

EFFECTS OF FERTILIZER TYPES AND PLANT SPACING ON THE GROWTH PARAMETERS AND DRY MATTER YIELD IN *Jatropha curcus* L.

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Abstract

Field experiment was 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 types and plant spacing on the growth parameters and dry matter yield of *Jatropha curcus*. The treatments consisted of three levels of plant spacing (1, 2, and 3m) and six fertilizer types (0, 250, 300 and 350kgNPK/ha, 2500kg/ha of poultry manure and 2500kg/ha of cow dung) which were arranged and laid out in a randomized complete block design with three replications. The results of this experiment revealed that the growth parameters assessed were significantly affected by fertilizer types and plant spacing. The 350kg NPK/ha produced the tallest plants, higher number of leaves, leaf area, number of primary and secondary branches, canopy diameter and dry matter yield in 2009, 2010 and 2011 seasons. However, narrower plant spacing produced the taller plants with higher number of leaves and number of primary and secondary branches. The dry matter yield was however, higher at wider spacing. Based on the results of this study therefore, it could be concluded that for maximum production of dry matter in *Jatropha*, 350 kgNPK/ha and 3m x 3m plant spacing could be suggested for farmers adoption in the Nigerian Savannah.

Keywords: *Jatropha*, fertilizer, growth parameters, Dry matter

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 a 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 types, both organic and inorganic are very limited (Jaafar, 1999, Vilavong, 2010, Mahapatra and Panda, 2011). Results elsewhere indicated that the growth and development of *Jatropha* is significantly affected by fertilizer types and planting spacing (Evangelista,

2009). Growth parameters like plant height, number of leaves, leaf area, and dry matter yield were reported to be significantly affected by fertilizer types and levels and plant population (Evangelista, 2009; khrishna *et al.*, 2008; Veenaat *et al.*, 2009; Saxena *et al.*, 2011). This study was therefore, undertaken to determine the effect of fertilizer types and plant spacing on the growth parameters and dry matter yield of *Jatropha* in the Guinea Savanna agro ecology.

Materials and Methods

Field experiment was 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 x 3m, 2x 3m and 3m x 3m) and six levels of fertilizer (0, 2500 kg cow dung, 2500 kg Poultry manure, 250, 300 and 350 kgNPK/ha), which

were factorially combined and laid out into a randomized complete block design with three replications.

The land was cleared, ploughed and harrowed to obtain a fine tilt. 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 8m² and the net plot size was 3m². The cow dung and poultry manure treatments were applied during land preparation and the NPK fertilizer was applied in three splits application. The first application was at planting, 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 (2009). 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 assessed were plant height, number of leaves, leaf area, number of primary and secondary branches, canopy diameter and dry matter yield. The plant height was measured using a meter rule and thread. This was done by placing the meter rule at the base of the plant from the ground level to the top of the growing canopy. The number of leaves per plant was obtained by counting all the leaves of the sampled plant and their mean recorded. The number of primary branches was obtained by counting all the primary branches of the sampled plants and the mean recorded.

The leaf area was collected using graphical method from 10 fully expanded leaves and the average leaf area was multiplied with the total number of leaves and expressed cm² as discussed by Kalannavar, 2009) The number of secondary branches was also obtained through counting.

The canopy diameter was determined by crown diameter methods as discussed by Inah (1991) and Yakubu *et al.* (1999). This was achieved by using calibrated meter tape laid on the ground from one side of the crown of the tree crops and the other side of the crown perimeter and was repeated perpendicular to the fruits. The mean of the diameter was recorded.

The dry matter yield was determined by drying a representative sample of the plant at a temperature of 80°C for 24 hours in an oven. The dry matter was calculated by using the loss weight and the fresh weight as described by Kalannavar (2009).

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 to separate the significantly different means (Duncan, 1955).

Result

The effect of fertilizer and spacing on the plant height of *Jatropha* is shown in Table 1. Application of fertilizer significantly increased the plant height of *Jatropha*. Highest plant height were insistently recorded when 350kgNPK/ha was application all the years (Table 1) in 2009, wet season, application of 300 and 250kg NPK/ha and poultry manure at 250kg/ha produced statistically similar plant height. 250kgNPK/ha cow dung per hectare produced significantly taller plants, than control. Similar results were also obtained in 2010 wet season however, in 2011 season, 250kg NPK and 250kg of poultry manure produced similar plant height. The shortest plant height was recorded in the control (Table 1).

Plant spacing significantly affected the plant height of *Jatropha* 1m plant spacing consistently produced tallest plants in all the three years. It was followed by 2m and the lowest was obtained when 3m plant spacing was used (Table 1) the interaction between fertilizer and plant spacing was not separated in affecting the plant height of *Jatropha*.

