Effects of Different Soil Textures on Early Propagation of Physic Nut (*Jatropha curcas* L.)

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Abstract

This study evaluated the effects of different soil textures on early propagation of (Jatropha curcas L.) through an experiment conducted at the Teaching and Research Farm of Delta State University, Asaba Campus, Asaba, Nigeria. Two propagation materials (seeds and stem cuttings) and three soil textures (sandy loam, loam and clay) were used in a 2 x 3 factorial experiment in a completely randomized design, replicated three times. The results revealed that physic nut seeds planted in sandy loam soil emerged first at 3.2 days having 86% germination, followed by loamy soil at 4.7 days having 62% germination and clay soil at 6.0 days having 49% germination. The stem cuttings planted in sandy loam soil also sprouted first at 12.8 days having 45% germination, followed by loamy soil at 18.4 days having 39% germination and clay soil at 23.9 days having 26% germination. The results indicated that sandy loam soil had best potential for establishing Jatropha curcas as shown by the pronounced effect of the soil on plant height , number of leaves and leaf area which were higher ($P<0.05$) than those obtained from other soil textural types used.

Keywords: *Jatropha curcas*, soil texture, propagation, germination, stem cuttings

Introduction

Jatropha curcas is a species of flowering plant in the family, Euphorbiaceae. *Jatropha curcas* L. is the commonest species found in Nigeria, but many other species exist in different parts of the world. Common names include physic nut, Barbados nut, and purging nut. The plant has grey bark, and attains 8 - 10 metres in height. It is a drought-resistant perennial plant with a productive life of more than 40 years.

Jatropha plantations are used for controlling soil erosion and increasing the habitat for wild animals. *Jatropha* plants are also used as shade plants for coffee; tomato and pepper plants. The oil from *Jatropha curcas* is mainly converted into biodiesel for use in diesel engines for transportation and industrial rural electrification. The cake can be used for fish or animal feed (if detoxified), biomass feedstock to power electricity plants, or as biogas or high-quality organic fertilizer. It can also be used as a bio-pesticide and for medicinal purposes (FACT Foundation, 2007). The seeds or beans are used as a laxative in traditional medicine. The latex/sap is also used for wound-healing while the leaves are useful as tea against malaria and other human ailments. *Jatropha* is also used for soap and organic fertilizer production, for medicinal purposes and for making insecticides for pest control, due to the fact that the plant has repellant attributes to some insects (Okigbo *et al*., 2009).

It is a multipurpose, drought-resistant tree which can be cultivated in areas of low rainfall (Pratt *et al.,* 2002). The greatest advantage of *Jatropha curcas* is its capability to grow on marginal lands, its ability to reclaim problematic lands and restore eroded areas and its products diversity which include bio-diesel, soap and organic fertilizer production, and medicines for the treatment of skin and other human diseases (Heller, 1996; Henning, 2008).

Today, *Jatropha curcas has* gained much attention (Grimm, 1996; Heller, 1996; Henning, 2000a; Pratt *et al.,* 2002) for both non-oil and oil producing countries around the world. *Jatropha curcas* L, is a multipurpose plant, contains high amount of oil in its seeds which can be converted to biodiesel. *Jatropha curcas* is probably the most highly promoted oilseed crop at present in the world.

Jatropha can grow better on well-drained soils with good aeration. It can also adapt to marginal soils with low nutrient content and is not sensitive to variations in day length. *Jatropha* is also a fast growing plant, depending on factors such as rainfall conditions and the propagation materials used (stem cuttings or seeds).

