Soil chemical properties and growth response of Jatropha to Rice Husk Dust and NPK in Ebonyi State, southeastern Nigeria.

Abstract

The present study investigated the combined effect of rice husk dust (RHD) (0.1.2.3.4 and 5 ton ha^{-1}) and NPK fertilizer (0, 1, 2, 3, 4 and 5 ton ha^{-1}) arranged factorially in Randomized Complete Block Design (RCBD) on selected soil fertility indices (pH, organic carbon, organic matter, total nitrogen, available phosphorus, exchangeable bases, exchangeable acidity and effective cation exchange capacity) and growth parameters of Jatropha (number of leaves, plant height, number of branches and stem girth) in an ultisol of southeastern Nigeria. Results showed significant ($P<0.05$) improvement in all soil chemical properties and growth parameters of plant compared to control which had no treatment. However, the effects varied with treatment levels and interactions. While the effects increased with rate of application, interactions consistently showed superior effect on all parameters studied. Thus, combining RHD and NPK may increase the soil fertility and growth of Jatropha. Treatments combination of 5tonha^{-1} RHD and 3tonha^{-1} NPK and 5tonha^{-1} RHD and 5tonha^{-1} NPK relatively gave the most appreciable result in soil chemical properties and growth of Jatropha respectively, thus are recommended.

Keywords: Jatropha, Rice Husk Dust, Soil Properties, Growth and NPK

Introduction

Energy is fundamental to all human activities (Osueke and Ezugwu 2001). It has a major impact on every aspect of our socio-economic life. Future economic growth crucially depends on the long-term availability of energy from sources that are affordable, accessible and environmentally friendly (Aransiola, *et al*., 2012). However, the rapid population growth and the continuous depletion of the over dependent non-renewable crude oil reserves have led to serious global energy crisis. Horn (2004), revealed that as at the year 2010, the world consumed nothing less than 35 billion barrels of oil per year. With this fact, more dependants are on the oil producing nations, such as Nigeria, Mexico, etc. Consequently, the oil checks are becoming smaller and smaller and very soon will be insignificant relative to the world's need (Aransiola *et al*., 2012). Khan (2002) has predicted that before the end of the 21st century, the world's reserve of fossil fuels would have been expended.

Nigeria is a country that despite its abundant energy resources, still faces energy crisis such as epileptic electric supply, shortage of petroleum products and incessant increase in prices of fuel. These realities have a boost to the search for renewable and sustainable alternatives to fossil fuels, which must be technically feasible, economically competitive, environmentally acceptable and easily available (Dermibas, 2009; Lateef *et al*., 2014). Research showed that a very common plant in the tropics and especially Nigeria, Jatopha can provide bio-disesel from its seed (Lateef *et al*., 2014).

Jatropha curcas plants are usually found economically un-useful and invaluable, except when they are used as fences for house, a factor that has limited its propagation in Nigeria. Jatropha plants which are abundantly found in abandoned lands can be easily propagated by cuttings in arid and semi-arid conditions and is well effective in erosion control.

Despite the energy supply potentials and the economic relevance of Jatropha, studies on the commercial production of the plant using conventional nutrient input programmes is still limited.

Agronomists have long recognized the benefit of maintaining and increasing soil organic matter and one of the organic fertilizer sources is rice husk dust (Njoku *et al*., 2015). During rice refining processes, the husks are removed from grains. It is of little commercial value and because of its high silicon dioxide content; it is not useful to feed either human or cattle, but can be incorporated into the soil to enhance soil and crop productivity. For example, organic modification of soil with rice husk was found effective in the yield of many crops like cowpea and rice (Njoku *et al*., 2015). The increasing heaps of rice husk around rice mills in Ebonyi State and the evident that there will be continuous growth of this heaps due to the present federal government policies on ban on rice importation may in long-run become a threat to our environment if nothing is done to remove these wastes.

Considering the present and future scenarios of energy prospects occasioned by poor electricity supply and the decline in the quality and quantity of Nigerian crude oil, there is urgent need to explore the potentials of rice husk dust and NPK fertilizers on commercial Jatropha production for sustainable energy supply in Ebonyi State. This study was therefore designed to investigate the combined effect of decomposed rice husk and NPK fertilizers on soil fertility maintenance and growth of Jatropha in an ultisols of southeastern Nigeria.

