EFFECTS OF ORGANIC MANURE ON THE GROWTH OF *JATROPHA CURCAS L* SEEDLINGS IN ANYIGBA KOGI STATE, NORTH CENTRAL NIGERIA

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Abstract

A pot experiment was conducted to assess the effect of organic manure on the growth of Jatropha curcas L seedlings at the Faculty of Agriculture, Kogi State University, Anyigba. There were seven treatments, namely, three (3) levels of poultry droppings (PD) (20g, 40g and 60g/kg soil) designated as T_1, T_2 and T_3, respectively, three (3) levels of solid cattle dung (CD) (40g, 80g and 120g/kg soil designated as T_4, T_5 and T_6), respectively, and control (no organic manure) designated as T7. All the treatments were replicated three (3) times. Jathropha curcas L seeds were sown into plastic buckets and observed for the period of six (6) weeks. Growth parameters measured were plant height, leaf count, stem girth, numbers of branches and fresh weight. Mean separation using F-$LSD_{0.05}$ showed that 80g cow dung/kg soil (T_5) gave optimal level of organic manure required for Jatropha curcas throughout the growth period of the seedlings. All the treatments having organic manure were significantly better than the control ($P < 0.05$) except at two weeks after planting where all the treatments gave the same number of leaves and at the sixth week after germination where only 80g branches. As a result, 80g cow dung/kg soil (T5) is therefore recommended for raising Jatrophus curcas L seedlings in Anyigba, Kogi State.

Key words: *jatropha curcas, cow-dungs, seedlings, poultry dropping, plastic bucket*

INTRODUCTION

Jatropha curcas L. (Latin name) is often referred to as "Jatropha". It is a plant that produces seeds with high oil content (FACT, 2011). *Jatropha curcas* L. is a species of flowering plant in the spurge family Euphorbiaceae that is native to the American tropics, most likely Mexico and Central America (Janick and Robert, 2008).

FACT (2011) described Jatropha as a promising crop with many applications. As a result, current interest by investors, farmers and non-governmental organization (NGOs) is mainly attributed to its' potential as an energy crop. It has the capacity of reducing soil erosion caused by rain water possibly by the profusion of the adventitious and lateral roots near the surface which binds the soil and keeps it from being washed out by heavy rains. Jatropha hedges reduce wind erosion by lessening wind velocity and binding the soil with their surface roots (Henning, 2004). Jatropha tree can also serve as fuel woods where suitable species are unavailable. This is because of it hollow and soft nature. Jatropha is used in many tropical and sub-tropical countries for land demarcation and livestock barrier since the leaves are toxic and a non-target source of feed for livestock. Jatropha helps in rehabilitation of degraded lands since they are able to use their tap root to extract minerals leached down the profile and help return them back through leave fall and other organic remains. Heller (1996), reaffirmed that Jatropha extract have many uses in traditional societies. The extract from the stem (latex) has medicinal qualities of stopping bleeding and healing of wounds, and as remedy for various skin problems. The bark and roots can be used to prepare fish poison. A decoction of the root can be used to treat diarrhoea and gonorrhoea. The dried and pulverized root bark is made into poultices and taken internally and externally to expel worms and treat jaundice. The leaves can be used to treat malaria, hypertension, cough and as antiseptic after child birth. The leaves sap is used externally to treat haemorrhoids. The current interest in the seed is because it is used for biofuel, soap making and for illumination. The oil can induce abortion when applied internally and externally (FAO, 2010). in that, the seeds can be processed into bio-oil that has good characteristics for direct combustion in

compressed ignition engines or. The pressed residue of the seed (press cake) is a good fertilizer and can also be used for biogas production.

Jatropha curcas L. has been identified as most suitable oil seed bearing plant as a result of its numerous encouraging qualities like short gestation period, compliance in a wide range agro-climatic conditions, high oil recovery and quality and hardy nature. It can be planted on degraded lands through Joint Forest Management (JFM), as farmer's field boundaries, road sides, both sides railway track, fallow lands and as agro forestry crop. The use of organic manure on the other hand reduce dependence on inorganic fertilizers which are characterized with supply of only specific nutrients in them to the soil, but fertilizer from organic source increases soil organic matter, cation exchange capacity(CEC) and a host of macro and micro essential plants nutrient. According to Maheswarappa *et al* (1999), the use of organic manures to meet the nutrient requirement of crops would be an inevitable practice in the years to come for sustainable agriculture since organic manure generally improves the soil physical, chemical and biological properties along with conserving the moisture holding capacity of soil thus resulting in enhance crop productivity along with maintaining the quality of crop produce.