Jatropha plant can actually survive in various soil texture such as poor stony soils (Aderibigbe *et al*., 1997), and the plant can also be grown in arid wastelands with high degree of acidity (Gadeker, 2006*).* The best soils for *Jatropha* are aerated sands and loams of at least 45 cm depth (Gour, 2006). Heavy clay soils are less suitable and should be avoided, particularly where drainage is impaired as *Jatropha* is intolerant of waterlogged conditions. Ability to grow in alkaline soils has been widely reported, but the soil pH should be within 6.0 to 8.0/8.5 (FACT, 2007). There is evidence from northwest India that *Jatropha* is tolerant of saline irrigation water, although yields under these conditions are not documented (Dagar *et al.,* 2006). The plant can grow in wastelands and grows on almost any terrain, even on gravelly, sandy and saline soils. It can thrive in poor and stony soils although new research suggests that the plant's ability to adapt to these poor soils is not as extensive as had been previously stated (Achten, 2008)

Jatropha is also known for its ability to survive in very poor dry soils in conditions considered marginal for agriculture, and can even root into rock crevices. However, survival ability does not mean that high productivity can be obtained from *Jatropha* under marginal agricultural environments. Based on these findings the objective of this study was to identify the best soil texture required for propagation of *Jatropha curcas* for optimum benefits in the rainforest agro-ecological zone of Nigeria.

Materials and Methods

The experiment was carried out at the Teaching and Research Farm of Agronomy Department, Delta State University, Asaba Campus, Asaba, Nigeria. The university is located on Latitude 6^o14'N and Longitude 6^o49' E in a tropical region with a mean annual rainfall of 1500.0 - 1847.3mm, mean annual temperature of 23.8^oC, mean humidity of 77.2% and monthly sunshine of 4.8 bars.(Ministry of Aviation 2016).

Seeds of Physic nut and 20cm stem cutting length (measuring 40mm by diameter) were sown in pots containing three different textures of soils namely: sandy loam, loam and clay. The seeds and stem cuttings were sown directly into polythene pots filled with 2.5kg of the different soil types. The soil samples were collected at a depth of 0-15cm with a tubular sampling auger. Representative soil samples of the three different soil media were taken and bulked, air-dried at an ambient temperature of 27.3^0 C for 3 days, sieved with a 2mm mesh sieve and taken for laboratory determination.

Soils collected were analyzed to determine texture and particle size composition as adopted by Aliero (2012). The samples were put together as samples A, B and C. Particle size distribution of the soil samples was determined by the hydrometer method with 0.5N Sodium hexameta-phosphate added as dispersing agent. The texture of the soils was finally determined using the USDA textural triangle.

The area for the experiment was cleared, debris packed and burnt in order to control crop diseases, weeds, pests, and to maintain crop yields. The pot experiment was a 2 x 3 factorial experiment in a completely randomized design, with propagation materials (seeds and stem cuttings) and soil textural types (sandy loam, loam and clay) as factors. The propagules (seeds and 20 cm stem cutting length) were sown in the three different soil textural types (sandy loam, loam and clay soils) on the same day. One seed and one stem cutting were sown in each of the polythene bags. The polythene bags were arranged and placed 1m x1m apart. The seeds were planted to a depth of 3cm while the stems were planted to a depth of 5cm in the soil. A total number of 54 polythene bags were used for the pot experiment which was replicated thrice.

Parameters Measured

Three plants were randomly selected from the rows and tagged for sampling for the pot experiment at 2, 4, 6, 8, 10 and 12 weeks after planting. The data collected were:

i. Plant height (cm), measured with a measuring tape from the base of the plant to the tip of the last leaf,
ii. Number of branches, determined by counting the branches of each of the 3 tagged plant,
iii. Number of leaves, which was also determined by counting the leaves of the 3 tagged plants,
iv. Leaf area (cm^2) were measured using a graph method.

Data collected were subjected to analysis of variance (ANOVA), while the significantly different means were separated with Duncan multiple range test (DMRT) test at 5% level of probability.

Results

Particle size distribution and chemical properties of the soil types

The particle size distribution and chemical properties of the soils used for the pot experiment are presented in Table 1. Sandy loam had the highest proportion of total sand (55.80%) while clay had the lowest (30.40%). Silt content was highest in loam and lowest in sandy loam (46.00% and 19.40% respectively).

