

Effects of Inorganic Fertilizer Application on Plant Growth and Dry Matter Yield of Physic Nut (*Jatropha Curcas* L.)

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Abstract. Recent global interest on biofuels, the potential of *Jatropha curcas* L. for production of biodiesel, and adaptation of this specie to survive as a commercial crop on marginal sites that have not been well understood gave rise to an experiment that evaluated the effects of inorganic fertilizer application on the growth and dry matter yield of *J. curcas*. The pot experiment was carried out at the crop pavilion of the Department of Agronomy, University of Ilorin, Nigeria (80 291N, 40 401E) and was designed as a completely randomized design (CRD) with five replicates. Number of leaves per plant (LNO) and plant height (PHT) were taken at two weekly intervals from 3 to 16 weeks after fertilizer application (WAF). Dry matter (DM) yields were taken at 8, 14, and 16 WAF. Data collected were subjected to the analyses of variance (ANOVA), and significant means were separated using the least significant difference at 5 percent probability level (LSD0.05). Results show that application of fertilizer at any rate produced significantly higher LNO, PHT, and DM values than the control. Though there were no appreciable variations among the fertilizer rates, the highest values of the parameters were obtained with the application of 120 KgN/ha. Further studies are recommended to validate the fertilizer optimum fertilizer requirements of the plant species.

Keywords. *Jatropha curcas* L., biofuel, inorganic fertilizer application, plant growth, dry matter

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1. Introduction

Jatropha curcas L. belongs to the family of *Euphorbiaceae*, a perennial plant that grows in most of the tropics (Francis *et al.*, 2005) (see photo 1). The plant can grow almost anywhere, including gravel and sandy and saline soils (Russel and Webbi, 1996). Normally,



Photo 1: *Jatropha curcas* L.

J. curcas can tolerate long periods of drought by shedding most of its leaves to reduce transpiration loss (Heller, 1996). It grows to between 3-5m in height but can attain a height of up 8-10m under favorable conditions (Adeoye *et al.*, 2011). As reviewed by Achten *et al.* (2008), seeds of *Jatropha* contain 34.4% oil on a mass basis, and depending on the extraction method, 38-99% of the oil can be extracted. As claimed by Openshaw (2000), *J. curcas* is able to replace kerosene and diesel and to substitute fuel woods. The plant has attracted special attention from many countries due to its characteristics mentioned above and demand for feedstock for biodiesel production as regards to green energy policy vis-a-vis required blending of diesel adopted by many countries (Rajgopal & Zilberman, 2007). *Jatropha* has been regarded as one the major crops to be promoted for growing

in marginal lands for biodiesel production (Kheira & Atta, 2009; Kumar *et al.*, 2011). By 2008, this species had already been planted over an estimate of 900,000ha globally with an overwhelming 85% of plantations in Asia, 13% in Africa, and 2% in Latin America. By 2015, it is expected that *J. curcas* may be planted on 12.8 million hectares worldwide (Kant & Wu, 2011) in an aim to blend fossil diesel with biofuel across the world under the climate change campaign to palliate green house (GHGs).

Water and supply of nutrients are considered to be the two environmental inputs that contribute most to crop productivity (Lenka *et al.*, 2009; Wang *et al.*, 2011). Several studies have observed significant advantages in applying inorganic fertilizers (Akinrinde, 2006). Inorganic fertilizer exerts strong influence on plant growth, development, and yield (Stefano *et al.*, 2004). Amidst the upcoming and almost little information about the nutrient requirements of this plant, some findings including those of Young *et al.* (2010), and Mohapatra & Panda (2011) have reported that the application of fertilizer improved the growth and yield of *Jatropha* plants.

While many studies have assessed the yield and physical properties of the oil, nutrient, and water, demand of physic nut as a commercial crop is not well defined. Hence, the large-scale cultivation and yield improvement studies, with emphasis on the nutritional requirements of physic nut on marginal lands of the tropics, need to be addressed. Therefore, the objective of this study was to assess the effects of inorganic fertilizer application on crop growth and dry matter yield of physic nut (*Jatropha curcas* L.)