Information on *Jatropha curcas* L. is pausy as a multi-purpose plants, efforts are being made to make available, conditions under which it can be used on large scale. Finally, the research strives for reduction in total dependence on the use of inorganic fertilizer due to the current economic implications. The objectives of this study are to assess the response of *Jatropha curcas* L. seedlings to different levels and sources of organic manure and to recommend the optimum level of organic manure suitable for the growth of *Jatropha curcas* L. seedlings.

MATERIALS AND METHODS

Soil Sampling. Soil samples were collected at the predetermined depth of 0-15cm from farm land within the Kogi State University Research and Demonstration farm, air dried sieved and passed through 2mm sieve. The soil samples were analysed in the Soil and Environmental laboratory for physical and chemical properties.

Soil Analysis. The P^H of each sample was read using a P^H meter according to Maclean, 1982. The electrical conductivity was measured using the EC electron. (Rayment et al.,2011). The percentage clay, silt and sand were determined according to Bouyocous (1962). The textural classes of the soils were determined using the textural triangle. Organic carbon and organic matter were determined by wet dichromate acid oxidation method (Nelson and Sommers, 1982). The nitrogen content of the soil was determined using Kjeldahl method. (Bremner and Mulvancy, 1982). Available phosphorus was determined by Bray and Kurtz (1945) extraction procedure. The exchangeable cations Ca^{2+}, Mg^{2+}, Na^{2+} and K^+ were extracted in ammonium acetate solution (NH_4OAC) buffered at pH 7 (Thomas, 1982). Exchangeable Acidity (Al^{3+} and H^+) were extracted with KCl (Thomas, 1982) and determined by titration with 0.05n NaOH using phenolphthalein as indicator. Percentage base saturation was calculated by multiplying the quotient of TEB to ECEC by 100

$$\%\ \text{Base saturation} = \frac{Ca + Mg + K + Na}{ECEC} \times 100$$

Manure Analysis. Samples of poultry manure (PM) and cow dung (CD) were taken to Biochemistry Laboratory, Faculty of Natural Science, Kogi State University, Anyigba for nutrients composition analysis. The samples were analyzed for total N, P and K following the procedures outlined in the soil analysis section. The results of these analyses are in Table 2.0.

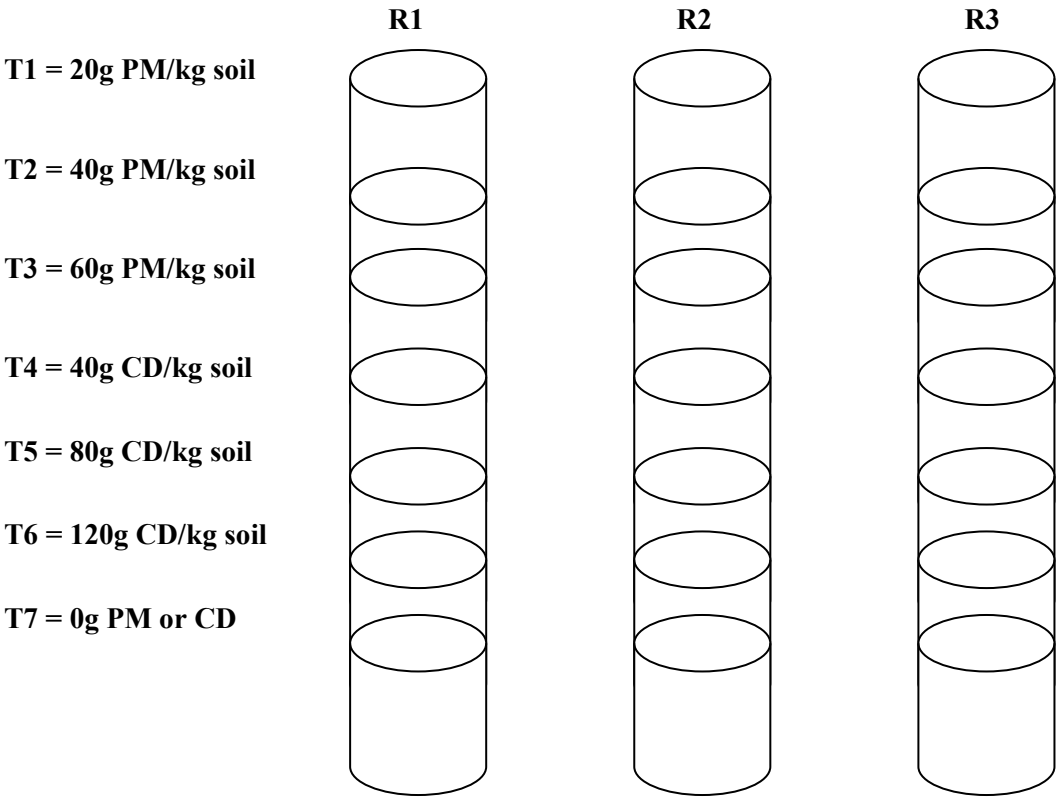
Site Description. The pot experiment was conducted in nine (9) weeks to check the effects of organic manure on the growth of *Jatropha curcas* L. seedlings at the Faculty of Agriculture, Kogi State University, Anyigba, Kogi State, Nigeria.

