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Influence of Compost, Indole-3-acetic Acid and Gibberellic Acid Application on Productivity of Jatropha

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Abstract

The problem of climate change on agricultural production and human health has brought about global need for alternative source of energy like biodiesel. In order to meet the global demand for biodiesel, strategies to improve growth and yield of Jatropha would be of great importance. A single application of plant growth hormones (PGH) and compost was evaluated on the growth and yield parameters of *Jatropha curcas*. The experiments comprises of three concentrations (100 mg\l, 150 mg\l and 200 mg\l) each of indole 3 acetic acid and gibberellic acid and three rates (10 t\ha, 20 t\ha and 40 t\ha) of compost and the untreated soil which served as the control. Each treatment was in four replications set up in a completely randomized design (CRD). The results revealed that gibberellic acid at 150mg\l and indole-3-acetic acid at 200 mg\l significantly ($P \leq 0.05$) increased the chlorophyll content, growth and dry matter yield parameters of Jatropha. However, growth and yield of *Jatropha curcas* were improved by the application of compost compared to the control (7.25 to 9.00, 18.08 to 19.23 and 2.80 to 3.25 for number of leaves/plant, leaf area and stem girth respectively). The values were not as high when compared to plants treated with plant growth hormones. Hence, gibberellic acid or indole-3-acetic acid at 150 mg\l and 200 mg\l respectively could be used for rapid development of seedlings.

Key words: Chlorophyll, Growth, Nutrient uptake, Plant Growth Hormone, Yield

Introduction

Jatropha (*Jatropha curcas*) is one of the plants being promoted for biodiesel production (Janick *et al.*, 2008, WAC, 2007). Its improvement through proper agronomic practices has become an area of focus by researchers. Efforts have been made to demonstrate the use of hormones to enhance growth and rooting of Jatropha stem (Davies, 1996 and 2010, Maya *et al.* 2010, Sevik and Guney 2013). The limiting effects of available nutrients in the soil has however, been linked with the production of smaller root systems by the taller treated plants. The use of organic manure has been employed to supplement for the limited available nutrients in the soils put to Jatropha production (He & Zhang, 2014). The application of composts had been reported to be important key ingredients in improving soil quality amendment and crop yield. *(Liu et al.,* 2009: Adejumo *et al.,* 2011). Hence, the performance of Jatropha may be further investigated using compost and PGH like indole-3-acetic acid (IAA) and gibberellic acid (GA_3). Therefore, this study was designed to determine the single effect of compost and synthetic hormones on the growth, photosynthetic pigments and nutrient uptake of Jatropha.

Materials and Methods

Research location, soil and compost analyses

The experiment was carried out in October, 2012 at the screen house of the Department

of Crop Protection and Environmental Biology, University of Ibadan, Nigeria. Soil used for the experiment was collected beside the screen house using shovel. The soil so collected were air-dried in the screen house, sieved through 2mm sieve and kept for usage in the screen house and laboratory analysis. Soil pH was estimated using glass electrode pH meter in ratio 1:2 (soil: water) according to Jackson (1973). Particle size was determined according to hydrometer method (Bouyoucos, 1951). Compost used was made from wild sunflower (Tithonia *diversifolia)* and poultry manure in ratio 3:1 (on dry weight basis) after sorting and chopping using Partially Aerated Composting Technique (PACT-2) proposed by Adediran *et al.* (2003).The heap was left to decompose for a period of three months. Continuous turning and watering was done fortnightly to quicken the decomposition rate, after which the matured composts were evacuated from the heap, air- dried, shredded and sample taken for physico-chemical analysis. Both soil and compost samples were digested and total nitrogen content was analyzed using kjeldehl method (Ma and Zuazaga, 1942). Available phosphorus was extracted with Bray-1 and available P determined by a modified single solution method (Murphy and Riley 1962). Exchangeable cations of the soil were extracted with 1N ammonium acetate, Na and K in the extract were determined by flame photometry, while Ca and Mg were determined by atomic absorption spectrophotometer.

Experimental design, treatment application and data collection

Soil of 5kg each was filled into 5-L capacity pots and 2 seeds of *Jatropha curcas* L. were planted per pot and later thinned to one seedling/pot three weeks after sowing. Watering and weeding were carried out regularly. At five and seven weeks, insect Pest (*Aphis craccivora*) was controlled with insecticides: Deltamethrin and Carbofuran respectively at 1.5 ml\l of sterile distilled water using sprayer.