2. Materials and Methods

A pot experiment was carried out at the crop pavilion of the Department of Agronomy, Faculty of Agriculture, University of Ilorin, Ilorin, Kwara State, Nigeria (8°29'N, 4°40'E). It is a southern Guinea savanna ecological zone. The experiment was designed in a completely randomized design (CRD) with five fertilizer rates (0, 30, 60, 90 and 120Kg N/ha) evaluated. Each experimental unit was replicated five times. Each experimental unit

was a ten liter pot (10L) filled with 10kg top soil, moistened and maintained at the appropriate moisture contents by periodic addition of water as required. Ten seeds of *Jatropha* were planted in each pot. Three weeks after planting (WAP), seedlings were reduced to four in each experimental unit. Each pot was later fertilized at five rates of 0, 15.3, 30.7, 46, and 61.3 grams per pot equivalent to 0, 30, 60, 90, and 120 kg N/ha using NPK 15:15:15 and urea fertilizers. The fertilizer treatments were applied as 0g NPK+0g Urea (0 kg N/ha), 15.3g NPK +0g Urea (30 kg N/ha), 15.3g NPK+5.0g Urea (60 kg N/ha), 15.3g NPK +10g Urea (90 kg N/ha), and 15.3g of NPK +15g of Urea (120 kg N/ha). The applications were done in two equal splits at four and eight weeks after planting.

Watering of the plants was done at three day intervals and at two weeks after the first fertilizer application. Data collection on the parameters below started and continued at two weekly intervals until harvest when the final dry matter was taken:

(i) Plant height:

This was measured using meter tape to measure the plant from the soil level to the top of the main branch. The heights of two tagged plants were measured and the average height recorded.

(ii) Number of leaves per plant:

The number of leaves per plant in each of the two tagged plants was determined by counting the leaves and taking the average.

(iii) Dry Matter Determination:

One plant each was harvested from each pot at 8 weeks after fertilizer application. The plant was put inside of a labeled brown envelope and oven-dried at 80°C until constant weight. Thereafter, the weight was recorded as dry matter (DM). The process was repeated at 12 WAF for another dry matter determination. The final dry matter was determined by harvesting the remaining two plants at 16 WAF.

Data Analyses

All data collected in the experiment were subjected to Analysis of Variance (ANOVA) using a general model with Genstat Discovery (Edition 4) statistical package. Significant means were

separated using the least significant difference (LSD_{0.05}) at 5% probability level.

3. Results and Discussion

Soil status: The soil used for this study is sandy loam in texture; it has low organic content with low total nitrogen, implying low soil fertility. The soil is moderately acidic. This suggests that the soil was well suited for the growth of *J. curcas*, evaluated in line with the report of Kumar and Sharma (2008) that *Jatropha* thrives well in soils with a pH range of 6-9 and prefers a well drained soil. Also from the results of the soil analyses, it could be inferred that the soil has lower organic matter. This suggests that it has little humus, resulting in fewer nutrients and poor fertility, thereby justifying the need for the additional fertilizer input to boost crop yield.

Effects on Leaf Production

Akinrinde (2006) showed significant a response of various crop species to the application of inorganic fertilizers. The results of the analyses of variance on the number of leaves per plant at various growth stages showed that the effects of fertilizer application was highly significant ($p < 0.001$) on leaf production at most growth stages except at 2, 6, and 16 weeks after fertilizer application (WAF) (Table 2 and Figure 1). This was in line with the report of Aziz (2007) and Shedeed *et al.* (1986) who observed that N is a major nutritional requirement for increasing plant growth. They also observed a significant

gradual increase in the number of leaves per plant in eggplant with the application of N.P.K fertilizer. The number of leaves per plant varied with different rates of fertilizer application, with 120kgN/ha producing the highest number. However, the differences were not significant at all periods of measurement. This agrees with the positions of Rajaona (2011) and FAO (2010) that higher nutrient levels in the soil translate into increased growth and production in *Jatropha*. Similarly, the crop and vegetative yield parameters of vegetable amaranth have been found to respond significantly to NPK compound fertilizer application (Ainika and Amans, 2011).