Treatment and Experimental Design. Seven (7) treatments were chosen from the two sources of available organic manures viz; three (3) levels of solid poultry manure (20g, 40g and 60g/kg soil) designated as T_1, T_2 and T_3 respectively, three (3) levels of solid cattle manure (40g, 80g and 120g/kg

soil) designated as T_4, T_5 and T_6 respectively, and control (no organic manure) designated as T_7. All the treatments were replicated three (3) times and laid out in a Completely Randomized Design (CRD).

Two (2) kilograms of the soil mixed with varying amounts of poultry manure (PM) or cow dung (CD) at the rate of 20g PM, 40g PM, 60g PM, 40g CD, 80g CD, 120g CD, and 0g PM or CD per kg soil were measured into twenty-one (21) polythene pots of size 12 x 10 x 10cm with the seven (7) treatments replicated three (3) times as shown in fig. 1.0. Viable seeds were collected from Agricultural Development Project (ADP), Anyigba and sown directly into the polythene pots two (2) weeks after the soil was incubated with the treatments and observed for six (6) weeks.

Fig. 1. The treatment layout



Data Collection of Growth Parameters. The plant's growth parameters collected fortnightly for six (6) weeks after germination were the plant height, number of leaves and stem girth. The number of branches and fresh weight were also measured at the end of the sixth (6^{th}) week after planting. A measuring tape was used for the measurement of the plant height from the soil surface to last top leaf and recorded in centimeter for all plants. For the n**umber of leaves**, all the visible leaves were counted and recorded per plant. The veneer caliper was used to measure the plant's stem diameter, divided by two (2) and substituted for "r" in the equation ($A = \pi r^2$). Where "*A*" equals the girth size of the plant. For the n**umber of branches**: all the visible branches were counted and recorded per plant. The plants were uprooted for fresh weight and tied in polythene bags separately then measured with a weighing balance after which the weight of the polythene bag was subtracted.

Data collected were subjected to analysis of variance (ANOVA) and Fisher's Least Significant Difference (F-LSD).

RESULTS AND DISCUSSION

Table 1. Soil physical and chemical properties.

Soil properties	Value
Sand (%)	87.93
Clay (%)	10.79
Silt (%)	1.28
Textural class	Loamy Sand.
Total nitrogen (%)	0.02
Available phosphorus (ppm)	5.05
K (cmol/kg)	2.20
Ca (cmol/kg)	3.32
Mg (cmol/kg)	1.28
Na (cmol/kg)	0.79
Organic carbon (%)	0.48
CEC (cmol/kg)	8.35
pH in H2O	6.7
pH in KCl	6.5

Table 2. Nutrient composition (%) of cow dung and poultry manure.

properties	Cow dung (cd)	Poultry manure (pm)
Total nitrogen (%)	2.20	3.27
P (%)	1.72	2.00
K (%)	2.15	2.4

The percentage total nitrogen content of both samples were higher than those of P and K. But 30 - 40% of the total N becomes available during the first cropping season whereas, P and K are considerably more available (Logsdon, 1977). However, Stephens (1960) reveal that the slow N release could be of advantage in the cultivation of long season crops.