Table 2 showed the effect of fertilizer and plant spacing on the number of leaves of physic nut. The results obtained in 2009 and 2011 followed similar trend. The application of 350kgNPK/ha consistently produced significantly higher number of leaves. It was followed by 300kgNPK/ha poultry manure and 250kgNPK/ha produced similar number of leaves. The lowest number of leaves was recorded in the control. In 2010 however, 350kg and 300kgNPK/ha produced similar number of leaf which was significantly higher than the number of leaves recorded in poultry manure and cow dung. Although, poultry manure and cow dung produced similar number of leaves which was significantly higher than the control.

The effect of plant spacing significantly affected the number of leaves of *Jatropha* in 2009 season only (Table 2). The use of 1m between plants produced the highest number of leaves. It was followed by 2m and lowest was recorded when 3m plant spacing was used. The interaction between fertilizer and plant spacing on number of leaves was not significant. The leaf area of *Jatropha* was also significantly affected by fertilizer and plant spacing in all the years of the experiment (Table 3). The application of 350kg NPK/ha produced significantly

larger leaf area than all of applied fertilizer in 2009 season. The control produced the lowest leaf area. Similarly in 2010 and 2011 wet seasons 350kg NPK/ha produced the highest leaf area. It was followed by 300kg NPK/ha. Poultry manure and 250kg NPK/ha produced similar leaf area in 2011. The lowest leaf area was recorded in the control.

The leaf area was also significantly affected by spacing (Table 3) the widest plant spacing (3m) consistently produced the longest leaf area in all the years. It was followed by 2m. However, the smallest leaf area was obtained when the narrowed plant spacing was used.

The number of primary branches was significantly influenced by fertilizer and plant spacing (Table 4) the application of 300 kg NPK/ha produced higher number of primary branches than all other applied fertilizer it was followed by 300 kg NPK/ha and 250 kg NPK/ha the poultry manure and cow dung application produced similar number of primary branches in 2009 wet seasons. All level of applied fertilizer produced significantly higher number of primary branches than control in all the years of the experiment (Table 4) in 2010 and 2011 wet seasons 350 and 300kgNK/ha produced similar number of primary branches. However, 300 and 250kg NPK/ha also produced number of primary branches. The application of poultry manure and cow dung produced similar primary branches which was significantly higher than control. However, in 2011 wet season, poultry manure application produced significantly higher number of primary branches than three recorded in cow dung (Table 4).

The effect of plant spacing significantly affected the number of primary branches in 2009 wet season only (Table 4). The use of narrower plant spacing had the highest number of primary branches than the other spacing (Table 4). The interaction between fertilizer and plant spacing was not significant on number of primary branches in all the years.

Table 5 showed the effect of fertilizer and plant spacing on the number of secondary branches in *Jatropha*. The application of NPK fertilizer significantly increased the number of secondary branches in all the years. 350kg of NPK per hectare produced the highest number of secondary branches in all the years in 2009 poultry manure and cow dung produced similar number of secondary branches with the control. In 2010, poultry manure and 250kg NPK/ha produced significantly higher number of secondary branches than cow dung and the control which were similar. In 2009 and 2010 wet season the narrower plant spacing produced the highest number

of secondary branches. It was followed by 2m while the wider spacing had the lowest number of secondary branches. However, in 2011 wet season, 2m and 3m spacing produced similar number of secondary branches. The interaction was not significant on the number of secondary branches.

The canopy diameter significantly increased with the addition of fertilizer (Table 6). In 2009, 350 kg NPK/ha produced the highest canopy diameter. It was followed by 350 and 250kgNPK/ha which were similar but significantly higher than poultry manure. The differences between the means of canopy diameter produced by poultry manure and cow dung were also significant. The lowest canopy diameter was obtained in the control. The highest canopy diameter was also obtained when 350kg NPK/ha was used in 2010. It was followed by 300 kg NPK/ha which was significantly higher than 250 kg NPK/ha. The differences in the means of poultry manure cow dung and 250kgNPK/ha were similar but the result of 2011 revealed that 350kg NPK/ha produced the highest canopy diameter. It was followed by 300 and 250kgNPK/ha which were similar but significantly higher than the canopy diameter produced in poultry manure. However, poultry manure and canopy produced similar canopy diameter which was significantly higher than control.

The effect of plant spacing on the canopy diameter was not significant. Similarly, the interaction between fertilizer and plant spacing on the canopy diameter was not significant.

