Effects of Different Stem Cutting Lengths on the Growth and Yield of Physic Nut (*Jatropha curcas* L.) in the Rainforest Agro-ecological Zone of Nigeria

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Abstract

This study was conducted to evaluate the effects of different lengths of stem cuttings on the growth and yield of physic nut plant (Jatropha curcas L.). The experiment was carried out at the Teaching and Research Farm of Delta State University, Asaba Campus, Asaba, Nigeria. Three lengths of stem cuttings used were: 40cm, 50cm and 60cm. A cumulative seed weight/yield of 2,313kg/ha, 1,649kg/ha and 910kg/ha were obtained for 60cm, 50cm and 40cm stem cuttings respectively. The results of the oil extracted also showed that 12.2kg of seeds processed from 60cm stem cutting produced highest oil quantity of 350ml, followed by 8.4kg of seeds from 50cm stem cuttings producing 240ml and 3.8kg of seeds from 40cm cuttings produced 120ml of oil quantity. The results showed that the 60cm stem cutting length performed better in growth characters and yield related components when compared with the 50cm and 40cm stem cutting lengths. Significant yield differences were observed among the different stem cutting lengths.

Keywords: *Jatropha curcas*, stem cuttings, growth, yield, oil.

Introduction

Physic nut *(Jatropha. curcas* L*)* I is a drought resistant large shrub or small tree, belonging to the genus *Euphorbiaceae*. It is a multipurpose plant which can be cultivated in areas of low rainfall (Pratt *et al.*, 2002). *Jatropha* is suitable for quick and efficient domestication compared with other woody species (Achten *et al*., 2010). There are various names used to describe the plant per region/country. It is most commonly known as Physic nut, but goes by different names in different localities. In Mali, it is known as *Pourghere*, as *bagani* in the Ivory Coast, *tabanani* in Senegal, and as *makaen/mmbono* in Tanzania. In Nigeria it is known as *binidazugu/cinidazugu* in Hausa, *lapa lapa* in Yoruba, and *Wuluidu* in Igbo (Blench, 2003, 2007). Producing oil-containing seeds (Jongschaap *et al*., 2008), *Jatropha curcas* L. is the commonest species of the plant found in Nigeria, although many other species exist in different parts of the world.

Jatropha grows better on well-drained soils with good aeration, and is well adapted to marginal soils with low nutrient contents and is not sensitive to variations in day length. *Jatropha* is also a fast-growing plant, and depending on many factors such as rainfall conditions, it can be propagated from stem cuttings or from seeds. Cuttings are a fast and cheap way of propagating *Jatropha*. Traditionally, however, cuttings of fifty to sixty centimetres long, or slightly more, are generally used by farmer to establish their live fences (Henning, 2009). One advantage of stem cuttings is that they are clones with the same genetic characteristics as the mother plant, and in case a high yielding mother plant

is selected, the cuttings will have the same properties. Usually, the survival rate of the plant depends on the length and thickness of the cutting. Recommended size for stem cutting length varies from 25 to 120 cm. Cuttings taken from the middle or lower parts of year-old branches show greater survival rates (Kaushik and Kumar, 2006, cited in Achten, 2008).

There are major constraints to *Jatropha curcas* cultivation in Nigeria (Yammama, 2011), which include poor knowledge of suitable stem cutting length for propagation (Henning, 2000). Cuttings of *Jatropha* usually root more quickly and grow faster into productive trees than seeds do. Opinions are divided on the cutting lengths that are ideal for use by farmers for best growth and productivity of *Jatropha.* This study was therefore designed to determine the most suitable stem cutting length for the growth and yield of *Jatropha* in rainforest agro-ecological zone of Delta State, Nigeria.

Materials and Methods

The experiment was carried out at the Teaching and Research Farm of the Department of Agronomy, Delta State University, Asaba Campus, Asaba, Nigeria. The Farm is located on Latitude 5º 31' N and Longitude 5º45' E, in a tropical climatic region which has mean annual rainfall of 1500.0 - 1847.3mm, mean annual temperature of 27ºC, mean humidity of 77.2% and monthly sunshine of 4.8 bars (Ministry of Aviation, 2016).

Field Establishment and Experimental Design

Surface soils (0-15cm) were sampled with a tubular sampling auger. The field experiment was carried out using three different stem cutting lengths of 40cm, 50cm and 60cm.