The treatments used were PGH (100 mg\l, 150 mg\l and 200 mg\l of Indole-3-acetic and Gibberellic acid concentrations respectively), while Compost was applied at the rate of 10, 20 and 40 tons\ha and the control soil without any amendment. The experiment was arranged in a Completely Randomized Design with four replications and was tested on the Jatropha seedlings.

At four weeks after sowing (WAS) 250 ml of the different concentrations of hormones; 0 mg\l (control), 100 mg\l, 150 mg\l, 200 mg\l of Indole-3-acetic acid and Gibberellic acid respectively were applied once by soil drench. Similarly, equivalent amounts of the different rates of compost at 10 tons\ha, 20 tons\ha and 40 tons\ha were incorporated into the soil a week before sowing in the pots using hand trowel.

Data collection commenced at 6 weeks after sowing on stem height, leaf area per plant using leaf area meter (LI-3000C), number of leaves per plant and stem girth. At harvest, fresh weight of leaves per plant, stem, root and total yield were taken and then oven dried at 70°C until constant weight to obtain dry matter weight. The dry matter weights were milled and samples were taken and wet-digested according to the method of Chapman and Pratt (1978) for nutrient concentration analysis. The Phosphorus was photometrically determined using the molybdate-vanate method; the Potassium and sodium were measured using Lang-M8D flame-photometer, while Magnessium, Fe, Mn

and Zn were determined using the Atomic Absorption Spectrophotometer (Perkin-Elmer 100 B).

Chlorophyll Analysis

Leaf sampling was done at harvest (16 weeks after sowing) by taking two grams of fresh leaf tissue (young and old) and leaf samples were crushed using mortar and pestle. Eighty percent (80%) of acetone (50 ml) was added to allow the tissue to be thoroughly homogenized and then the supernatant was decanted through a filter paper into a 100 ml volumetric flask and made up to the volume (100 ml) with 80% acetone. 5 ml of the solution was transferred into a 50 ml volumetric flask and made-up to volume with 80% acetone. Absorbance was measured at 652 nm using spectrophotometer (Model Spectrum Lab 752s, Bausch and Lomb, U.S.A). The amounts of chlorophyll in the leaves of the plants were calculated based on the formula of Mackinney, (1941).

Thus: Total chlorophyll (c) $= \frac{D652 * 1000}{34.5}$ g\l

D652 is absorbance at 652nm.

Statistical Analysis

Data collected were subjected to statistical analysis as specified by Snedecor and Cochran (1990). Treatment means were separated using least significant difference (LSD) at 5% level of probability.

Results

Physico-chemical properties of Soil and Compost

The results of the chemical and physical properties of the soil and compost used for the experiment showed that the soil used is slightly acidic with pH value of 6.09. The nitrogen content of the soil and compost were 0.34% and 0.64% respectively. The analytical result of soil and compost revealed that compost had high nutrient values in terms of N, P, K, C, Ca and Mg. However, the soil Fe content of 38.00 mg\kg was higher than the compost 12.74 mg\kg (Table1).

Growth parameters

Generally the results showed that there were significant differences ($P \leq 0.05$) in terms of number of leaves per plant of Jatropha treated with PGH and compost compared with control. Gibberellic acid at 200 mg\l gave the highest number of leaves per plant (14.50) when compared with the other treatments and control (7.25). However, among the plants treated with indole-3-acetic acid at 150 mg\l had the lowest mean number of leaves per plant (6.75) while, indole-3-acetic acid at 200 mg\l had the highest (8.75) though, the mean values were not significantly different ($P \leq 0.05$) from Jatropha plants treated with 100 mg\l and 150 mg\l of indole-3-acetic. Compost at the rate of 40 tons\ha had the highest number of leaves per plant (10.75) but the mean differences were not significantly different ($P \leq 0.05$) from 20 and 10 tons\ha with 9.00 and 7.75 leaves per plant respectively (Table 2).