Soil pH was generally acidic for all three textural types, and ranged from 6.3 for clay to 5.5 for loamy soil while the proportions of organic C, total N and available P were low for sandy loam, moderate for loam and high for clay. The amounts of Ca^{2+}, Mg^{2+} and K^{+} in the soil types were also highest in clay, moderate in loam and relatively low in sandy loam.

Effect of soil texture on seedling emergence

Days to emergence of seeds in sandy loam soil were 3.2 days, while those of seeds sown in loam and clay soils were 4.7 and 6.0 days respectively (Figure 1a). The seeds planted in sandy loam soil emerged first, followed by loamy soil and the last were those planted in clay soil. Significant ($P < 0.05$) differences were observed in percentage germination of the seed among the different soil textures.

Percentage germination of seeds planted in sandy loam soil was 86%, followed by loam having 62% germination and clay soil having 49% germination (Figure 1b). It was observed that germination of *J. curcas* seed was significantly ($P<0.05$) better in sandy loam soil than in loamy and clay soils. Seeds planted in clay soil had the least germination percentage and the least emergence rate.

Table 1: Particle size distribution and chemical properties of the soils used for the pot experiment

Particle Size Diet	Sandy loam	Loam	Clay
Fine sand (%)	15.80	26.80	10.00
Coarse Sand (%)	40.00	7.80	20.40
Total Sand (%)	55.80	34.60	30.40
Silt (%)	30.00	46.00	19.40
Clay (%)	14.20	20.20	50.20
Soil pH (H_20)	5.6	5.5	6.3
Organic C (%)	0.76	0.86	1.24
Total N (%)	0.58	0.76	0.76
Avail. P ($mgkl^{-1}$)	8.32	8.76	10.24
Ca (Ca^{2+})(mmol)	3.45	4.20	5.35
Mg (Mg^{2+})(cmol)	0.76	1.58	2.40
K (K^+)(cmol)	0.17	0.23	0.35
CEC (cmol(+)/kg	8.35	12.14	14.13