A field measuring 48m x 18m and covering an area of 864m^2 was cleared, ploughed and harrowed to enable soil aeration and easy root penetration. The area was divided into three blocks of 4 plots per block. Each plot measured 12m x 6m each, with 1m between plots and 1m between blocks.

The three stem cutting lengths of *Jatropha,* 40cm, 50cm and 60cm each, with an approximate stem diameter of 40mm, were planted directly in the field in June 2013. The stem cuttings were spaced 2m x 2m apart (Achten, 2008) such that each plot had 12 stands in 4 rows. The stem cuttings were planted at a depth of 5cm in the soil. Weeding was done manually at three weekly intervals.

Parameters Measured

Three plants were randomly selected from the rows and tagged for sampling at 4, 8, 12, 16, 20, 24 and 28 weeks after planting. The following data were collected:

Plant height (cm), which was measured using a measuring tape from the base of the plant to the tip of the last leaf, Number of branches, which was determined by counting the branches of the 5 tagged plants, and Number of leaves which was obtained by counting the leaves of the 5 tagged plants. Leaf area (cm^2) was measured using the graph method, while Number of pods and Number of seeds were obtained by counting the number of dried pods and seeds respectively. Seed weight (kg/hectare) was determined by weighing the seeds collected from the tagged plants with the use of a weighing balance

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

Results

Variations in the cumulative number of stem cuttings (40cm, 50cm and 60cm long) of *Jatropha* with open buds, and number of dead stem cuttings at 4, 8, 12 and 16 weeks after planting are presented in Table 1. The results show that there were significant ($P < 0.05$) differences among the different cutting lengths. Four weeks after planting in the field, about 12% of 60 cm stem cuttings had produced open buds. The 60cm stem cutting length was also the first to sprout. The 60cm stem cutting sprouted 9 days after planting, while 50cm stem cutting and 40cm stem cutting sprouted at 16 and 23 days after planting respectively. At eight weeks after planting, the percentage of stem cuttings with open buds had increased to 60% for 60cm stem cutting length, (30%) for 50cm stem cuttings and (16%) for the 40cm stem cuttings. By twelfth week, the percentage of cutting with open buds reached 80% for the 60cm stems, 60% for 50cm stem cuttings and 20% for the 40cm stem cuttings.

Table 1: Cumulative number of stem cuttings (40cm, 50cm, 60cm long) with open buds and number of dead stem cuttings at different sampling periods

	Weeks After Planting (WAP)											
	4			8			12			16		
Parameters	40	50	60	40	50	60	40	50	60	40	50	60
Stem cuttings with open buds	10c	14b	17a	26c	33b	43a	45c	69b	86a	58c	101b	130a
Dead stem cuttings	15a	10b	9b	24a	13b	7c	26a	14b	8c	26a	18b	14c
Total	25a	24a	26a	50a	46a	50a	71c	83b	94a	84c	119b	144a

a,b,c: Within each row within each WAP, means with different letters differ significantly ($P<0.05$)

By the sixteenth week, the 60cm stem cutting length had about 90% sprouting rate compared to the 50cm which had about 70% while 40cm stem cuttings which had about 40% sprouted stem cuttings. Also four weeks after planting about 25% of 40cm stem cuttings had died. The 60cm stem cutting recorded least dead stem cuttings followed by the 50cm stem cutting at 4, 8, 12, and 16 weeks after planting respectively, while the 40cm stem cuttings recorded the highest number of dead stems during the planting season. At eight weeks after planting, the percentage of dead stem cuttings increased to 30% for 40cm stem cutting length, (12%) for 50cm stem cuttings and (5%) for the 60cm stem cuttings. By twelfth week, the percentage of dead stem cutting had reached 47% for 40cm stem cuttings, 24% for 50cm stem cuttings and 8% for 60cm stem cuttings. By the sixteenth week, the amount of dead cutting stems from 40cm stem cutting length had increased to 60% compared with 50cm and 60cm stem cuttings which had about 30% and 10% dead stem cuttings respectively.