On plant height, Gibberellic acid resulted to significant ($P \leq 0.05$) increased plant height compared with other treatments. Jatropha plants treated with 150 mg\l of gibberellic acids had the highest plant height of 40.25cm while those treated with compost at 20 tons\ha had the lowest mean plant height (21.00cm). Jatropha plants treated with 150 mg\l of gibberellic acid had the highest leaf area per plant of 22.74 cm^2, which does not differ significantly ($P \leq 0.05$) from other treatments but significant over the control

Table1: Physical and chemical properties of compost and pre-cropping soil in Oct. 2012 at Ibadan, Nigeria

Properties	Soil	Compost
Nitrogen (%)	0.34	0.64
Available Phosphorus	3.0 (mg/kg)	3.05 (%)
Exchangeable Potassium	0.09 (cmol/kg)	3.04 (%)
pH	6.09	6.2
% Silt	11.40	-
% Sand	82.6	-
% Clay	6.00	-
C (g\kg)	8.45	26.20
Ca	3.60 (cmol\kg)	9.43(mg/kg)
Mg	2.33 (cmol\kg)	6.75 (mg/kg)
Fe (mg\kg)	38.00	12.78
Cu (mg\kg)	8.31	75.00
Zn (mg\kg)	46.50	135.56

Table 2: Effect of compost and hormones on growth parameters of Jatropha at 6 WAS

Treatment	Number of Leaves/plant	Plant Height (cm)	Stem Girth (cm)	Leaf Area(cm^2)
Control	7.25def	22.75c	2.80cd	18.08d
C10	7.75def	22.00c	2.25d	19.56bcd
C20	9.00cd	21.00c	3.25bc	19.23bcd
C40	10.75cd	22.75c	3.25bc	21.16abc
A100	7.00ef	25.38bc	4.13ab	18.50cd
A150	6.75f	25.75bc	3.75ab	19.77bcd
A200	8.75de	25.50bc	3.75ab	21.16ab
G100	10.75bc	33.25ab	3.25bc	21.71ab
G150	12.25b	40.25a	3.75ab	22.74a
G200	14.50a	37.50a	3.50abc	21.43ab

Means followed by the same alphabets in the same column are not significantly different by LSD (P=0.05), C = compost, A= indole-3-acetic acid, G= gibberellic acid, WAS = Weeks After Sowing

Table 3: Effect of Compost and Hormones on the Micro and Macro nutrients content of Jatropha

Treatment	P	Mn	Mg	Na	K	Fe	Cu	Zn
	←			%			→	
Control	0.62	0.15	0.69	1.01	5.05	0.04	0.03	6.01
C10	0.50	0.13	1.05	1.54	5.65	0.09	0.84	0.01
C20	0.50	0.15	0.73	0.78	2.96	0.02	0.29	0.01
C40	0.64	0.13	0.55	0.11	0.33	0.03	0.21	0.01
A100	0.67	0.19	1.25	1.76	5.33	0.09	0.41	0.01
A150	0.67	0.17	1.68	2.28	7.81	0.11	1.41	0.02
A200	0.56	0.05	0.54	0.76	3.83	0.04	0.36	0.01
G100	0.56	0.20	1.56	1.79	9.13	0.11	0.84	0.02
G150	0.48	0.11	0.22	0.05	5.10	0.02	0.24	0.01
G200	0.50	0.04	0.88	0.11	5.93	0.03	0.22	0.01
LSD	0.02	0.02	0.15	0.25	0.77	0.01	0.13	0.59

C = compost, A= indole-3-acetic acid, G= gibberellic acid,
10, 20, 40 (t/ha)
100, 150, 200 (mg/L)

