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ASSESSMENT OF GROWTH PERFORMANCE OF *Jatropha curcus* L. AS AFFECTED BY FERTILIZER AND PLANT SPACING

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**Abstract**

Field experiment were conducted at the Nursery site of the Federal College of Forestry, Jos, Plateau State, Nigeria during the 2009, 2010 and 2011 wet seasons to investigate the effect of fertilizer rates and plant spacing on the growth performance of *Jatropha curcus*. The treatments consisted of three levels of plant spacing (1, 2, and 3m) and six levels of fertilizer (0, 250, 300 and 350kgNPK/ha, 2500kg/ha of poultry manure and 2500kg/ha of cowdung) which were arranged and laid out in a randomized complete block design with three replications. The results of these experiments revealed that the growth indicators investigated were significantly affected by fertilizer and plant spacing. The 350kg NPK/ha produced the highest leaf area index, leaf area ratio, net assimilation rate, relative growth rate and crop growth rate in 2009 and 2010 seasons. However, in 2011, 2500kg/ha of cow dung produced the highest leaf area ratio. Planting at a spacing of 1m between plants consistently produced higher leaf area index in both years. However the 3m plant spacing had the highest leaf area ratio, net assimilation rate, relative growth rate and crop growth rate in three years of the study. Based on the results of this study therefore, it could be concluded that for maximum growth of *Jatropha curcus* L. The 350kg NPK/ha and 3m plant spacing could be suggested for farmers adoption in the Nigerian Savannah.

**Keywords:** *Jatropha*, fertilizer, growth indicators

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**Introduction**

*Jatropha curcus* L. (Physic nut) is a tropical plant belonging to the family euphorbiaceae cultivated as hedges in many parts of the world. It is adapted to both arid and semi arid conditions and used for prevention of soil erosion and source of viscous oil that is used in the manufacture of candles, soap and cosmetics. The crop is also used as diesel or substitute for fossil fuel to control green house gas accumulation in the atmosphere (Foldle and Kazhagap, 1999).

*Jatropha* also provide a meal that served as a highly nutritious and economic protein supplement used in animal feeds (Becker and Makker, 1998). Despite its numerous benefits the management of *Jatropha* has not been optimized yet. Factors such as variety, fertilizer rates, plant spacing and plant population besides pests and diseases, have been the major constraints in the commercialization of the crop. Not much work have been accomplished (Ghosh *et al.*, 2006), particularly in Nigeria where the crop is believed to thrive well. Information on the contribution of plant spacing and fertilizer rate both organic and inorganic is very limited (Jaafar, 1999, Vilavong, 2010, Mahapatra and Panda, 2011). This study was therefore undertaken to determine the effect of fertilizer rates and plant spacing on the growth performance of *Jatropha*.

**Materials and Methods**

Field experiments were conducted during the raining seasons of 2009, 2010 and 2011 at the Nursery site of the Federal College of Forestry Jos. The experimental site was located at latitude 9°56'N and Longitude 8° 53'E and 1,217m above sea level in the Northern Guinea Savanna ecological zone of Nigeria (Kowal and Knabe, 1972). The area recorded an annual rainfall of 1499.7mm, 1686.9mm and 1837.5mm in 2009, 2010 and 2011 seasons, respectively. The physicochemical properties of soil of the experimental site following the method described by Jackson (1969) revealed that the soil was sandy clay loam with pH of 5.3.

The treatments consisted of three levels of plant spacing (1m x3m, 2mx3m and 3m x3m) and six fertilizer types (0, 2500kg cow dung, 2500kg Poultry manure, 250, 300 and 350 kgNPK/ha), which were factorially combined and laid out in a randomized complete block design with three replications.