Materials and Methods.

Experimental Site

The research was conducted at the Teaching and Research Farm, Department of Horticulture and Landscape Technology, Akanu Ibiam federal polytechnic Unwana from April 2020 to March 2021 under rainfed conditions. Geographically,Unwana is latitude $5^0$48'N and longitude $7^0$55'E (Azu et *al.*, 2018). The climate and vegetation type are generally humid tropical rainforest with annual rainfall of about 3500mm and daily temperature range of 32^oC- 21^oC (Nwagbara,2007). According to Njoku *et al*; (2006), the temperature is generally high throughout the year with annual relative humidity of between 60-80%.The soils which are derived from shale and sand stone belong to the order 'Ultisol" and have been classified as typic hapludult (Federal Department of Agriculture and land Resources, 1985; Nwaogu and Ebeniro, 2009). Table 1 is the representation of the results of some physical and chemical properties of the soil used for the study.

Table1.Some physical and chemical properties of the soil and rice husk dust (RHD) used for the study.

Properties	Values	RHC
Sand (%)	58.13	-
Silt (%)	11.58	-
Clay (%)	35.29	-
Texture	Clayey – loam	-
pH (H_2O)	4.00	8.00
pH ($Cacl_2$)	3.56	7.31
Org. C. (%)	1.58	3.10
Org. M (%)	2.75	
Total N (%)	0.13	2.82
Av. P (mg/kg)	9.21	21.23
Ca (cmol. /kg)	3.03	5.59
Mg (cmol. /kg)	1.21	2.22
K (cmol. /kg)	0.30	1.87
Na (cmol. /kg)	0.01	0.14
Exc. Acidity	2.44	-

ECEC	6.99	-
B.S%	65.09	

The soil used for the experiment was relatively rich in soil nutrient, but was highly acidic indicting its inability to release nutrients especially phosphorus to growing crops (Brady and Weil, 2008)

Experimental materials.

Rice husk was obtained from a local rice mills in Afikpo, Ebonyi State, Nigeria, while theJatropha seeds used for this experiment were obtained from the National Institute of Horticulture sub-station, Umulolo, Okigwe, Imo State. Similarly, the nutrient compositions of the RHD used for the study in shown in Table 1.Results showed that rice husk dust was rich in nutrients including organic carbon, available phosphorus and basic cations. Worthy of note are the high content of calcium and nitrogen. Other Researchers have also reported high nutrient content in rice husk (Njoku and Mbah, 2012; Paul *et al.,* 2007; Mansaray, 2007). According to Gailhre *et al.,* (2013), rice hull contains numerous elements essential for plant growth, including nitrogen, phosphorus and potassium.

Nursery establishment and management

The Jatropha seeds were sown in polythene bags filled with free-draining growth media containing adequate organic matter. Growth media containing a mixture of sand, topsoil and poultry manure at the ratio of 1:1:1 was used for raising the seeds. All nursery management practices such as watering, weeding, pest control were observed throughout the three months nursery period.

Field Experiment.

A total land area of (400m x 130m) was used for the experiment. The experiment was layed out in a Randomized Complete Block Design (RCBD) in a factorial pattern with three blocks consisting of 36 plots per block. Each plot measured 1.8m x 1.8m in area with spacing of 1.0m between plots and 2.0m between blocks. Thirty six (36) treatments in total comprising of six rates (0, 1, 2, 3,4, and 5tonha^{-1}) Rice Husk Dust and six rates (0. 1, 2, 3, 4, and 5tonha^{-1}) NPK, replicated three times were applied. Seedlings were transplanted one month after treatment applications with one seedling per plot, and these gave a total of one hundred and eight (108) observational units.

Data Collection

Agronomic parameters collected from each plot at six month after planting were plant height: measured as the length from the base of the plant to the tip of the shoot with the aid of a meter, stem girth by measuring with a caliper, number of leaves and branches by counting.