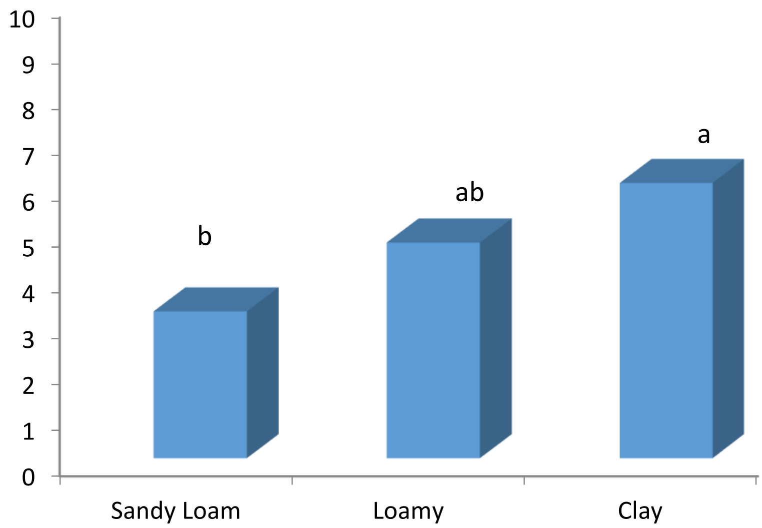

Figure 1a: Effect of soil texture on days to seedling emergence

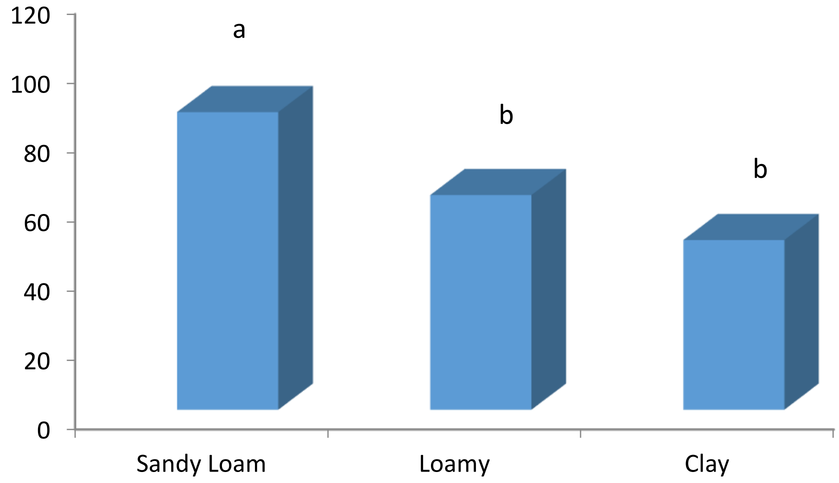

Figure 1b: Effect of soil textures on percentage germination of seedings

Effect of soil texture on sprouting of stem cuttings

The effect of soil type on days to sprouting of the stem cuttings is shown in Figure 2a. The effect of the three soil texture on the sprouting of the stem cutting showed that there were significant ($P < 0.05$) differences among the different soil textures. Stem cuttings planted in sandy loam sprouted first, and also recorded highest number of stem sprouts. The percentage of sprouted stem cuttings (Figure 2b) was higher in sandy loam soil followed by loamy soil and the least was recorded in clay soil. Percentage number of sprouted stem cuttings in sandy loam soil had 45% germination in 12.8 days, while that of loamy soil was 39% in 18.4 days and clay soil 26% in 23.9 days.

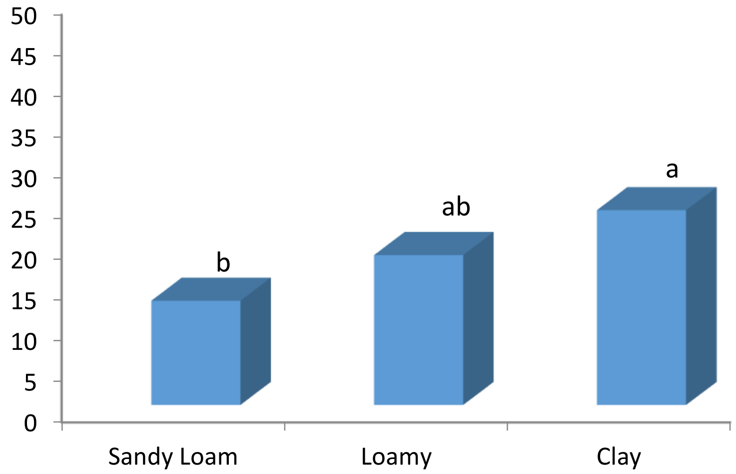

Figure 2a: Effect of soil types on days to sprouting of stem cuttings

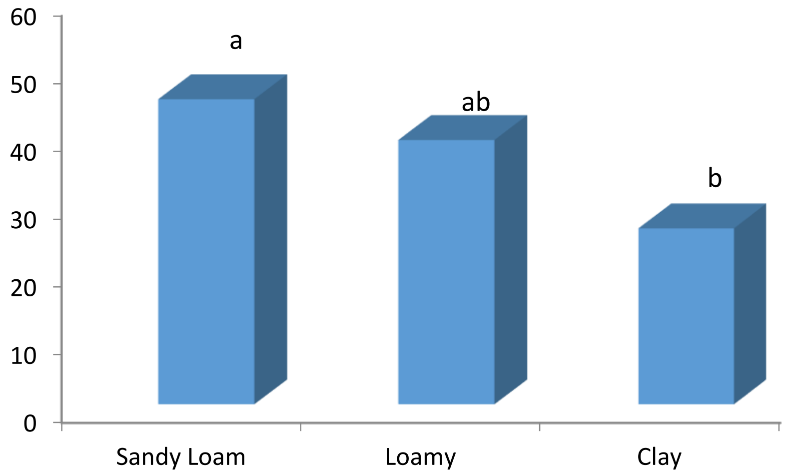

Figure 2b: Effect of soil types on percentage germination of sprouted cuttings

Effect of soil textures on the growth of seeds

The results obtained from the effect of three soil textures on the growth of seeds of *J. curcas* are presented in Table 2.