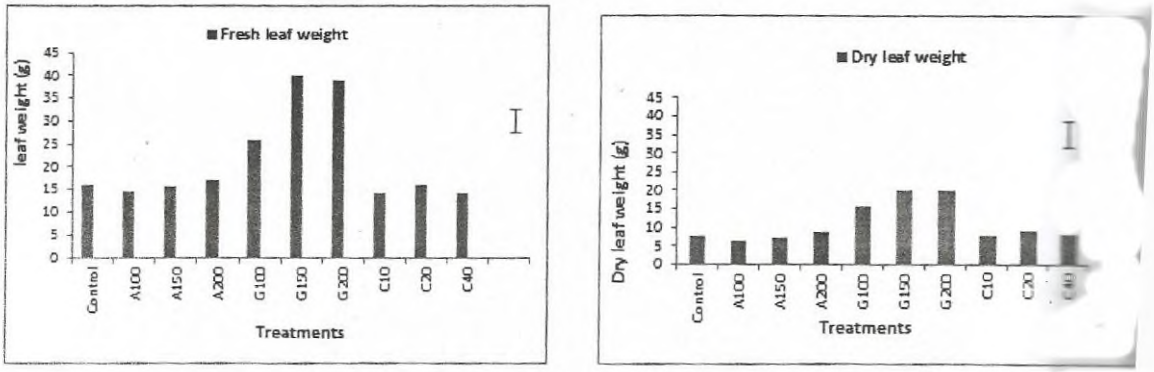
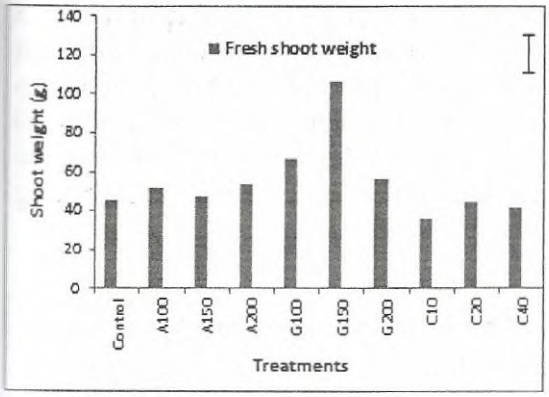


Figure 1: Effect of Compost and plant growth hormones on Fresh and Dry Leaf weight of *Jatropha* harvest (16WAS). Bar is LSD for comparing treatment means, C=compost (t\ha), A= Indole 3 (mg\l), G= Gibberellic acid (mg\l).



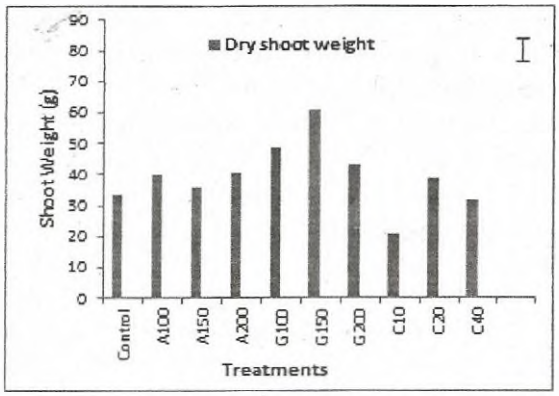


Figure 2: Effect of Compost and plant growth hormones on Fresh and Dry Shoot weight of *Jatropha curcas* at harvest (16WAS). Bar is LSD for comparing treatment means, C=compost (t\ha), A= Indole 3 acetic acid (mg\l), G= Gibberellic acid (mg\l).

with the lowest leaf area value (18.08 cm^2). Likewise, Jatropha plant treated with 100 mg\l of gibberellic acid had the highest stem girth of 4.13cm which is not significantly different from other PGH treatments other than control and compost (2.80cm and 2.25cm respectively) (Table 2).

Yield parameters

The leaf fresh and dry weight of Jatropha plants treated with 150 mg\l and 200 mg\l of gibberellic acid had higher mean values of 39.8, 19.9 and 38.7, 19.7 respectively, compared with other treatments including control (15.9, 6.2). However, significant effects were not detected among the plants treated with indole-3-acetic acid and compost when compared with the control (Figure 1). The results of shoot fresh and dry weight of Jatropha plants treated with gibberellic acids, indole-3-acetic acid and compost showed that application of 150 mg\l gibberellic acid has mean values of 106.6 and 60.9 and were significantly different ($P \leq 0.05$) compared to the control, compost and indole-3-acetic. These were followed by gibberellic acids applied at 100 mg\l with means of 66.4 and 48.9 for shoot fresh and dry weight respectively (Figure 2). The same trends were observed in the root fresh and dry weight. Application of gibberellic acid performed better than other treatments. However, the root fresh weight of Jatropha plant treated with gibberellic acid 150 mg\l has mean value 12.1 and the root dry weight of plant treated with gibberellic acid 200 mg\l were not significantly different from other PGH treatments. The use of plant growth hormones enhanced root formation more than compost at lower rates (10tons/ha and 20tons/ha) (Figures 3).