Table 1

Pre-planting soil physical and chemical properties

Soil Properties	Value
Texture	Sandy Loam
Sand (%)	85.62
Silt (%)	6.00
Clay (%)	8.48
Soil pH (Water)	5.6
Exchangeable Ca ⁺⁺ (Cmol/kg)	2.70
Exchangeable Mg ⁺⁺ (Cmol/kg)	1.85
Exchangeable Na ⁺ (Cmol/kg)	0.42
Exchangeable K ⁺ (Cmol/kg)	0.51
Total Acidity H ⁺ (Cmol/kg)	0.92
Available P (mg/kg)	3.48
Cation Exchange Capacity (Cmol/kg)	6.48
Total Nitrogen (%)	0.50
Organic Carbon (%)	0.86
Organic Matter (%)	1.48

Table 2

ANOVA Table showing the mean squares from the analyses of variance for the number of leaves per plant from 2 to 16 WAF

Source of variation	df	Means of square (ms)							
		2	4	6	8	10	12	14	16 WAF
Rep	4	1.96	2.94	12.14	11.7	33.76	12.76	7.54	16.54
Fert	4	7.46ns	20.24**	56.94ns	215.50***	199.46***	130.46***	76.74***	25.64ns
Error	16	2.54	3.37	21.34	18.7	12.09	14.38	10.12	11.21
Total	24								

, * denote effects significant at 1 and 0.1 percent probability level; ns denotes effects not significant ($p > 0.05$); WAF denotes Weeks After Fertilizer application

Table 3

ANOVA Table showing mean squares from the analyses of variance for plant height from 2 to 16 WAF

Source of variation	df	Means of square (ms)							
		2	4	6	8	10	12	14	16 WAF
Rep	4	95.46	68.66	181.7	286.6	268.6	259.1	275.36	297.94
Fert	4	70.76ns	205.66***	319.6ns	561.1**	583.9**	498.0**	584.46**	633.14**
Error	16	7.54	14.81	175.1	106.7	119.9	105.5	99.21	96.62
Total	24								

, * denote effects significant at 1 and 0.1 percent probability level; ns denotes effects not significant ($p > 0.05$); WAF denotes Weeks After Fertilizer application

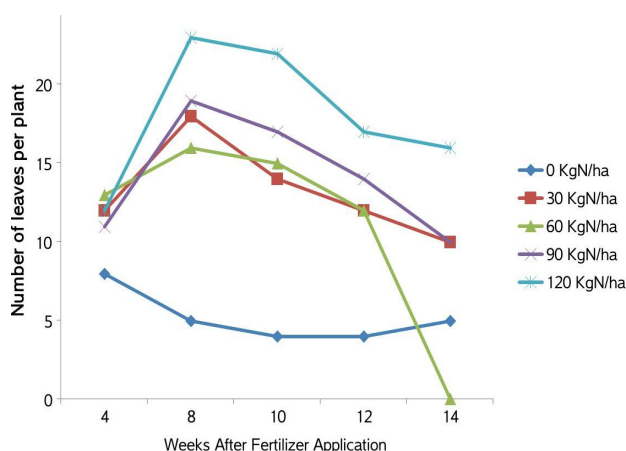


Figure 1: Effects of rates of fertilizer application on number of leaves per plant in *Jatropha curcas L.*

The findings of Aziz (2007) and Shedeed *et al.* (1986) confirmed that N is required for tissue differentiation. Therefore, its role in increasing plant growth and development may account for the significantly smaller number of leaves per plant obtained at all stages in the present study with no fertilizer application (control). In this study, leaves of *Jatropha* were found to decrease over time in correlation with the findings of Devkota and Jha (2011); Sánchez-Díaz and Aguiroola (2000) who observed that *Jatropha* drops its leaves in response to water stress to avoid evapotranspiration.