The land was cleared, ploughed and harrowed to obtain a fine tilth. Planting was carried out in May 2009 according to the treatments. The inter-row spacing of 3m was used during the experiment. The gross plot size was 8m<sup>2</sup> and the net plot size was 3m<sup>2</sup>. The cow dung and poultry manure treatments were applied during land preparation and the NPK fertilizer was applied in three split applications. The first application was at planting while, the second was in 2010 and the third in 2011.

The experimental site was weeded manually at 30 and 60 days after fertilizer application as described by Kalannavar (2008). The crop was irrigated during dry season. Six plants were randomly sampled from the net plot for the assessment of the growth performance of the crop. The parameters measured were leaf area index, leaf area ratio, net assimilation rate, relative growth rate and crop growth rate. These parameters were measured as follows:-

The leaf area index (LAI) was calculated. This was done by considering the ratio of leaf area of few plants per plot to the land area upon which they grew as described by Kalannavar (2008) in the equation below:

$$\text{LAI} = \frac{\text{Leaf area per plant (cm}^2\text{)}}{\text{Land area occupied by the plant (cm}^2\text{)}}$$

The leaf area ratio is the ratio of the total leaf area to total dry weight of plant. This was determined using a destructive method from 10 fully expanded leaves of randomly sampled plants per plot using the formula:

$$\text{Leaf area ratio (LAR)} = \frac{\text{LA}}{\text{W}}$$

Where, LA = Leaf area

W = Total dry weight of plant.

Crop growth rate is a measure of the rate of dry matter production at a given time interval (Evans, 1972). This was computed from few randomly sampled plants per plot using the formula:

$$\text{Crop growth rate (CGR)} = \frac{W_2 - W_1}{T_2 - T_1}$$

Where  $W_2$  and  $W_1$  are dry weights at times  $T_2$  and  $T_1$  respectively

Net assimilation rate is a measure of the increase in plant material per unit of assimilatory material present per unit time (Watson, 1952 and 1958). This was computed from few randomly sampled plants per plot using a formula:

$$\text{NAR} = \frac{W_2 - W_1}{T_2 - T_1} \times \frac{\log_e A_2 - \log_e A_1}{A_2 - A_1}$$

Where  $W_2$  and  $W_1$  represent total dry weights of plant at times  $T_1$  and  $T_2$  when the corresponding leaf area was  $A_2$  and  $A_1$  respectively. While  $\log_e$  represents the natural logarithm.

Relative growth rate is a measure of the increase in plant material or biomass per unit of material present per unit time (Briggs *et al.*, 1920). This was

computed from few randomly sampled plants per plot using the formula:

$$\text{RGR} = \frac{\log_e W_2 - \log_e W_1}{T_2 - T_1}$$

Where  $W_2$  and  $W_1$  represent dry weights of plant at times  $T_2$  and  $T_1$  respectively.

While  $\log_e$  represents the natural logarithm.

All the data collected were subjected to statistical analysis using F test as described by Snedecor and Cochran (1967) and Duncan Multiple Range Test was used for mean separation (Duncan, 1955).

## Results

The effect of fertilizer and spacing on the leaf area index is shown on Table 1. Application of fertilizer significantly influenced the leaf area index. The highest leaf area index was obtained when 350kgNPK/ha was applied. It was followed by 300kg and 250kg per hectare of NPK fertilizer, respectively. Application of 2500kg of cow dung and poultry manure produced similar leaf area index which was significantly higher than the control. In 2009 season however, poultry manure application at the rate of 2500kg/ha produced higher leaf area than cow dung and the control which were similar (Table 1). In 2011 season, NPK fertilizer at the rate of 350 and 300kg/ha had similar trend in which 1m plant spacing produced the highest leaf area index. It was followed by 2m which was significantly higher than 3m plant spacing.

