments	Day's intervals 1-3	4-6	7-9	10-12
	Seeds				
A.	**Freshly collected seeds of *Jatropha curcas* dried for a couple of weeks at room temperature**	0	50	30	10
	Vegetative parts				
B.	**Upper stem**	0	0	0	0
C.	**Middle stem**	0	10	0	0
D.	**Lower stem**	0	0	0	10
	SE-⁺	**0**	**11.9**	**7.1**	**2.6**

Table 1: Percentage Germination and Sprouting of Various Jatropha Propagules per Day's Intervals in a 2-Week Nursery Observation

The propagules selected for this experiment were used because they were those having the simplest and cheapest propagative process that could easily be handled even by peasant farmers, who may be interested in the cultivation of *Jatropha curcas.* This is in connection with the report of Rockefeller Foundation (1998); Salami, *et al,* (2009_1); Salami, *et al,* (2009_2) and USDA-ARS (2015) that Jatropha can be established from seeds, wildlings and vegetatively from cuttings.

3.1. Germination and Sprouting

Each of the 4 treatments commenced germination and sprouting simultaneously the 4^{th} day of insertion. This is corroborated in Salami (2008) and Salami, *et al,* (2009_1) reports that the purging nut commence seed germination and vegetative sprouts within a week. However, a substantial die back was recorded from Treatments B, C, and D which were propagules from the vegetative parts, shortly after the commencement of sprouting. This resulted into nil in treatment B, and 10% output for each of the treatments C and D respectively, while germination from Treatment A was 90% at the end of the nursery experiment (See Table I). Success of cuttings were however discovered has to do with right size, right age, right strain, and right source as coincidentally observed in Jatropha Bio-diesel (2007); Becker, K., *et al,* (2013); Valdes-Rodríguez, *et al,* (2013) and PROTA, (2015) analysis.

3.2. Analysis of Variance (ANOVA)

Significant difference exists between Treatment A and other treatments B, C and D. At 0.05 level of significance, 3DF for treatments and 16DF for error/residuals, F calculated was 23.46, while F tabulated was 3.24. Mean separation with LSD also indicated highly significant difference between Treatments A, B, C, and D, but no significant difference between Treatments B, C, and D with each other (Table II). In support of these results moreover, Rijseenbeek (2004) and Salami, *et al,* (2009_1) observed that cutting surface is an entry point for fungi and insects, very importantly as the plant specimen is characterized with high water contents favourable to continuous biological processes. This may be grossly responsible to the premature die back of Treatments B, C, and D in the nursery. Total failure of Treatment B may also be due to the fact that, the tip stems used were green and more tender than the cane stems and the caudices, which also made continuous photosynthesis accrued on the plants stock in view of the presence of chlorophyll as analyzed by Iloeje (1991), and reported in Salami, *et al,* (2009_1) account. This biological activity may have exhausted the in-stored nutrients in the experimental specimen B, as they had not developed roots to tap nutrients independently for sustenance and proliferation, leading to massive evapotranspiration from the said propagules, and resulting in consequent emancipation in lieu of dehydration, and subsequently, a total failure.

4. Conclusion

An empirical knowledge of the right propagule for plant propagation is a pre-requisite to the success and sustainable conservation of such plant species in management concept. This knowledge would however optimize the financial records of such project for maximum output. *Jatropha curcas* was professed as Nigeria's green gold, and was projected for bio-diesel production, which is perceived to have simple propagative methods; but the wild fruitless approach on the propagation exercise only lasted for a very few years and collapsed, dropping into the dustbin as usual like the *Simodsia schinensis* (Jojoba) project of the 80s.

Source	DF	SS	MS	F cal	F tab 5%
Treatment (t-1)	3	10.55	3.52	23.46**	3.24
Error t (r-1)	16	2.40	0.15		
Total (t x r –1)	19	12.95			

Table 2: Analysis of Variance Testing Significant Difference in the Germination and Sprouting Of Variable Propagules of Jatropha Curcas in the Nursery
*** Highly Significant*

In a nutshell, the truth of the matter remains that an appropriate selection of propagules for plant multiplication would go a long way to pervert wastage of physical and mental resources for a substantial forward leap in the productive process. With respect to this experiment therefore, seeds were discovered to be best over vegetative propagules for multiplication purposes on *Jatropha curcas*.

5. Recommendations

Jatropha propagation is highly recommended through its seeds. This is because seedlings are less prone to infection at the early stage of development than the stakes. Same time, seedlings usually have tap and aerial roots for good anchorage, while plant materials from cuttings only possess aerial roots which are less susceptible to good anchorage on the field. Finally, seedlings are better shaped to suit potential taste than stocks developed from cuttings, which usually incline to profuse and disorganized branching system.

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