Similarly soil samples were taken from each plot at six month after planting and the following chemical parameters were determined according to standard methods: Particles size distribution: This was determined using the Bouyocous hydrometer method as described by Benton (2001). Soil pH was determined in soil to water and soil to $CaCl_2$ at the ratio of 1:2.5, using glass electrode pH meter (Udo *et al*., 2009). Organic carbon was determined by the wet oxidation method of Walkey and Black as described by Pansu and Gautheyrous (2006).Total nitrogen determination was done by the macro Kjeidahl digestion method (Simmone *et al.*, 1994). Exchangeable acidity was determined by the 1M KCl extraction procedure as described by Udo *et al*., (2009).Exchangeable basic cations (K^+, Ca^{2+}, Mg^{2+}, Na^+) were determined by the ammonium acetate method (Carter and Gregoich, 2008). Effective Cation Exchange Capacity (ECEC) was obtained by summation of all the exchangeable cations and exchangeable acidity as described by Udo, *et al.,* (2009). Base Saturation was obtained mathematically with:

$$\text{BS (\%)} = \frac{\text{TEB}}{\text{ECEC}} \times \frac{100}{1}$$

BS = Base saturation, TEB =Total Exchangeable Bases, ECEC = Effective Cation Exchange Capacity

Statistical Analysis

All data were subjected to (ANOVA) using GENSTAT 2009 version and means that showed significant difference were separated using Least Significant Difference (LSD) test at 5% level of significance.

Result and Discussion

Effect of Rice Husk Dust and NPK fertilizer on selected soil chemical properties.

Table 2 represents the results of the combined effect of rice husk dust and NPK on selected soil chemical properties. The soil pH was significantly affected following rice-husk dust and NPK application both as single and combined application. Increased RHD addition consistently increased the pH, while on the other hand, consistent addition of NPK presented slight decreasing trend on soil pH. The high soil pH in the amended plots is attributed to high Ca, Mg and K associated with the rice-husk dust whose effect on the soil can be likened to that of lime (Lickaz 2002). Mbah et al. (2017) reported that soil pH increases following organic waste application. However, the most appreciable increase in soil pH was recorded in the plot that had 5tonha^{-1} RHD and 2tonha^{-1} NPK (6.27), representing about 56.59% increase from the control plot. Adediran et al., (1999), strengthened by Ano and Asumugha (2000) reported better improvement in soil fertility properties when organic and mineral fertilizers are combined than the lone application of either of them.The result showed that pH remained slightly acidic following amendment. According to Mbah and Onweremadu (2009) organic wastes when used as soil amendment reduced soil acidity to levels required for crop production. Nnabude and Mbagwu (2001) observed that amendment of soil with unburnt and burnt rice mill wastes failed to completely eradicate acid in strongly acidic soils and they attributed this finding to the production of $C0_2$ and organic acids during organic matter decomposition.

The mean and interactive of RHD and NPK had significant effect ($P < 0.05$) on organic carbon, soil organic matter and total nitrogen. While there was significant increase in organic carbon and organic matter as a result of increased application of RHD as lone treatment, increased addition of NPK had negative relationship with both organic carbon and organic matter. The highest amount of organic carbon and organic matter (2.00% and 3.46% respectively) were recorded in plot that had 5tonha^{-1} RHD and 3tonha^{-1} NPK, while their least values were obtained in plot that had only 5tonha^{-1} NPK. This findings can be justified on the bases that while organic manures improve soil biology and organics at sustainable levels (Awodun, 2007), mineral fertilizers use at consistent manner are known to destroy soil health especially soil organic matter (Awodun, 2007). The interaction between 5tonha^{-1} RHD and 3tonha^{-1} NPK generally had the best improvement on organic carbon and organic matter with about 80% increase when compared with the control plot. Similar reports on the effect of RHD on soil organic matter has been made by Njoku *et al*., (2015) and Njoku and Mbah, (2012).