Table 2 shows the effect of fertilizer and plant spacing on the leaf area ratio of *Jatropha* during 2009, 2010 and 2011 season. The leaf area ratio was significantly affected by both fertilizer and plant spacing. In 2009 and 2010 wet seasons, 350kgNPK/ha produced the highest leaf area ratio which was followed by 300kgNPK/ha. However the lowest LAR was produced when no fertilizer was applied in all the three years of the experiments. However in 2011, the highest leaf area ratio was obtained when 2500kg cow dung was used (Table 2). The plant spacing significantly affected LAR in 2009 and 2011 seasons. The widest plant spacing (3m) produced the highest LAR in all the years and the narrower plant spacing produced the lowest LAR (Table 2).

The effect of plant spacing and fertilizer on Net assimilation rate (NAR) of *Jatropha* during the 2009, 2010 and 2011 wet seasons is shown in Table 3. The application of fertilizer significantly affected the NAR. It almost followed the same trend in 2009 and 2010 where the application of 350kgNPK/ha

produced the highest NAR and was followed by 300kg NPK/ha. The lowest NAR was obtained when no fertilizer was used on *Jatropha* in 2011 season, also the use of 350kg NPK/ha had the highest NAR. It was followed by 300kgNPK/ha, 250kgNPK/ha and 2500kg of poultry manure which were similar but significantly higher than when 2500kg of cow dung and the control treatments were used.

The plant spacing of 3m produced the highest NAR, and was followed by 2m and the lowest was obtained at the narrower spacing (Table 3). The effect of fertilizer and plant spacing on the relative growth rate (RGR) was also significant (Table 4) the trend were almost similar in both years. The application of 350kgNPK/ha consistently produced the highest RGR in all the years. It was followed by 300kgNPK/ha and the lowest obtained when no fertilizer was applied to the crop.

The effect of plant spacing was also significant in affecting the RGR of *Jatropha*. The widest plant spacing produced the highest RGR and the narrower spacing had the lowest (Table 4).

Table 5 shows the effect of fertilizer and plant spacing on the crop growth rate of *Jatropha* during the 2009, 2010 and 2011 wet seasons. The application of 350kg and 200kg of NPK per hectare produced similar CGR in 2009 which were significantly higher than the other fertilizer treatments. It was followed by 250kg NPK/ha. The application of 2500kg of poultry manure produced higher CGR than 2500kg of cow dung and the lowest CGR was recorded when no fertilizer was applied to the crop in all the years of the study. However, in 2011 season, 250kg NPK and 2500kg of poultry manure produced similar CGR which was significantly higher than all the fertilizer treatments (Table 5). It was followed by 350kg NPK/ha which had higher CGR than 2500kg of cow dung and the control (Table 5).

The effect of spacing was also significant in affecting the CGR in 2009 and 2010 season only (Table 5). The trend was similar in both years. The widest plant spacing produced similar CGR with 2m spacing which were significantly higher than the narrower spacing. The effect of spacing was not significant in affecting the CGR in 2011 season.

Table 6 shows the correlation making between the parameters assessed on affects by fertilizer and plant spacing in *Jatropha*. The correlation coefficient showed a significant strong and positive relationship between all the parameters studied in 2009, and 2010 we seasons. However, in 2011 season, significantly but negative correlation were obtained recorded between LAR and LAR, and NAR, LAR and RGR non-significant positive correlation was recorded between LAI and NAR and

LAI and RGR. However, a non significant negative correlation was obtained between LAI and CGR, NAR and CGR and CGR and RGR.

### **Discussion**

The performance of *Jatropha* was significantly affected by fertilizer application and plant spacing. The parameters assessed responded significantly to both fertilizer and spacing. Application of 350kg NPK/ha produced the highest leaf area index than all the fertilizer treatments in all the three years of the study. Significantly higher LAI ranging from 0.98 – 1.02 in 2009, 6.36 – 1.01 in 2010 and 0.98 – 1.92 in 2011 could be attributed to increased availability of plant nutrients which triggered growth and emergence of new leaves (Longnecker, 1994).