Effects on Plant Heights

Plant height variation was highly significant among the different rates of fertilizer application

at most periods of measurement with the exception of 2 and 6 WAF when there were no significant effects ($p > 0.05$) (Table 3). This shows the importance of nitrogen for the growth of the plant, which is in agreement with the report of Tisdale *et al.* (2003) who showed that N is necessary for most physiological growth processes, and its absence or deficiency causes stunted growth. Fashina *et al.* (2002) also reported improved cell activities, enhanced cell multiplication and enlargement, and luxuriant growth with the availability of sufficient growth nutrients from inorganic fertilizer. There were linear responses of plant heights to the application of fertilizer in *Jatropha*. Application of 30kgN/ha fertilizer produced the tallest plants, which were similar to the heights obtained with other fertilizer rates (except with the control plants, which gave the shortest plants). The consumption of a marginal level of fertilizer by *Jatropha* was in consonance with the reports of earlier workers (Henning, 2007; Ouwens *et al.*, 2007) who observed that *Jatropha* is adapted to marginal soils with low nutrient contents but demands fertilization in order to support high biomass production. Paul and Driscoll (1997) observed that the primary target of N limitation is the growing meristem of the plant and decreased rate of photosynthetic activity, which can be attributed to reduction in plant heights under N deficiency. This could explain the reason for the lowest values recorded throughout the periods with no fertilizer input.