As anticipated, nitrogen increased proportionately with treatments application both as lone and combined treatments. This observation can be related to the fact that both RHD and NPK are precursor to nitrogen supply. Nitrogen values ranged from 0.09% in control plot to 0.42 in plot that had 5tonha^{-1} RHD and 3tonha^{-1} NPK representing about 82.35% increase. The high organic matter in RHD and nitrogen associated with both materials could be responsible for the observed increase in total nitrogen which is in agreement with the observations of Suma *et al*., (2017) who reported increased nitrogen when soils were amended with rice hull and rice straw.

Table 2. Mean effect of rice husk compost and NPK on soil chemical properties

RHD +NPK		pH	Aval. P	Org. C	Org. M	Total N	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	TEA	ECEC
(t/ha)	H2O	$CaCl_2$	(mg/kg)	(%)	(%)	(%)	→			(Cmo1/kg)	←	
Control	4.81	3.98	4.72	0.49	0.85	0.09	2.51	1.77	0.16	0.02	3.12	7.58
0 + 1	4.71	3.82	4.78	0.15	0.26	0.12	2.48	1.41	0.23	0.03	3.01	7.16
0 + 2	6.61	3.31	5.07	0.13	0.22	0.18	2.40	1.40	0.27	0.04	3.00	7.11
0 + 3	4.51	3.31	5.98	0.11	0.19	0.24	2.34	1.33	0.39	0.01	3.00	7.07
0 + 4	4.37	3.26	7.05	0.10	0.17	0.25	2.37	1.20	0.54	0.01	3.11	7.23
0 + 5	4.36	3.21	6.83	0.07	0.12	0.31	2.17	1.11	1.19	0.01	3.17	7.65
1 + 0	4.91	4.07	4.96	1.10	1.89	0.10	2.70	1.79	0.19	0.03	3.02	7.73
1 + 1	4.88	3.95	5.13	1.12	1.94	0.19	2.73	1.81	0.37	0.05	2.88	7.84
1 + 2	4.74	3.85	5.40	1.09	1.89	0.22	2.70	1.87	0.62	0.07	2.75	8.01
1 + 3	4.71	3.81	7.61	1.06	1.82	0.28	2.64	1.85	0.96	0.05	2.70	8.20
1 + 4	4.61	3.76	11.14	1.03	1.78	0.29	2.70	1.71	1.22	0.02	2.74	8.39
1 + 5	4.61	3.51	10.95	1.00	1.73	0.33	2.63	1.53	1.96	0.02	2.79	8.98
2 + 0	5.00	4.16	5.04	1.23	2.13	0.16	2.72	1.99	0.47	0.06	3.00	8.22
2 + 1	4.97	4.10	5.22	1.29	2.23	0.20	2.77	2.04	0.49	0.07	2.53	7.90
2 + 2	5.01	4.25	6.84	1.30	2.25	0.26	2.80	2.13	0.88	0.09	2.40	8.30
2 + 3	4.98	4.01	8.97	1.27	2.20	0.29	2.77	2.21	1.17	0.07	2.34	8.56
2 + 4	4.91	3.99	14.80	1.20	2.07	0.33	2.76	2.01	1.40	0.05	2.37	8.59
2 + 5	4.87	3.84	12.67	1.42	1.99	0.36	2.71	1.88	2.07	0.03	2.42	9.11
3 + 0	5.12	4.21	5.29	1.45	2.46	0.17	2.99	2.01	0.29	0.09	2.95	8.33
3 + 1	5.02	4.17	6.22	1.55	2.51	0.24	3.02	2.12	0.66	0.10	2.50	8.40
3 + 2	5.13	4.37	9.71	1.50	2.68	0.29	3.19	2.22	0.97	0.11	2.44	8.93
3 + 3	5.12	4.59	10.88	1.53	2.60	0.31	3.14	2.30	1.28	0.09	2.40	9.21
3 + 4	5.01	4.52	18.18	1.71	2.65	0.36	3.09	2.25	1.92	0.07	2.48	9.81
3 + 5	4.98	4.40	17.06	1.51	2.61	0.37	2.98	2.07	2.18	0.05	2.49	9.77
4 + 0	5.51	4.76	8.20	1.63	2.61	0.21	3.03	2.16	0.43	0.10	2.90	8.62
4 + 1	5.66	4.63	8.66	1.75	2.82	0.25	3.11	2.23	0.84	0.11	2.44	8.73
4 + 2	6.14	4.72	10.48	1.81	3.03	0.31	3.27	2.27	1.01	0.12	2.39	9.06
4 + 3	6.01	4.59	13.92	1.81	3.13	0.34	3.71	2.34	1.35	0.11	2.30	9.81
4 + 4	5.98	4.52	23.12	1.53	3.09	0.37	3.20	2.30	1.98	0.07	2.32	9.87
4 + 5	5.87	4.40	21.47	1.79	2.96	0.40	3.13	2.12	2.28	0.06	2.36	9.95
5 + 0	6.13	5.00	11.45	1.73	2.99	0.27	3.11	2.21	0.58	0.11	2.16	8.17
5 + 1	6.14	4.79	11.88	1.78	3.07	0.29	3.18	2.27	1.00	0.14	2.13	8.72
5 + 2	6.27	4.84	12.47	1.82	3.15	0.33	3.75	2.30	1.13	0.13	2.07	9.38
5 + 3	6.13	4.82	16.37	2.00	3.46	0.36	3.80	2.37	1.50	0.12	2.00	9.79
5 + 4	6.01	4.74	25.14	1.91	2.97	0.39	3.36	2.34	2.08	0.09	2.10	9.97
5 + 5	5.95	4.52	22.45	1.79	3.09	0.42	3.28	2.22	2.35	0.07	2.20	10.1
LSD(0.05)												
RHD	0.08	0.069	0.379	0.013	0.069	0.008	0.079	0.021	0.053	0.009	0.01	0.17
NPK	0.08	0.069	0.379	0.013	0.069	0.008	0.079	0.021	0.053	0.009	0.01	0.17
Interact	0.19	0.169	0.929	0.032	0.171	0.020	0.194	0.051S	0.731	0.021	0.025	1.02