Table 2: Effect of Soil Textures on Growth Parameters of *Jatropha* Propagated by Seed at Different Weeks after Planting (WAP)

	WAP					
Soil types	**2**	**4**	**6**	**8**	**10**	**12**
Number of Leaves						
Sandy Loam	3.3a	4.7a	13.7a	19.0a	25.3a	30.3a
Loamy soil	1.7b	2.7b	4.0b	9.3b	11.3b	12.7b
Clay	0.3c	0.0c	2.2c	4.0c	5.3c	6.0c
Number of Branches						
Sandy Loam	2.0a	2.7a	4.3a	5.7a	5.7a	7.0a
Loamy soil	0.7b	1.3b	1.7b	2.0b	2.0b	2.7b
Clay	0.7b	1.0c	1.0c	2.0b	2.0b	2.0c
Leaf Area (cm^2)						
Sandy Loam	1020a	1275a	1594a	2360a	2679a	3285a
Loamy soil	191b	287a	382b	542b	701b	82b
Clay	45c	95b	287c	310b	382c	478c
Plant Height (cm)						
Sandy Loam	5.3a	9.3a	11.3a	14.7a	19.3a	26.0a
Loamy soil	2.0b	2.7b	3.0b	5.0b	7.7b	11.0b
Clay	0.7b	1.0c	2.0c	2.0c	4.0c	5.0c

a,b,c: Within each column, within a variable, means with different letters are significantly different ($P<0.05$)

The results showed that there were gradual increases in the growth characters such as plant height, number of branches, number of leaves, and leaf area with plant age in the different soil textures. The results further indicated that there were significant differences at $P \leq 0.05$ among the soils textures.

The highest mean values of 26.00cm, 7.00, 30.33 and 3285cm^2 for plant height, number of leaves, number of branches and leaf area respectively were recorded for sandy loam soil at 12 weeks after planting and the lowest mean values of 5.00cm for plant height, 2.03 for number of branches, 6.00 for number of leaves and 478.4cm^2 for leaf area were recorded for clay soil at 12WAP respectively.

Throughout the sampling period, plant height ranged from 0.68cm to 26.00cm, number of branches ranged from 0.66 to 7.00, number of leaves ranged from 0.29 to 30.33 and leaf area ranged from 45.4cm^2 to 3285cm^2 for sandy loam soil

Effect of soil texture on the growth of stem cuttings

The effect of soil textures on 20cm stem cutting is recorded in (Table 3). The results showed that there was a gradual increase in plant height and number of leaves with plant age.

Table 3: Effect of Soil Texture on Growth at different weeks after planting (WAP) of *Jatropha* propagated by stem cuttings

	WAP		
Soil Types	**4**	**8**	**12**
Number of Leaves			
Sandy Loam	8.5a	17.0a	23.3a
Loamy soil	2.0b	3.3b	7.0b
Clay	3.3b	5.3b	8.3b
Leaf Area (cm^2)			
Sandy Loam	569.3a	665.0a	762.6a
Loamy soil	364.5b	353.2b	582.7b
Clay	387.5b	560.7a	349.2c
Plant Height (cm)			
Sandy Loam	12.0a	10.0a	18.6a
Loamy soil	3.7c	5.7b	10.6b
Clay	6.7b	8.7b	7.6c
Number of Branches			
Sandy Loam	3.0a	3.0a	8.7a
Loamy soil	2.0b	3.7a	6.0a
Clay	2.7a	4.7a	7.0a

a,b,c: Within each column, within a variable, means with different letters are significantly different ($P<0.05$)

Significant differences at $P \leq 0.05$ were observed in plant height at 4 and 12 weeks after planting. Throughout the sampling period for the stem cuttings, the plant height ranged from 3.66cm to 18.6cm, number of branches from 2.00 to 8.66, number of leaves from 2.00 to 9.33 and leaf area ranged from 349.2cm^2 to 762.6cm^2.