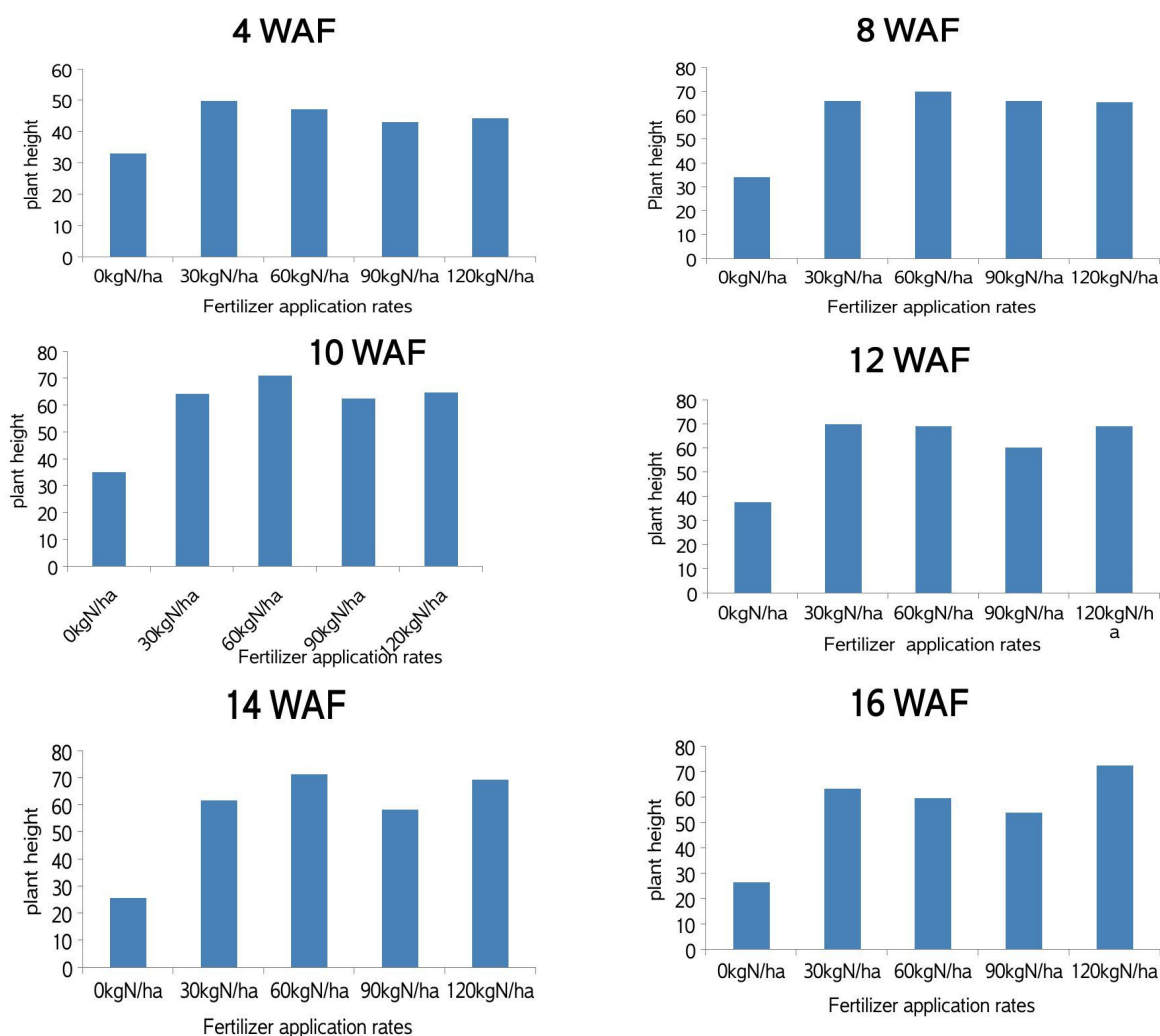


Figure 2: Effects of inorganic fertilizer application on plant heights of *J. curcas* at 4, 8, 10, 12, 14 & 16 WAF. *Error bars are standard error of mean (n=5)

Table 4

ANOVA Table showing mean squares from the analyses of variance for dry matter yield

Source of variation	df	Means of square (ms)		
		DM @ 8 WAF	DM @ 12 WAF	Final DM
Rep	4	16.9	475.1	24885
Fert.	4	298.3ns	2079.0**	33821*
Error	16	108.3	293.6	7285
Total	24			

*, ** denote effects significant at 1 and 0.1 probability level respectively; ns denotes effects not significant; DM denotes Dry Matter

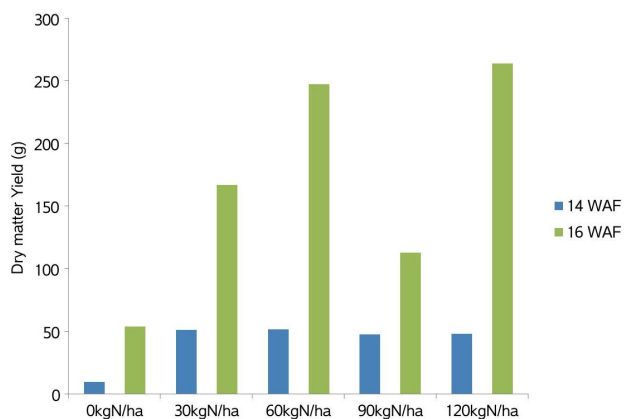


Figure 3: Effects of rates of fertilizer application on dry matter yield in *Jatropha curcas* at 14 and 16 Weeks after Fertilizer Application *Error bars are Standard Error of means (n=5)

Effects on Dry Matter Production

Dry matter yield was not significantly affected by the application of fertilizer at an early age of 8 WAF (Table 4 and Figure 3), while the parameter was influenced by the treatment when measured at a later stage of 12 WAF and at the final determination at 16 WAF. The application of 60kgN/ha resulted in highest dry matter at 12 WAF and 120kgN/ha at 16 WAF. These results were similar to the study of Oyinlola & Jinadu (2012) who recorded the highest dry matter values with the application of 30 and 120kgN/ha from their study of tomato. Also, according to Okoro-Robinson & Bello (2012), the best dry weight of *Telfaria* was observed from 60kgN/ha fertilizer application. However, the responses of this plant to various fertilizer rates were similar. Zero fertilizer application gave the lowest values, as they had to rely on the native soil fertility, which, from the result of chemical analysis, was deficient in nitrogen. In correlation with the results of this study, Umeh, *et al.* (2011); Oyinlola & Jinadu (2012); Okoro-Robinson & Bello (2012)

reported the least values for dry matter in soybean, tomato, and *Telfaria*, respectively with zero fertilizer application. Similarly, Nafiu *et al.* (2011) reported that all treated plants performed better than the control in terms of yield in egg plants.

4. Conclusion

Inorganic fertilizer application had significant effects on *J. curcas*, as the lowest values of the measured parameters were obtained with no fertilizer application throughout the periods of evaluation with optimum fertilizer rates resulting in significantly higher values of the measured parameters in this study. Therefore, from the results of this study, application of 30kgN/ha could be considered for optimum growth and dry matter production of *J. curcas*. More studies are recommended to further evaluate the effects of inorganic fertilizers at various application rates on *Jatropha curcas* for optimum growth and dry matter yield.

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