Dry matter production was significantly increased with application of fertilizer (Table 7). In 2009 and 2011 wet seasons, 350kgNPK/ha produced the highest dry matter yield. It was followed by 300kgNPK/ha. Also 250kgNPK/ha produced higher dry matter than the organic fertilizer used. Although, poultry manure and cow dung produced similar dry matter which was significantly higher than control (Table 7). In the 2010 wet seasons 350kg and 300kgNPK/ha produced similar dry matter yield. However, the highest dry matter yield was obtained in 300kgNPK/ha. All the other fertilizer produced similar dry matter yield with control (Table 7).

The widest plant spacing produced the highest dry matter yield than the other levels, of spacing (Table 7). Plant spacing did not significantly affect dry matter production in 2010 and 2011 seasons. The interaction was not significant in affecting the dry matter production in *Jatropha* in all the years of the experiment.

Discussion

The results of this study demonstrated the important of fertilizer and plant spacing on the growth and dry matter yield of *Jatropha*. The significant increase in the height of *Jatropha* plants due to fertilizer application up to 350kg NPK/ha might be due to maximum supply of nutrients increasing better up take of nutrients which resulted in the synthesis of nucleic and amino acids. Thereby enhancing growth of meristematic tissues which increased cell division and plant growth. This result agreed with the findings of Veena *et al.* (2009) Saxena *et al.* (2001) and Mahapatra and Panda (2011).

Closer plant spacing resulted into higher plant height due to competition for high the result of this experiment correlated the finding of Kalannaver *et al.* (2009) and Ghosh *et al.* (2006). Application of fertilizer led to increase in the number of leaves of *Jatropha* in all the years of the experiment. 350kg NPK/ha produced the highest number of leaves in all the years. Leaf production under high level of fertilizer agreed with the finding of Aziz (2007), and Mahapatra and Panda (2011).

The differences in means of number of leaves due to plant spacing were not significant in 2010 and 2011 seasons. However in 2009 season the narrower plant spacing produced the highest number of leaves. This was because in the later years, leaf production and retention season established (Vilavong, 2010). Application of 350kgNPK/ha gave significantly higher leaf area of *Jatropha* than all other fertilizer treatments. This might be due to the fact that N, P and K have significant effect on the growth of *Jatropha*. The result agreed with the findings of Ghosh *et al.* (2008) and Veena *et al.* (2009). The leaf area of *Jatropha* increase with increasing plant spacing. Vilavong (2010) also reported similar trend in *Jatropha*.

Increasing NPK rates resulted in a corresponding increase in the number of primary branches in *Jatropha*. However, number of primary branches decrease with increase in plant spacing in 2009 season. The report of Azeez (2007) and Vilavong (2010) supported the results obtained in this study.

Significant and progressive increase in number of secondary branches was also obtained with application of fertilizer. The increase in number of secondary branches may be attributed to increase in plant height and number of primary branches. The narrower spacing produced the highest number of secondary branches.

The application of fertilizer significantly influenced the canopy diameter of *Jatropha*. 350kgNPK/ha gave the highest canopy diameter in both years of the study. This may be attributed to the production of higher leaf area, more number of leaves and plant highest. This agreed with the finding of Watson (1958). There was no significant variation in canopy diameter due to spacing probably maximum canopy development was not attained during the period of the study.

Dry matter production significantly increased with fertilizer application upto 350kgNPK/ha in both years. The significant increase in dry matter yield indicated the importance of N, P and K in the growth and development of *Jatropha*. Also wider plant spacing produced highest dry matter yield, could be attributed to low competition in widely spaced plants. This corroborates the finding of Watson (1958).

Based on the result of this experiment therefore, it could be concluded that 350kgNPK/ha and 3m x 3m spacing could be suggested for better dry matter production in *Jatropha*.

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Table 1: Effect of Fertilizer and Plant Spacing on the plant height of Jatropha in 2009, 2010 and 2011 wet seasons at Jos.

	2009	2010	2011
Fertilizer			
Control	36.27d	122.11e	238.08e
2500 COD	75.49c	144.36d	253.51d
2500 PM	84.10b	153.88c	265.63c
250 NPK	85.68b	167.74b	273.12c
300 NPK	88.99b	172.87b	284.03b
350 NPK	99.18a	178.92a	292.94a
LS	*	*	*
SE+	1.78		
Plant spacing (m)			
1	85.01a	161.89a	271.10a
2	77.47b	157.64b	267.40a
3	72.37c	152.92c	265.16b
LS	*	*	*
SE	1.26	1.26	1.70
Interaction	NS	NS	NS