Application of RHD and NPK as single and combined treatments led to significant ($P <0.05$) increase in soil available phosphorus. The phosphorus values ranged from 4.72 mg/kg in the control plot to 25.14 mg/kg in the plot that had 5tonha^{-1} RHD and 4tonha^{-1} NPK showing an increase of 84.20%. Playing prominent role in this observation, is the high organic matter content in the RHD which reduced acidity through its lime function and by breaking down phosphorus fixation caused by the sesquioxide and certain soil minerals, thereby releasing the adsorbed phosphorus for plant uptake in phosphorus deficient soils (Gilbert, 2009; Cordell *et al*., 2009).

Significant effect ($P < 0.05$) on exchangeable bases (Ca^{+}, Mg^{++}, K^{+} and Na^{+}) due RHD and NPK application both singly and interactively were observed. Apart from K^{+} which increased with the lone application of NPK, all other cations slightly decreased increased application of NPK. The lone application of RHD on the other hand, consistently increased all the basic cations studied. With the exception of Na^{+} which had its highest value (0.14 cmol/kg) in plot treated with 5tonha^{-1} RHD and 1tonha^{-1} NPK all other basic cations ((Ca^{+}, $Mg^{++}$and K^{+}) recorded their highest values (3.80 cmol/kg, 2.37 cmol/kg and 1.50 cmol/kg respectively) in experimental plot treated with 5tonha^{-1} RHD and 3tonha^{-1} NPK.). Relative to control, the basic cations have increased by 60.22%, 57.25% and 90.36% for Ca^{++}, Mg^{++} and K^{+} respectively in the plot treated with 5tonha^{-1} RHD and 3tonha^{-1} NPK, while Na^{+} was increased by 87.50% in the plot that had 5tonha^{-1} RHD and 1tonha^{-1} NPK . The high basic cation content of RHD earlier observed in this study must have influenced the result. Rice husk dust being an organic material contains large amount of organic matter which when decomposed is able to release differs basic cations to the soil (Brady and Weil, 2008). There are also reports of increased basic cations in the soil and reduction in soil acidity due to rice husk dust application (Aadu and Akamigbo, 1990; Njoku and Mbah, 2012