Effect of Organic Manure on Height.

Table 3. The effects of organic manure on height of *Jatropha curcas* L. at two (2), four (4) and six (6) weeks after planting (WAP).

TREATMENTS	HEIGHT(CM)		
	2 WAP	4 WAP	6 WAP
T_1 = 20g PM / kg soil.	12.00[b]	15.93 [b]	20.43 [c]
T_2 = 40g PM / kg soil.	12.77 [a, b]	18.60 [a]	22.53 [b]
T_3 = 60g PM / kg soil.	12.67 [a, b]	17.33 [a, b]	22.67 [b]

T_4 = 40g CD / kg soil.	14.17 [a]	18.53 [a]	22.90 [a, b]
T_5 = 80g CD / kg soil.	12.67 [a, b]	18.73 [a]	24.23 [a]
T_6 = 120g CD / kg soil.	12.00 [b]	18.33 [a]	23.23 [a,b]
T_7 = Control.	09.57 [c]	12.33 [c]	17.53 [d]
Significant	**	**	**
CV	7.6 %	4.7 %	4.0 %
F-$LSD_{0.05}$	1.63	1.42	1.54

Means followed by same letter(s) are not significantly different from each other ($p < 0.05$).

From Table 3, at two weeks after planting, 40g CD/kg soil, T_4 gave the highest height (14.17cm) which was not significantly different from 80g CD/kg soil, T_5 (12.77cm), 60g PM/kg soil, T_3 (12.67cm) and 40g PM/kg soil, T_2 (12.77cm). Whereas, 40g CD/kg soil, T_4 (14.17cm) was significantly different from control, T_7 (9.57cm), 20g PM/kg soil, T_1 (12.00cm) and 120g CD/kg Soil, T_6 (12.00cm). However, 40g PM/kg soil, T_2 (12.77cm), 60g PM/kg soil, T_3 (12.67cm) and 80g CD/kg soil, T_5 (12.67cm) were not statistically different from each other and from 20g PM/kg soil, T_1 (12.00cm) and 120g CD/kg soil, T_6 (12.00cm) but shows a statistically significant difference from control, T_7 (9.57cm).

At four weeks after planting, 80g CD/kg soil, T_5 (18.73cm) showed the best height and was not significantly different from 120g CD/kg soil, T_6 (18.53cm), 40g CD/kg soil, T_4 (18.60cm) but significantly different from control, T_7 (12.33cm) and 20g PM/kg soil, T_1 (15.93cm). Similarly, 20g PM/kg soil, T_1 (15.93cm) was not significantly different from 60 g PM/kg soil, T_3 (17.33cm) but was significantly different from control, T_7 (12.33cm).

At six weeks after planting, 80g CD/kg soil, T_5 (24.33cm) gave the best height. However, it was not significant from 120g CD/kg soil, T_6 (23.23cm) and 40g CD/kg soil, T_4 (22.90cm) but showed a statistically significant difference from 40g PM/kg soil, T_2 (22.53cm), 60g PM/kg soil, T_3 (22.67cm), 20g PM/kg soil, T_1 (20.43cm) and control, T_7 (17.53cm). Whereas, 40g CD/kg soil, T_4 (22.90cm) and 120g CD/kg soil, T_6 (23.23cm) were not significantly different from each other as well as from 40g PM/kg, T_2 (22.53cm) and 60g PM/kg soil, T_3 (22.67cm) but were significantly different from 20g PM/kg soil, T_1 (20.43cm) and control, T_7 (17.53cm). 20g PM/kg soil, T_1 (20.43cm) was also significantly different from control, T_7 (17.53cm).

Effect of Organic Manure on Number of Leaves.

Table 4. Shows the effects of organic manure on number of leaves of *Jatropha curcas* L. at two (2), four (4) and six (6) weeks after planting (WAP).