* =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_{0.05}

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

	2009	2010	2011
Fertilizer			
Control	19.11e	55.33d	1698.47e
2500 COD	36.44d	85.89c	1959.65d
2500 PM	43.89c	91.44c	2328.14c
250 NPK	46.78c	96.67bc	2389.25c
300 NPK	51.78a	109.56ab	2601.77b
350 NPK	63.44a	123.67a	2875.25a
LS	*	*	*
SE+	0.98	4.1	85.19
Plant spacing (m)			
1	47.56a	95.50	2351.74
2	43.61b	93.67	2291.53
3	39.56c	92.11	2275.01
LS	*	NS	NS
SE	0.69	2.91	60.24
Interaction	NS	NS	NS

* =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_{0.05}

Table 3: Effect of Fertilizer and Plant Spacing on the leaf area (cm²) of Jatropha in 2009, 2010 and 2011 wet season at Jos.

	2009	2010	2011
Fertilizer			
Control	41.73C	63.27e	144.67d
2500 COD	78.45B	83.69d	129.36d
2500 PM	80.22B	92.37d	174.78c
250 NPK	105.64B	124.31c	173.08c
300 NPK	145.20B	147.62b	216.81b
350 NPK	171.60A	168.70a	251.34a
LS	*	*	*
SE+	1.46	4.43	12.17
Plant spacing (m)			
1	93.07c	104.67c	176.99b
2	103.59b	113.14b	162.51b
3	114.76a	122.78a	205.52a
LS	*	*	*
SE	1.04	3.13	8.60
Interaction	*	NS	NS

* =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_{0.05}

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

Fertilizer	2009	2010	2011
Control	1.79e	4.71d	9.01e
2500 COD	2.53d	8.92c	12.02d
2500 PM	2.66d	8.97c	13.73c
250 NPK	3.34c	10.25b	13.16bc
300 NPK	3.64b	11.04b	14.99ab
350 NPK	4.16a	11.83a	15.67a
LS	*	*	*
SE+	0.08	0.23	0.38
Plant spacing (m)			
1	3.15a	9.38	12.97
2	3.00b	9.27	13.03
3	2.91b	9.21	13.44
LS	*	NS	NS
SE	0.05	0.17	0.27
Interaction	NS	NS	NS

* =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_{0.05}

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

	2009	2010	2011
Fertilizer			
Control	14.71c	31.27d	52.42d
2500 COD	15.94c	33.01d	53.76d
2500 PM	17.11c	35.01c	55.29c
250 NPK	19.67b	36.37c	57.78b
300 NPK	20.99ab	37.75b	59.22b
350 NPK	22.38a	40.40a	61.41a
LS	*	*	*
SE+	0.73	0.56	0.46
Plant spacing (m)			
1	19.63a	37.10a	57.50a
2	18.34b	35.49b	56.61ab
3	17.53c	34.32c	55.82b
LS	*	*	*
SE	0.82	0.40	0.32
Interaction	NS	NS	NS

* =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_{0.05}

Table 6: Effect of Fertilizer and Plant Spacing on the Canopy Diameter of Jatropha in 2009, 2010 and 2011 wet season at Jos.

	2009	2010	2011
Fertilizer			
Control	0.23e	1.24a	3.30e
2500 COD	0.46d	1.75c	3.64d
2500 PM	0.57c	1.89c	3.6cd
250 NPK	0.72b	1.94c	3.82bc
300 NPK	0.90b	2.34b	3.92b
350 NPK	1.18a	2.78a	4.18a
LS	*	*	*
SE+	0.04	0.05	0.04
Plant spacing (m)			
1	0.64	1.95	3.74
2	0.67	1.99	3.76
3	0.72	2.03	3.78
LS	NS	NS	NS
SE	0.03	0.03	0.02
Interaction	NS	NS	NS

* =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_{0.05}

Table 7: Effect of Fertilizer and Plant Spacing on Dry matter Yield of Jatropha in 2009, 2010 and 2011 wet seasons at Jos.

	2009	2010	2011
Fertilizer			
Control	865.03e	2925.03b	24003.54e
2500 COD	961.67d	6725.86b	30800.48e
2500 PM	1040.95d	7513.28b	36070.88d
250 NPK	1298.32	9576.39b	48589.07c
300 NPK	1642.78b	20133.36a	62200.46b
350 NPK	1871.63	16182.50ab	99950.64a
LS	*	*	*
SE+	27.07	3403.51	
Plant spacing (m)			
1	1245.60b	8754.68	48215.12
2	1284.22ab	9023.90	50044.20
3	1310.38a	13749.06	52548.21
LS	*	NS	NS
SE	19.14	2406	2056.10
Interaction	NS	NS	NS

* =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_{0.05}