The total exchangeable acidity (TEA) and the Effective Cation Exchange Capacity were significantly improved by the application of RHD and NPK. While there was significant increase in ECEC due to the addition of the experimental materials, there was sharp decrease in the concentration of TEA due to the interactive effect of RHD and NPK and the lone application of RHD. Relative to control, there was a decrease of about 40.23% in TEA and an increase of 57.13% in ECEC, due to the amendments. Using burnt and unburnt rice husk dust, Njoku and Mbah (2012), reported a decrease in TEA and an increase in ECEC relative to non-rice husk treated soils. According to Adeleye *et al*. (2010), the application of organic amendment increased soil exchangeable Mg, Ca, K, and Na, and lowered exchangeable acidity. Other studies have reported the role of organic waste materials in soil buffering, cations release, pH moderation, phosphorus release, reduction in TEA and increase in CEC (Mbagwu *et al.*, 1991, Owolabi *et al*., 2003 and Azu *et al*., 2017).

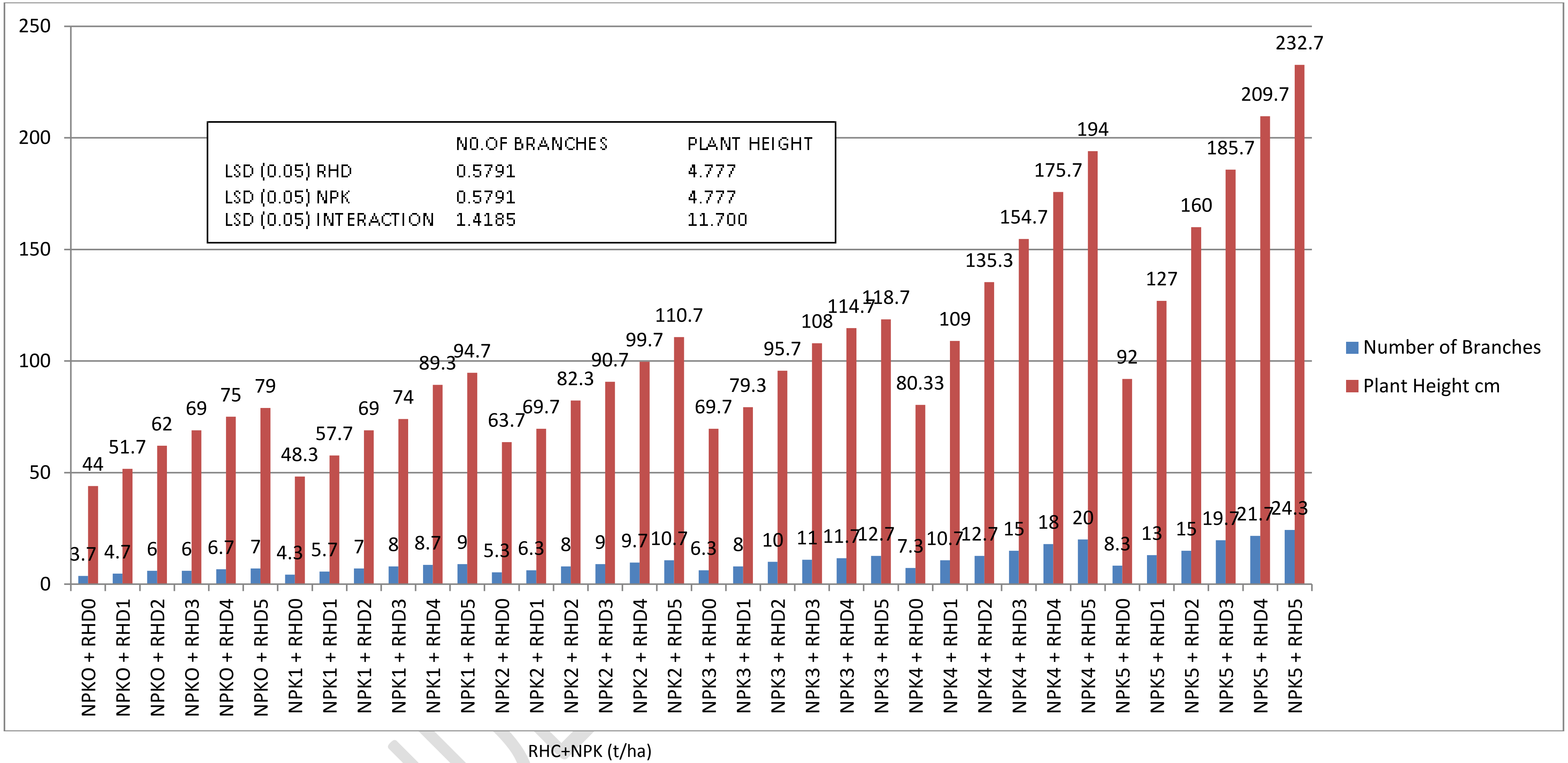
EFFCT OF RHD AND NPK ON GROWTH PARAMETERS OF JATROPHA

Number of branches and Plant Height: All treatments enhanced both the number of branches and plant height as compared to control after six months of experimentation. The lone treatments and interactions between RHD and NPK was found effective in increasing the number of branches and plant height (Fig. 1). The analysis of variance revealed that the number of branches and plant height were significantly ($P<0.05$) increased by the interaction effect of RHD and NPK. These increases were proportional to the amendment rates and the maximum number of branches and plant heights (24.33 and 232.7 cm) were recorded in the plot treated with 5tonha^{-1} RHD and 3tonha^{-1} NPK. This in relation to control represents about 78.48% and 84.10% increase in number of branches and plant height respectively. The probable reason for these observations could be due to increased nutrients release especially nitrogen from both amendments that promotes vegetative growth of plants (Brady and Weil, 2008). These findings is in accordance with the work of Suma *et al*., (2017), who reported a striking increase in the nitrogen content and growth parameters of rice which were amended with rice husk hull. Also, Njoku and Mbah, (2012) and Njoku *et al*., (2015) reported increased maize performance due to rice husk dust application.

Number of leaves and stem girth: As expected, these parameters had increased relative control (Fig 2). These increases were statistically significant (P<0.05). Relative to control, the number of leaves and stem girth had increased by 80.55% and 66.51% respectively due the addition of RHD and NPK. These results correspond to increased nutrient release by the treatments especially nitrogen which plays major role in vegetative growth of plants (Brady and Weil, 2008).