TREATMENTS	NUMBER OF LEAVES		
	2 WAP	4 WAP	6 WAP
T_1 = 20g PM / kg soil.	02.67[ns]	06.77 [b]	18.00 [c]
T_2 = 40g PM / kg soil.	02.67 [ns]	07.00 [b]	17.67 [c]
T_3 = 60g PM / kg soil.	03.00 [ns]	06.00 [b, c]	19.00 [b, c]
T_4 = 40g CD / kg soil.	03.00 [ns]	06.67 [b]	19.67 [a, b]
T_5 = 80g CD / kg soil.	02.67 [ns]	09.33 [a]	21.33 [a,
T_6 = 120g CD / kg soil.	02.67 [ns]	06.00 [b c]	20.00 [a, b]

T_7 = Control.	02.33 ^{ns}	04.33 ^{c}	08.67 ^{d}
Significant	NS	**	**
CV	18 %	15.6 %	4.4 %
F-$LSD_{0.05}$	0.86	1.80	1.38

Means followed by same letter(s) are not significantly different from each other ($p < 0.05$).

In Table 4, at two weeks after planting, there was no statistically significant difference recorded among all the treatment means and control. At four weeks after planting, 80g PM/kg soil, T_5 (9.33) gave an outstanding performance which was significant from all other treatments. Though 120g CD/kg soil, T_6 (6.00) and 60g pm/kg soil, T_3 (6.00) were not statistically different from each other as well from 20g PM/kg soil, T_1 (6.77), 40g PM/kg soil, T_2 (7.00), 40g CD/kg soil, T_4 (6.67) and control, T_7 (4.33). Whereas, 20g PM/kg soil, T_1 (6.77), 40g PM/kg soil, T_2 (7.00) and 40g CD/kg soil, T_4 (6.67) were significantly different from control, T_7 (4.33).

At Six weeks after planting, 80 CD/kg soil, T_6 (21) produced the largest number of leaves. Though, it was not significantly different from 120g CD/kg soil, T_5 (20.00) and 40g CD/kg soil, T_4 (19.67) but was significantly different from all other treatments. Similarly, 40g and 120g CD/kg soil, T_4 and T_6 (19.67 and 20.00) were not significantly different from each other and from 60g PM/kg soil, T_3 (19.00) but was significantly different from 20g and 40g PM/kg soil, T_1 and T_2 (18.00 and17.67) and control, T_7 (8.67). 20g and 40g PM/kg soil, T_1 and T_2 (18.00 and 17. 67) were also significantly different from control, T_7 (8.67) but not statistically different from 60g PM/kg, T_3 (19.00).

Effects of Organic Manure on Girth Size.

Table 5. The effects of organic manure on girth sizes of *Jatropha curcas* L. at two (2), four (4) and six (6) weeks after planting (WAP) are shows in table 5.

TREATMENTS	GIRTH SIZES(CM)		
	2 WAP	4 WAP	6 WAP
T_1 = 20g PM / kg soil.	01.57 ^{b}	02.77 ^{b}	03.47 ^{e}
T_2 = 40g PM / kg soil.	01.63 $^{a, b}$	02.83 $^{a, b}$	03.90 ^{d}
T_3 = 60g PM / kg soil.	01.73 ^{a}	03.13 ^{a}	04.17 ^{c}
T_4 = 40g CD / kg soil.	01.73 ^{a}	03.00 $^{a, b}$	04.50 ^{b}
T_5 = 80g CD / kg soil.	01.53 $^{b, c}$	03.07 ^{a}	04.97 ^{a}
T_6 = 120g CD / kg soil.	01.50 $^{b, c}$	02.97 $^{a b}$	04.70 ^{b}
T_7 = Control.	01.40 ^{c}	02.30 ^{c}	03.07 ^{f}
Significant	**	**	**
CV	5.1 %	4.9 %	3.4 %
F-$LSD_{0.05}$	0.14	0.24	0.25

Means followed by same letter(s) are not significantly different from each other ($p < 0.05$).

In Table 5, at two weeks after planting, 60g PM/kg soil, T_3 (1.73cm) and 40g CD/kg soil, T_4 (1.73cm) were not significantly different from each other and from 40g PM/kg soil, T_2 (1.63cm) but were significantly different from all the other treatments. Similarly, 80g and 120g CD/kg soil, T_5 and T_6

(1.50cm and 1.53cm) were not statistically different from each other and from 20g and 40g PM/kg soil, T_1 and T_2 (1.57cm and 1.63cm) and control, T_7 (1.40cm). Though 40g PM/kg soil, T_2 (1.63cm) was significantly different from control, T_7 (1.40cm).