Similarly there was an increase in net assimilation rate (NAR) with fertilizer application up to 350kgNPK/ha. The increase in NAR could be attributed to the increase in LAI. When leaf area index was less than unity, there should be little shading and NAR May not be much affected by LAI.

The relative growth rate (RGR) was significantly increased by fertilizer application up to 350kgNPK/ha. This is because the fertilizer application also increased the leaf area index and leaf area ratio of *Jatropha* with each increase in LAI and LAR, there was a corresponding increase in RGR (Watson, 1958). The crop growth rate (CGR) was significantly influenced by fertilizer application. The highest crop growth rate was recorded by the highest fertilizer rate. According to Watson (1958) that CGR measures the accumulation of dry matter per unit area and is a reasonable measure of photosynthetic rate per unit area. A slight reduction in CGR in this study may be due to competition of growth resources such as light, nutrients and water.

The parameters assessed were also significantly affected by plant spacing. The narrower plant spacing produced the highest LAI and the wider spacing produced the lowest LAI. It could be attributed to accelerated removal of soil nutrients by plant which enhanced rapid vegetative growth over land area. The leaf area ratio was also significantly affected by plant spacing in 2009 and 2011 seasons. Wider spacing produced the highest LAR.

The net assimilation rate significantly increased with increase in plant spacing. The increase in NAR could be attributed to increase in LAI, the result consider the finding of Watson (1958). The result of this experiment revealed that plant spacing presently increase the relative growth rate of *Jatropha*. The result confirmed the finding of Watson (1958) who reported that with increase in LAI, there is a corresponding increase in RGR in crop. The crop

growth rate was increased with increase in plant spacing, and the wider plant spacing produced the highest crop growth rate in all the years. Similar results were also reported by Watson (1952; 1958).

The association among various parameters assessed during the experiment revealed a significant and positive correlation, the highly significant and positive correlation between those parameters indicated that these parameters are critical determinate of *Jatropha* growth. Those a consisted with the finding of Anonymous (2007) and Umamaheswari *et al.* (2009) who reported a strong association amongst these parameters. On the other hand the weak and negative association exhibited by some characters indicated that these characters may not be selected as growth contribution factors in *Jatropha* production because increase in one character may lead to a decrease in the other. This agreed with the finding of Das *et al.*, (2010). Based on the result of these experiment therefore, for increase growth and production of *Jatropha* 350kgNPK/ha and 3m plant spacing could be suggested for adoption in the Savanna agro ecology.