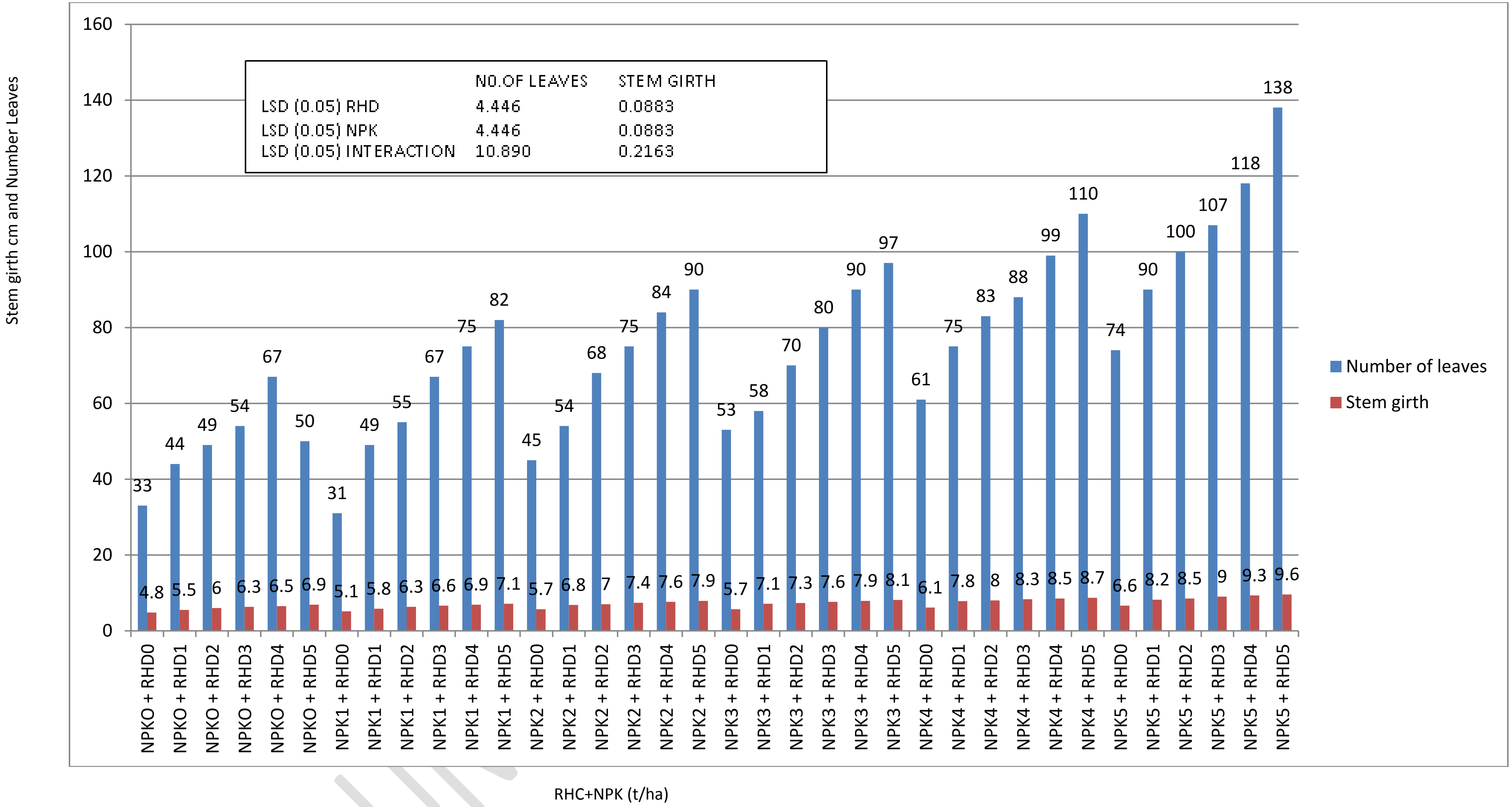
Jatropha curcas growth as demonstrated by plant height (cm), number of leaves, number of branches and stem girth were significantly influenced by the application RHD and NPK singly or in combination. These parameters increased with rates. These results agree with the findings of Oliver, (2016), who reported increased growth of Jatropha when produced in soil treated with a combination of organic and inorganic fertilizers.

Although *Jatropha curcas* has the ability to flourish under any condition even without fertilizer application but greater yield is obtained when fertilizer is applied as observed from the research work.



	NO.OF BRANCHES	PLANT HEIGHT
LSD (0.05) RHD	0.5791	4.777
LSD (0.05) NPK	0.5791	4.777
LSD (0.05) INTERACTION	1.4185	11.700

Fig1. **Mean effect of rice husk dust and NPK fertilizer on plant height and number of branches**



	NO.OF LEAVES	STEM GIRTH
LSD (0.05) RHD	4.446	0.0883
LSD (0.05) NPK	4.446	0.0883
LSD (0.05) INTERACTION	10.890	0.2163

Fig2. **Mean effect of rice husk dust and NPK fertilizer on number of leaves and stem girth**

Conclusion

Soil fertility properties and growth response of Jtrohpa produced in soil treated with different levels of rice husk dust and NPK was investigated in this study. The experimental findings showed significant improvement on soil chemical properties and growth parameters of Jatropha. Generally, interactions consistently showed better improvement on all variables studied. Treatment combination of 5tonsha^{-1} RHD and 4ton ha^{-1}NPK gave the best results in terms of soil chemical properties, while 5tonsha^{-1} RHD and 5ton ha^{-1}NPK had significantly highest improvement on all plant growth parameters. Thus to ensure long term soil fertility effect and sustainable Jatropha production in southeastern Nigeria, 5tonsha^{-1} RHD and 4ton ha^{-1}NPK and 5tonsha^{-1} RHD and 5ton ha^{-1}NPK should be practiced.

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