Chlorophyll content of old and young leaves of Jatropha

Chlorophyll content of old leaf of Jatropha plants treated with indole-3-acetic acid at 200 mg\l was the highest (3137.2 µg\g FW) while plant treated with compost at 20 tons\ha had the lowest chlorophyll content (755.9 µg\g FW). This is significantly different at ($P \leq 0.05$) from other indole-3-acetic acid treatments 100 mg/l (1341.8 µg\g FW) and 150 mg/l (1455.2 µg\g FW) as well as control (2116.6 µg\g FW).

However, indole-3-acetic acid at 200 mg/l was not significantly different at ($P \leq 0.05$) from gibberellic acid treatments at 150 mg/l and 200 mg\l with mean values of 2967.1 µg\g FW and 2343.4 µg\g FW respectively. The young leaves of Jatropha plant treated with indole-3-acetic acid at 200 mg/l had the highest chlorophyll content (2135.5 µg\g FW) which was significantly different at ($P \leq 0.05$) from young leaves of plants treated with gibberellic acid 200 mg/l (1039.4 µg\g FW), compost at 40 tons/ha (944.9 µg\g FW) and control (1020.5 µg\g FW) (Figure 4).

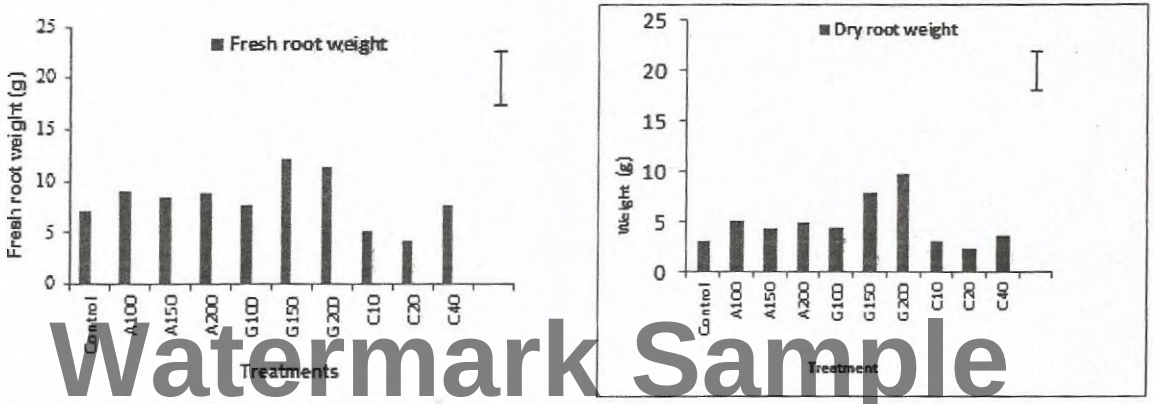


Figure 3: Effect of Compost and plant growth hormones on Fresh and Dry Root weight of *Jatropha curcas* at harvest (16WAS). Bar is LSD for comparing treatment means, C=compost (t\ha), A= Indole 3 acetic acid (mg\l), G= Gibberellic acid (mg\l).

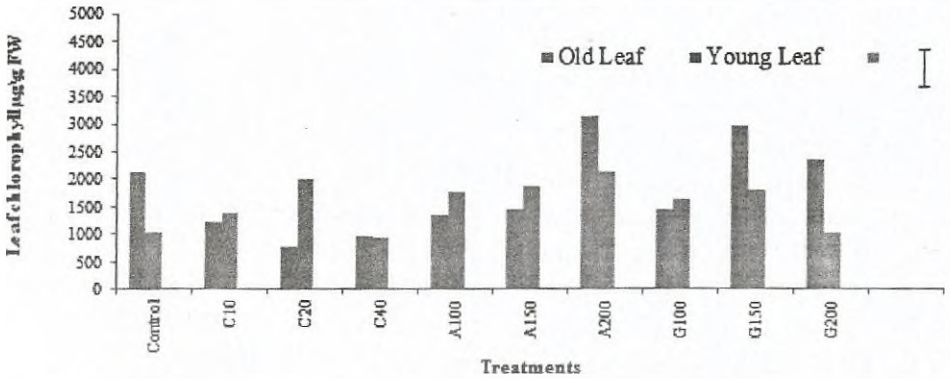


Figure 4: Effect of Compost and Hormones on Chlorophyll content of old and young leaves of *Jatropha curcas*. Bar is LSD for comparing treatment means, C= compost (t\ha), A= indole-3-acetic acid (mg/l), G = gibberellic acid (mg/l)