At four weeks after planting, 60g PM/kg soil, T_3 (3.13cm) and 120g CD/kg soil, T_6 (2.97cm) showed a non-significant difference from each other and from 40g PM/kg soil, T_2 (2.83cm), 40g CD/kg soil, T_4 (3.00cm), and 80g CD/kg soil, T_5 (3.07cm), but were significantly different from 20g PM/kg soil, T_1 (2.77cm) and control, T_7 (2.30 cm). In the same vein, 20g PM/kg soil, T_1 (2.77cm) was not significantly different from 40g PM/kg soil, T_2 (2.83cm), 40g CD/kg soil, T_4 (3.00cm), and 120g CD/kg soil, T_6 (2.97cm) but was significantly different from control, T_7 (2.30cm).

At six weeks after planting, 80g/kg soil, T_5 (4.97cm) showed an outstanding performance which was statistically different from all other treatment. Whereas, 40g CD/kg soil, T_4 (4.50cm) and 120g CD/kg soil, T_6 (4.70cm) were not statistically different from each other but were significantly different from all other treatment and were ranked second best. The 60g PM/kg, T_3 (4.17cm) was the third best and significantly different from all other treatments. 40g PM/kg soil, T_2 (3.90cm) was the fourth best which was also significantly different from all other treatments. In the same vein was 20g PM/kg soil, T_1 (3.47cm) and showed a significant difference from all other treatments. The least performed treatment was control, T_7 (3.07cm) which was also significantly different from all other treatments.

Effects of Organic Manure on Number of Branches and Fresh Weight, at 6WAP.

Table 6. Shows the the effects of organic manure on number of branches and fresh weight (g) of *Jatropha curcas* L. at the sixth week after planting (WAP).

TREATMENTS	NO. OF BRANCHES	FRESH WEIGHT (g)
T_1 = 20g PM / kg soil.	0.00 ^{b}	31.67 ^{c}
T_2 = 40g PM / kg soil.	0.33^{b}	34.00 $^{b, c}$
T_3 = 60g PM / kg soil.	0.00 ^{b}	36.33 ^{b}
T_4 = 40g CD / kg soil.	0.00 ^{b}	37.33 $^{a, b}$
T_5 = 80g CD / kg soil.	1.00 ^{a}	39.00 ^{a}
T_6 = 120g CD / kg soil.	0.00 ^{b}	37.33 $^{a b}$
T_7 = Control.	0.00 ^{b}	28.33 ^{d}
Significant	**	**
CV	115 %	4.7 %
F-$LSD_{0.05}$	0.38	2.84

Means followed by same letter(s) are not significantly different from each other ($p < 0.05$).

In Table 6, for number of branches; 80g CD/kg soil, T5 (1.00) gave an exceptionally good performance which was significantly different from all the other treatments. Though, the result is less reliable since the C.V was high as 115%. NB: the higher the CV the lower the reliability vice versa.

For the plants fresh weight, 80g CD/kg soil, T_5 (39.33g) was the highest weight recorded but was not significantly different from 40g and 120g CD/kg soil, T_4 and T_6 (37.00g and 37.00g) but was significantly different from the rest treatments. 40g and 120g CD/kg soil, T_4 and T_6 (35.00g and 37.00g) were not significantly different from each other and from 60g PM/kg soil, T_3 (36.33g) and 40g PM/kg soil, T_2 (34.00g) but were significantly different from 20g PM/kg soil, T_2 (31.67g) and control, T_7 (28.33g). Also, 20g pm/kg soil, T_2 (34.00g) but was significantly different from the control, T_7

(28.33g) and the rest treatments. The control, T_7 (28.33 g) showed the least weight and was statistically different from all the treatment means.

The experiment confirms the report of Karikari and Yavock (1987) that organic manure are superb sources of organic matter and nutrients since they show a consistent positive effects on the growth of *Jatropha curcas* L. seedlings.

80g cow dung /kg soil (T_5) always gives optimal level fertilizer required for *Jatropha curcas* throughout the growth period of the seedlings. Though, most of all the treatments having organic manure were significantly better than the control ($P < 0.05$) except at two weeks after planting were all the treatments gives the same number of leaves and at the sixth week after planting were only T_5 (120g CD/kg soil) showed significant difference in the number of branches.