The highest mean values of 18.6cm, 8.66, 9.33 and 762.6cm^2 for plant height, number of branches, number of leaves and leaf area respectively were obtained at 12 weeks after planting (WAP) for sandy loam, while the lowest mean values of 7.60cm, 7.00, 8.33 and 349.2cm^2 for plant height, number of branches, number of leaves and leaf area respectively were recorded for clay soil at 12 WAP. The effect of soil on the stem cuttings, from Table 3, showed that stem cuttings planted in sandy loam performed best in growth characters among the other two soil textures, loamy and clay soil. No significant differences were observed in the leaf area and number of branches at 8 and 12 weeks after planting.

Effect of propagule and soil texture interaction on Plant height (cm), Number of Leaves, Number of branches and Leaf area (cm^2).

The interaction effect between propagules and the three different soil textures is presented in Table 4. There was gradual increase in plant height, number of leaves, number of branches and leaf area with the age of the plant throughout the sampling period. Significant differences were observed ($P \leq 0.05$) in the interaction between propagules and the different soil textures in plant height and number of leaves throughout the sampling period.

Table 4: Effect of Propagule and Soil Texture Interaction on Number of Leaves, Plant height, Leaf area and Number of Branches at Different Sampling Periods

Types of propagule	Types of soil	Number Leaves	Plant Height (cm)	Leaf Area (cm^2)	Number of Branches
Week 4					
Seed	Clay	8.33	14.66	1148	9.00
	Sandy Loam	17.66	40.66	3603	8.66
	Loamy	8.33	13.00	2136	11.0
Stem	Clay	4.00	3.00	382	1.66
	Sandy Loam	13.00	11.33	1594	4.33
	Loamy	2.00	3.33	382	5.00
Propagule x soil type		*	*	*	**NS**
Week 8					
Seed	Clay	25.33	27.66	2583	24.6
	Sandy Loam	42.66	64.66	7814	32.0
	Loamy	35.33	27.00	4751	27.0
Stem	Clay	41.10	6.00	701.0	2.00
	Sandy Loam	25.00	19.33	2679	5.66
	Loamy	3.33	5.88	349	4.43
Propagule x soil type		*	*	*	**NS**
Week 12					
Seed	Clay	40.00	38.33	3763	32.0
	Sandy Loam	59.00	61.00	8962	51.3
	Loamy	94.00	109.30	1738	68.3
Stem	Clay	14.00	8.66	924	3.33
	Sandy Loam	38.00	26.66	4241	7.00
	Loamy	7.00	8.33	574	9.33
Propagule x soil type		*	*	**	**

* = Significant at 5% level of probability
** = Significant at 1% level of probability; NS = Not significant

The interaction of seed and sandy loam soil had the highest values for number of leaves, plant height and leaf area while the interaction seed and clay soil recorded the lowest values in plant height, number of leaves and leaf area at 4, 8 and 12 Weeks after planting (Table 4).

The interaction of stem and sandy loamy soil also had the highest values for plant height, number of leaves, number of branches and leaf area while the interaction of stem and clay soil also recorded least values in plant height, number of leaves, number of branches and leaf area at 4, 8 and 12WAP.

Discussion

The soil textures used for the study were subjected to particle size analysis to actually ascertain their textural classes. Clay soil was well structured, coherent, sticky and had plastic properties. Due to its compact nature, clay has a great tendency to hold water and nutrients. The sandy loam soil was characteristically sandier. The soil is loose, slightly sticky and slightly plastic. The water- and nutrient-holding capacity of this soil is moderate. The tendency of this soil to support plant growth is good due to the attributes of sand, silt and clay composition (Carter and Gregorich, 2008).