Assessment of Plant Growth Parameters

The growth parameters of the different stem cutting lengths of *J. curcas* assessed at 4, 8, 12, 16, 20, 24, and 28 weeks after planting (WAP) are presented in Table 2. The results indicate that there were gradual increases in all the growth parameters with plant age for the different stem cutting lengths. Stem cutting length therefore significantly ($P < 0.05$) influenced all the growth parameters measured in the resulting plants. The 60cm stem cutting length produced significantly higher plant heights, number of leaves and leaf areas, followed by the 50cm stem cuttings while the least values of these parameters were observed in the 40cm stem cuttings. The highest mean plant height values of 51.6, 103.3,

and 108.6cm were recorded for 60cm stem cutting lengths at 12, 16 and 24 WAP while the least mean values of 31.6, 63.6, and 140.7cm for plant height were recorded for 40cm stem cutting lengths at 12, 16 and 24 WAP respectively. The highest mean values of 230.3cm for plant height and 248.6 for number of leaves were recorded for 60cm stem cutting length at 28 weeks after planting. The highest mean values of 11.00 and 24879cm^2 for number of branches and leaf area respectively were also recorded for the 60cm stem cutting length at 28 WAP (Table 2).

Table 2: Effect of different stem cutting length of *Jatropha* on Number of Leaves, Plant height (cm), Number of branches, Leaf area (cm^2) on different stem cutting lengths

	Weeks After Planting						
Stem cuttings	**4**	**8**	**12**	**16**	**20**	**24**	**28**
Number of Leaves							
40	8.66b	22.33b	64.66b	82.6c	161.3a	182.0b	197.5b
50	8.66b	28.33b	58.00b	108.0b	110.0b	170.3b	189.0b
60	10.66a	38.00a	89.33a	136.0a	160.3a	236.3a	248.6a
Plant Height(cm)							
40	3.10a	8.00a	31.6b	63.6b	123.6a	140.6b	172.6b
50	2.82a	8.90a	41.3b	68.33b	118.6a	141.3b	180.5b
60	3.33a	9.36a	51.6a	103.3a	117.6a	180.6a	230.3a
Number of branches							
40	7.00b	3.00c	9.30a	4.33b	9.00b	9.00a	10.00a
50	7.66b	6.33b	9.00a	3.66b	7.66b	9.00a	11.00a
60	10.66a	12.66a	8.30a	7.00a	12.66a	10.66a	11.00a
Leaf area (cm^2)							
40	2508b	7176a	1245a	1694b	1862a	2115a	22391a
50	2672b	8152a	1359a	1617b	1909a	2137a	23692a
60	4731a	8286a	1579a	1933a	2086a	2405a	24879a

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

Table 3: Effect of different stem cutting lengths on Number of pods and seed weight at different sampling periods

	Weeks After Planting				
	16	20	24	28	Total Cumulative Yield
Stem cuttings					(kg/ha)
Number of Pods/plant					
40cm	10.33b	288.3a	188.0b	174.5c	661.13b
50cm	104.61a	236.3a	241.8b	275.8b	858.51ab
60cm	111.00a	191.0a	289.3a	365.2a	956.5a
Seed Weight (kg/ha)					
40cm	58.25c	625.0a	70.0c	175.5c	910c
50cm	125.8b	508.2b	465.0b	555.0b	1946b
60cm	558.3a	466.8c	605.0a	682.5a	2318a

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

Effects of Different Stem Cuttings on Yield

The effect of different stem cutting lengths on the yield of *J. curcas* is presented in Table 3. The results show that the *Jatropha* stem cutting length of 60cm performed better than the 50cm stem cutting length and the 40cm stem cutting length in the variables assessed. The results also show that there were significant differences in total fruit yield/plant determined in the stem cuttings.

Significant ($P < 0.05$) differences were observed in yield and yield components among the different stem length cuttings of the *Jatropha* plant as assessed. The highest yield values of 558.2kg/hectare, 4,66.7kg/hectare, 605kg/hectare and 682.5kg/hectare were recorded for 60cm stem cuttings at 16, 20, 24 and 28 weeks after planting (WAP) respectively, while the least yield values of 58.25kg/hectare, 625kg/hectare, 70kg/hectare and 157.5kg/hectare were recorded for 40cm cutting lengths at 16, 20, 24 and 28 WAP.