**References**

- Anonymous (2007). The effect of organic and inorganic fertilizer on the growth and yield of 4-month old *Jatropha* (*Jatropha curcas* L.). *Field Crops Abstract* 1: 234-239
- Becker, K. & Makker, H. P. S. (1998). Toxic effect of phorbol esters in carp (*Cyprinus carpio* L.). *Veterinary and human toxicology* **40**: 82-86.
- Briggs, G. E., Kidd, F. & West, C. (192). A quantitative analysis of plant growth. *Annual of applied Botany* 72: 202 – 203.
- Das, S. Misra, R. C. Mahapatra, A. K., Gantayat, B. P. & Pattnaik, K. (2010). Genetic variability, character association and path analysis in *Jatropha curcas*. *World applied science Journal* 8(11): 1304 – 1308.
- Duncan, D. B. (1955). Multiple range and multiple F Test. *Biometrics* 11: 1-42.
- Evans, G.C. (1922). The quantitative analysis of plant growth. Blackwell publisher Oxford London pp 1-200.
- Foldle, N and Kashyap, A. (1979). Exploring the potential of *Jatropha curcas* in rural development and environmental protection Rockteller Foundation New York.
- Ghosh, A. Patolia, J.S. Chaidhary, DR, Chikare Ja Rao, .N.; Kumar, D., Boricha G.N. Zala A (2006). Response of *Jatropha curcas* under different spacing to *Jatropha* deoiled cake. *Soil Condition and Fertilization* 34: 29-35.
- Jaafar, U. A. (1997). Effect of nitrogen sources on growth and yield of tomato (*Lycopersicon esculentum* L.) Unpublished B. Agric. Tech. project, ATBU Bauchi, Nigeria. pp 78
- Kalannavar, V. N. Angadi, S. S. Patil, V. C. Byadagi, A. S., Batil, S. Z. Angadi. S.S. (2009). Effect of major nutrients on growth and yield of *Jatropha curcas* L.) *Karnataka Journal of Agricultural Science* 22(5): 1095-1096.
- Kowal, J. M. and Knabe, D. T. (1972). An agro-chemistry After of the Northern states of Nigeria with explanatory rate ABU Press Zaria 142pp.
- Longnecker, N. (194). Nutrients deficiencies and vegetative growth in Mechanger of plant growth improved productivity. Ed. Basra, A. S. Mareat D. and Boca R. 137-172.
- Mahapatra, S. & Panda, P. K. (2011). Effect of fertilizer application on growth and yield of *Jatropha curcas* L. in an Acric Tropaguept of eastern India. *Notulae xientia Biologicae* b(1); 95-100.
- Snedecor, G.W. & Cochran, G. W. (1967). Statistical methods 6<sup>th</sup> edition, Iowa state University Press America. Pp 678s
- Steel, R. G. D. & Torrie J. H. (1960). Principles and Procedures of statistics 2<sup>nd</sup> edition Mccraw Hill Bank Company Inc. New York.
- Umamaheswari, F. Paramethma, and Manivannan, N (2009). Association analysis between yield and its compunets characters in *Jatropha*. *Electronic Journal of Plant breeding* 1: 78-81.
- Vilavong, S. (2010). Effect of different spacing and fertilization on growth and seed yield of the physic nut (*Jatropha curcas* L.) Unpublished M.Sc. thesis Thani Rajabjhat University 125pp.
- Watson, D. J. (1952). Physiological basis of variation in yield. *Advances in Agronomy* 42: 107-145.
- Watson, D. J. (1958). The dependance of net association rate in leaf area index. *Annual of Botany* 22: 37-54.

**Table 1: Effect of Fertilizer and Plant Spacing on the leaf area index of Jatropha in 2009, 2010 and 2011 wet seasons at Jos.**

	2009	2010	2011
<b>Fertilizer</b>			
Control	0.24e	0.36e	0.98b
2500 Cow dung	0.45d	0.49e	1.21b
2500 Poultry manure	0.46d	0.55d	1.36b
250 NPK	0.61c	0.73c	1.57b
300 NPK	0.86b	0.88b	1.69a
350 NPK	1.02a	1.01a	1.92a
LS	*	*	*
SE+	0.01	0.03	0.041
<b>Plant spacing (m)</b>			
1	0.59a	1.04a	2.34a
2	0.34b	0.56b	1.20b
3	0.25c	0.40c	0.82c
LS	*	*	*
SE	0.007	0.026	0.029

\* = significant at 5% level of probability. NS = Not significant, Means followed by the same letter within a treatment group are not statistically significant using LSD<sub>0.05</sub>

**Table 2: Effect of Fertilizer and Plant Spacing on the LAR of Jatropha in 2009, 2010 and 2011 wet seasons at Jos.**

	2009	2010	2011
<b>Fertilizer(kg)</b>			
Control	107.01f	44.41e	28991.77c
2500 Cow dung	154.81e	576.38d	38984.33a
2500 Poultry manure	179.90d	609.91d	24697.44d
250 NPK	231.76c	672.16c	34091.66b
300 NPK	260.83b	747.42b	18375.22c
350 NPK	345.67a	869.18a	24970.33d
LS	*	*	*
SE+	4.16	19.69	783.47
<b>Plant spacing (m)</b>			
1	203.88c	644.21	26810.72b
2	213.59b	654.26	28833.33a
3	222.52a	660.66	29411.33a
LS	*	NS	*
SE	2.94	13.92	553.99