CONCLUSION AND RECOMMENDATIONS

The research discovered after the experiment that all the treatments with organic manure showed significant difference ($p < 0.05$) from control except at two weeks after planting were no significant difference were observed in the number of leaves and at six weeks after planting were only the sixth treatment (T_5) shows difference in the number of branches. Therefore, the study has made known that organic manure is suitable for raising *Jatropha curcas* L. seedlings in the research area and environs. Also, the research shows that the sixth treatment (T_5) gives the best performance in nearly all the analysis on the plants growth parameters. Based on the results obtained from this research, the following are recommended: The use of organic manure especially poultry manure and cow dung for raising *Jatropha curcas* L. seedlings since Adepetun, and Corey (1975) confirms that organic manure improves the structure of the potting mixture and water holding capacity thereby enhancing nutrients uptake; and The use of 80g CD /kg soil application for nursery growth of *Jatropha curcas* L. seedlings in Anyigba.

REFERENCES

Achten, W.M.J., Verchot, L., Franken, Y.J., Mathijs, E., Singh, V.P., Aerts, R. & Muys, B. 2008. Jatropha bio-diesel production and use.*Biomass and Bioenergy,* 32: 1063–1084.

Adepetun, J. A. and Corey, R. B. (1975). Organic phosphorus as a predicator of plants available phosphorus in soils of Southern Nigeria. Soil Science 122:159 – 164.

Bouyoucos, G. H. (1951). A recalibration of the hydrometer method for making mechanical analysis, Agron J. 43:484-488.

Bray, R. H. and Kurtz, L. T. (1945). Determination of Total organic and available forms of phosphorus in soil sci. 45-59.

Bremner, J. M. and Mulvaney, C. S. (1982). Total Nitrogen. In: Page A. L., Miller R.. H., Keeney D. R. (eds), Method of soil analysis. Chemical and microbiological properties. Agronomy no.9. Part 2, 2nd edn. ASA & SSSA, Madison, Wisconsin, pp 595–622.

FACT Foundation (2011). *The Jatropha hand book: general data on Jatropha*. Fuels from Agriculture in Communal Technology. Pp 1. (available at http://www.fact-fuels.org).

FAO (2010). Integrated crop management, Jatropha : A small holder Bioenergy crop 8:17-20

Heller, J. (1996). Physic Nut *Jatropha curcas* L., promoting the conservation and use of underutilized and Negleted Crops. First edn. International Plant Genetics and Crop Plant Research Notes, Gartersleben (IPGRI), Rome, Italy, pp: 66.

Henning, R.K. (2004). *The Jatropha System – an integrated approachof rural development* (available at www.jatropha.de).

Janick, J. and Robert, E. P. (2008). The Encyclopaedia of fruit and nuts. Soil Science Society of America journal 15:142-427.

Karikari, S. K. and Yavock, J. Y. (1987). Organic fertilizer sources in Nigeria. In proceedings of National Fertilizer Seminar held at Port – Harcourt, Nigeria.

Logsdon, G. (1977). Farming with waste products. In R. Wolf (ed). Organic farming: Yesterday's and tomorrow's agriculture: 164 - 182. Rodale press publication.

Maclean, E. O. (1982). Soil pH and lime requirements in Page. A.L. (Ed) methods of Soil Analysis part 2 chemical and microbiological properties second edition, Agronomy Series No.9 America SocietyofAgronomy, Soil Science Society AmericaMadison, Wisconsin, USA.

Maheswarappa, H. P., Nanjappa, H. V., Hedge, M. R. and Balu, S. R. (1999). Influence of planting materials, plant population and organic manures on yield of East Indian Galangal and on soil physiochemical and biological properties.

Nelson, D. W. and Sommers, L. E. (1982). Total carbon, and organicCarbon, and organic matter. In: Page A. L. (ed) Method of soil analysis, chemical and microbiological properties. ASA & SSSA, Madison, PP 539–57

Rayment, G. E. and Lyons, D. J. (2011). Soil Chemical Methods; Australia. Volume 3 of Australian soil and land survey handbook.

Stephens, D. (1960). Fertilizer trials on peasant farms in Ghana. *Expl. Agric*. 28: 1 – 15

Thomas, G.W. (1982). Exchangeable cation. In A. L. Page, R.H. Moller and D.R. keeney (eds) method of soil analysis part 2. Second Edition. *America Society of Agronomy,* Madison Pp. 157 – 164.