The 60cm stem cuttings performed highest in fruit yield and were first to fruit and mature. The highest total cumulative yield values of 2,313kg/hectare were recorded for 60cm stem cuttings, while 40cm stem cutting lengths were the least to fruit and mature and it also had the least total cumulative yield value of 910kg/hectare.

Table 4 shows the quantity of seeds, volume of oil extracted and weight of nut cake associated with the different stem cuttings. These variables generally increased significantly ($P < 0.05$) with increase in stem cutting length.

Table 4: Quantity of oil Extracted and Weight of Physic Nut

	Stem cuttings (cm)		
Yield	**40**	**50**	**60**
Quantity of Seeds (kg/ha)	3.8b	8.4b	12.2a
Quantity of Oil (ml)	120c	240a	350?
Physic Nut Cake (kg)	1.7c	2.2b	3.8a

a,b,c: Within each row, means with different letters differ significantly ($P<0.05$)

Discussion

Field Establishment of Jatropha curcas Using Different Stem Cutting Lengths

From the results shown in Table 1, the different stem cutting lengths of *Jatropha* planted directly on the field, shows that 60cm stem cutting length and 50cm stem cutting length performed better in growth characters than the 40cm stem cutting lengths. The 60cm stem cutting lengths also had higher survival rate than the 50cm and 40cm stem cutting lengths.

From the results it was also observed that the 60cm stem cutting length performed better in yield than the 50cm and 40cm stem cutting length. Daey Ouwens *et al.,* (2007) in his research work stated that traditionally, cuttings of fifty to sixty centimeters long, or slightly more, are generally used by farmer to establish their live fences and his finding also agrees with the result of this research work.

Studies have also shown on the other hand that cuttings shorter than 10 cm have a very low survival rate and are not suitable for *J. curcas* propagation (Heller, 1996). Many other variables can influence the establishment of *J. curcas* such as direct planting of cuttings/cutting materials (length, diameter of branch, age, location of the cutting in the

tree), cutting time, storage of cuttings, fungicide treatment, planting time, depth of planting, soil moisture content and weed clearance (Heller, 1996).

Seed Yields of Jatropha curcas

Significant differences were observed in the seed weight/yield values among the different stem cuttings lengths planted in the field. The yield was highest with the 60cm stem cutting length; followed by 50cm stem cutting length and the least yield was obtained from 40cm stem cutting lengths. The 60cm stem cutting lengths had highest mean values of number of seed pods and seed weight, followed by 50cm stem cutting length and the least were in 40cm stem cutting lengths.

These differentials in yield values could be due to influence of the size of planting materials used which directly affected the plant establishment (Daey Ouwens *et al*., 2007). Research findings on yield of *Jatropha* have also shown that seed weight per 1000 seeds of 556.9g was obtainable (FACT, 2007), which is in consonance with the results of the seed weight obtained in this work.

Oil Extraction

The significantly higher quantity of oil extracted from seeds of 60cm stem cutting length as against smaller quantities obtained from seeds of the 50cm and 40cm stem cuttings must have been due to the significantly higher seed yield (number of pods, seeds and total seed weight) obtained from the 60cm cuttings. The least seed yield and quantity of oil were obtained from plants established with the 40cm stem cuttings. Therefore the differentials in the quantity of oil produced could be affected by the amount of seeds harvested and processed from each plot.

The quantity of oil obtained in this work was very small compared with that reported by Achtens *et al.* (2008), who used the Bielenberg ram press method which is a simple traditional method for *Jatropha* oil extraction, and produced 1 litre of oil from 4 kg of seeds. The difference in the quantity of oil obtained in this work may be attributed to the difference in the methods used in extracting oil from the seeds.

Conclusion

The study evaluated the effect of three different stem cutting lengths on the growth and yield of *J. curcas* propagation, in Oshimili South local Government Area of Delta State, Nigeria. The study has demonstrated that use of 60cm stem cuttings as against shorter stem cuttings (50cm or 40cm) for the propagation of *Jatropha curcas* resulted in significantly higher plant heights, number of leaves, number of branches, leaf area, number of flowers, number of fruits, number of pods and seed weights among the different length of stem cuttings, and the highest cumulative seed weight/yield value of 2,313kg/hectare while the 40cm stem cutting lengths produced the least cumulative seed weight/yield value of 910kg/hectare.

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