\* = significant at 5% level of probability. NS = Not significant, Means followed by the same letter within a treatment group are not statistically significant using LSD<sub>0.05</sub>

**Table 3: Effect of Fertilizer and Plant Spacing on the NAR of Jatropha in 2009, 2010 and 2011 wet seasons at Jos.**

	2009	2010	2011
<b>Fertilizer</b>			
Control	4.07c	31.07e	167.47c
2500 Cow dung	13.50d	48.82d	168.80c
2500 Poultry manure	1615d	50.67d	194.86b
250 NPK	26.26c	90.02c	192.41b
300 NPK	49.26b	106.22b	210.58b
350 NPK	68.47a	120.30a	220.63a
LS	*	*	*
SE+	0.79	2.90	6.09
<b>Plant spacing (m)</b>			
1	24.12c	67.32c	186.47c
2	29.30b	73.45b	182.67b
3	35.43a	82.77a	203.239a
LS	*	*	*
SE	0.50	2.06	4.30

\* =significant at 5% level of probability. NS = Not significant, Means followed by the same letter within a treatment group are not statistically significant using LSD<sub>0.05</sub>

**Table 4: Effect of Fertilizer and Plant Spacing on the RGR of Jatropha in 2009, 2010 and 2011 wet seasons at Jos.**

	2009	2010	2011
<b>Fertilizer</b>			
Control	0.95e	3.28d	130.02c
2500 Cow dung	2.77d	8.09d	133.73c
2500 Poultry manure	3.15d	8.66d	140.56bc
250 NPK	4.98c	26.97c	156.86b
300 NPK	7.32b	37.71b	158.56b
350 NPK	9.56a	47.38a	170.61a
LS	*	*	*
SE+	0.15	1.86	5.73
<b>Plant spacing (m)</b>			
1	4.02c	19.12b	148.38b
2	4.77b	20.29b	138.73b
3	5.58a	26.62a	160.06a
LS	*	*	*
SE	0.11	1.32	4.05

\* = significant at 5% level of probability. NS = Not significant, Means followed by the same letter within a treatment group are not statistically significant using LSD<sub>0.05</sub>

**Table 5: Effect of Fertilizer and Plant Spacing on the CGR of Jatropha in 2009, 2010 and 2011 wet seasons at Jos.**

	2009	2010	2011
Fertilizer			
Control	114.57e	247.16f	29616.81c
2500 Cow dung	186.26d	322.72e	29825.67c
2500 Poultry manure	212.30c	390.76d	37865.87a
250 NPK	287.97a	454.47c	28475.87a
300 NPK	307.17a	507.89a	2625.06b
350 NPK	*	*572.96a	*
LS	5.42	8.70	1067.24
SE+			
Plant spacing (m)			
1	220.63b	405.13b	31555.39
2	227.75ab	415.58ab	32185.01
3	237.72a	429.27a	33167.82
LS	*	*	NS
SE	3.83	6.15	754.65

\* = significant at 5% level of probability. NS = Not significant, Means followed by the same letter within a treatment group are not statistically significant using LSD<sub>0.05</sub>

**Table 6: Coefficients of Correlation between the parameters assessed in 2009, 2010 and 2011 wet seasons at Jos.**

	2009	2010	2011
Components			
LAR x LAR	0.44**	0.61**	-0.32**
LAI x NAR	0.39**	0.53**	0.20
LAI x RGR	0.37**	0.54**	0.23
LAI x CGR	0.50**	0.54**	-0.11
LAR x NAR	0.88**	0.95**	-0.40**
LAR x RGR	0.86**	0.94**	-0.34**
LAR x CGR	0.83**	0.85**	0.47**
NAR x RGR	0.93**	0.98**	0.72**
NAR x CGR	0.88**	0.77**	-0.14
CGR x RGRs	0.83**	0.77**	-0.27