Nutrients content of *Jatropha curcas*

The nutrient contents result shows that the phosphorus content of Jatropha plants treated with 100 mg/l and 150 mg/l of indole-3-acetic acid solution were higher ($P \leq 0.05$) with mean values of 0.67% compared with other treatments. The Cu content of Jatropha plant was significantly ($P \leq 0.05$) increased by PGH with value of 1.4% for A150 and compost with value of o.84% for 10t\ha. However, a significant decrease was detected in the Zn content across the treatments when compared with control. Mn and Na contents of Jatropha plants treated with indole-3-acetic acid at 100 mg/l (0.19%) and 150 mg/l (2.28%) respectively and gibberellic acids at 100 mg/l (0.20% and 1.79%) respectively showed significant difference ($P \leq 0.05$) compared to that of the control (0.15% and 1.01%). The same trends were observed in the Fe and Mg contents, application of gibberellic acids 100 mg/l, indole-3-acetic acid 100 and 150 mg/l and compost 10 t/ha performed better than other treatments.

Discussion

Efficacy of PGH and compost to increase biological yield parameters in Jatropha as observed in this experiment could be linked to the ability of PGH to stimulate plant physiological processes. Indole-3-acetic acid and Gibberellic acids have been shown to regulate different aspects of plant growth and development through its effect on processes including, root initiation and development, cell and stem elongation and differentiation, number of leaves and chlorophyll content. This agrees with the report of Woodward and Bartel, (2005) on the ability of hormones to stimulate physiological processes in plants.

Gibberellic acids treatments consistently had the highest yield in terms of plant height, leaf area, shoot weight and root weight. Exogenous application of gibberellic acid at 150 *mg\l* gave the best plant performance and an increased in the total plant biological yield components. Similar observations were also reported by Kaur *et al.*, (1998) that exogenous application of gibberellic acid causes an increased in germination and seedling growth by enhancing the availability of endogenous gibberellic acid. Moreso, the exogenous application of gibberellic acid increased the weight of fresh biomass of roots and shoots in Jatropha. These results agreed with the findings by Mohammed (2007) in bean and Jamil and Rha (2007) in sugar beet that the stimulatory effect of gibberellic acid on seedling growth may be very useful in the promotion of rapid production of vigorous seedlings for nursery or plantation establishment. A similar finding has also been reported in wheat (Akman, 2009). It is interesting that among the indole-3-acetic acid treatments 200 mg\l had the highest number of leaves and chlorophyll content. reported similar findings that indole-3-acetic acid is a key regulator of virtually every aspect of plant growth and development from embryogenesis to senescence. This is of great importance for commercial cultivation of *Jatropha curcas*. Compost at 20t\ha showed good performance and yield increase. This followed the trend as reported by Akanbi *et al.*, (2007) and Togun *et al.*, (2004) on the optimum vegetative growth and development of fluted pumpkin and tomato respectively as influenced by compost application. The old leaves of Jatropha treated with higher concentrations

of PGH contained a higher chlorophyll pigment which in turn increased the uptake of nutrient and dry matter accumulation.

Conclusion and Recommendation

This study has shown that Jatropha plants treated with PGH and compost performed better than the control. This has been linked with the inherent limiting effect of available nutrients in the tropical soils and the stimulation of endogenous growth regulatory substances by PGH. Hence, the exogenous single application of PGH could improve growth and yield of Jatropha. However, there is need to evaluate the effect of combination of compost 20t\ha with either gibberllin (150 mg\l) or indole-3-acetic acid (200 mg\l) on the growth and yield of *Jatropha curcas*, as well as the residual effects of compost in combination with indole acetic acid and gibberellic acid on the growth and yield response of *Jatropha curcas* in subsequent trials.

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