The results obtained from this work showed that *J. curcas* performed best in sandy loam soil and the reason could be that *J. curcas* is very well adapted to relatively sandy but fertile soil conditions, such as sandy loam, than to more compact soils like clay and loamy soils irrespective of the fact that loamy soils are said to be the best for agricultural purposes.

Loamy soils contain good proportions of soil fractions, sand, silt and clay. All the characteristics of these fractions are imparted in loamy soils, hence they are regarded as agricultural best soils (FMANR, 1990). They also have good aeration, water- and nutrient-holding capacity, are slightly sticky and coherent, well-structured and firm. From the results obtained in this work, *J. curcas* seedlings and stem cuttings also performed well in this soil, but not as well as in sandy loam.

Days to seedling emergence and germination percentage

The effect of different soil textures on days to emergence showed that *J. curcas* seeds thrived well in sandy loam soil, followed by loamy soil while the least days of emergence were observed in clay soil.

In terms of germination percentage, sandy loam soil also had the highest value of 86%, followed by loamy soil (62%) and clay soil (49%).

Days to emergence of seedling in sandy loam soil was 3.2 days while that of loamy soil was 4.7 days and clay 6.0 days. The seeds planted in sandy loam soil emerged first, followed by seeds planted in loamy soil and the last to emerge were seeds planted in clay soil.

This result agrees with the findings of a previous work by Heller (1996) who evaluated the growth and structural responsiveness of young *J. curcas* plants to sand, sandy-loam, and clay-loam from eastern Mexico. His findings demonstrated that loamy and sandy loam supported highest seedling emergence probably because of the good pore spaces found in this soil which allow for easy passage of air between the pore particles, and permit unhindered elongation of the radicle and plumule at germination. Clay soils are less suitable, and should be avoided, due to the tiny pore spaces, particularly where drainage is impaired, as *Jatropha* is intolerant of waterlogged conditions. Gour (2006) stated that the best soils for *J. curcas* are aerated sands and loams of at least 45 cm depth, and that heavy clay soils are less suitable and should be avoided.

Days to stem cutting sprouting

Sprouting of the stem cuttings were higher in sandy loam soil, followed by loamy soil and the least was recorded in clay soil. Clay had the least number of sprouted stem cuttings throughout the sampling period. The soil with earliest days to stem cutting sprouting were recorded in sandy loam soil in 12.8 days followed by loamy soil sprouting in 18.4 days and clay soil in 23.9 days. The least number of sprouted stem cuttings were recorded in clay soil but highest were recorded sandy loam soil. This result tallies with the results reported by Achten *et al.* (*2007*) that clay soils were less suitable media for propagation of *J. curcas* because they limited root system development, especially when they were saturated.

Effects of soil textures on growth characters of Jaropha curcas

Observation from the results clearly indicated that there were gradual increase in the growth characters such as plant height, number of branches, number of leaf and leaf area with plant age at 4, 8, 12, 16, 20 and 24 weeks after planting .

Throughout the sampling periods there were significant differences at ($P \leq 0.05$) for the seeds and stem cuttings planted in the different soil types. The increase in growth parameters is apparently depending on different treatments (Jongschaap *et al*, 2007; Achten *et al.,* 2008). The result obtained here also agrees with an earlier work done by Montes (2008) in which he who reported variability in plant architecture between different accessions.

Conclusions and Recommendation

The study evaluated the effect of three textural classes on *J. curcas* propagation, and the best stem cutting length for field the plant's establishment in the rainforest zone of Nigeria. The days to seedling emergence, days to stem cutting sprouting, germination percentage and most suitable soil type for propagating the plant were investigated. The study has demonstrated that

i. Sandy loamy soil was the most suitable soil texture type for propagating *J. curcas* by seed and stem cuttings in the area of study.

ii. Significant differences were observed in plant height, number of leaves, number of branches, leaf area, number of flower, number of fruits, number of pod and seed weight among the different length of stem cuttings.

iii. It is therefore, recommended that sandy loam soil which had comparably high emergence ability and growth performance be adopted as the best soil textural type for propagation of *J. curcas.*

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