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Effect of mulching materials on upland rice (*Oryza sativa l.*) in Port Harcourt, Rivers State, Nigeria

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ABSTRACT
This study was conducted to determine the effect of mulching materials on upland rice variety, FARO 57, at the Faculty of Agriculture Teaching and Research Farm located at the University of Port Harcourt, Rivers State, Nigeria. Three mulch types - Coconut husk, Dry Guinea grass, and Sawdust were compared with control where no mulch was used in a randomized complete block design with four replications. Growth and yield parameters were recorded, and were significantly influenced by the treatments. Rice mulched with coconut husk produced significantly ($p \leq 0.05$) higher grain yield of 142.16kg/ha followed by dry guinea grass mulch (122.66kg/ha), Sawdust mulch (72.33kg/ha) and control (65.16kg/ha), while the highest dry tiller weight (2,333.33kg/ha) and fresh tiller weight (4,750kg/ha) was obtained in coconut husk followed by dry guinea grass which had 2,250kg/ha and 4,583kg/ha respectively. The result showed highest plant height in dry guinea grass mulched plot (77.9cm). Early application of mulch facilitates faster decomposition and quicker release of nutrient for plant growth. Application of coconut husk and dry guinea grass at the rate of 2kg per plant in each case is recommended for rice cultivation in the study area.

Keywords: Mulch; upland rice, variety; coconut husk; sawdust.

INTRODUCTION

Rice (*Oryza sativa L.*) belongs to the family poaceae and is a staple food in many countries of Africa and other parts of the world. This is the most important staple food for about half of the human race (Imolehim and Wada, 2000). Saka and Lawal (2009) classified rice as the most important food depended upon by almost 50% of the world population for about 80% of their food need. More than 90% of total rice is cultivated in south and East Asia, having China and India as the leading producers (Remison, 2005). Due to the growing importance of the crop, Food and Agricultural Organization (FAO) (2001) estimated that annual rice production should be increased from 586 million metric tonnes in 2001 to meet the projected global demand of about 756 million metric tonnes by 2030. Nearly 100 million people now depend on upland rice as a daily staple food. The utilization of rice is increasing and the inequity between domestic productions has been increasing in sub–Saharan Africa (Oikeh *et al*., 2008). About 80% of rice in Africa is produced by small–scale farmers for their own utilization and local market (WARDA, 2007). Population increase, and change in consumer desire in favor of rice particularly in urban areas has comparatively increased rice demand in Sub–Sahara Africa than in any other place in the world (Somado *et al.*, 2008). Africa became a big competitor in the international rice market with about 32% of the world's import in 2006 with record of 9 million tonnes in that particular year (WARDA, 2007).

Upland rice which is known as dry land rice is normally grown under rain fed conditions without surface water accumulation for any significant period of time. This type of rice can be grown on wide range of soils varying from moderately–drained to well–drained soils such as sandy loam to sandy clay, respectively with soil pH range from 4.7 to 6.8. Upland rice is grown on rain fed fields, prepared and seeded when dry, much like wheat or maize, and depends on rainfall for moisture. Lowland rice, also known as paddy rice, is generally grown on soils that are flooded or irrigated. The yield of upland rice is much lower than the yield of lowland rice, this is because the upland rice is water deficit and use of low inputs by the farmers (Haefele *et al.*, 2013). These inputs mainly include fertilizers, insecticides, and herbicides. Use of low inputs is associated with drought, risk and poverty. Despite the lower yield, upland rice plays an important role due to low production cost and lack of drainage and irrigation facilities in the lowlands (Totin *et al.*, 2014). Rainfed upland rice ecosystems account for about 27% of the total rice area of the country and are used by 28% of the rice farmers (Diagne *et al.*, 2013).

Mulch is any material placed on the soil surface to conserve moisture, lower soil temperatures around plant roots, prevent erosion and reduce weed growth. Mulches can be derived from either organic or inorganic materials (Rumpel *et al.*, 2003). Mulching is the process or practice of covering the soil/ground to make more favorable conditions for plant growth, development and efficient crop production. Natural mulches such as leaf, straw, dead leaves and compost have been used for centuries, during the last 60 years. The mulch prevents direct evaporation of moisture from the soil and limits the water losses and soil erosion over the surface. The suppression of evaporation also has a supplementary effect; it prevents the rise of water containing salt which is important in countries with high salt content water sources (Ji and Unger 2001).
Organic mulch has been known to improve the organic carbon in the soil, facilitate better root penetration, development and extraction of nutrients from deep layer of the soil. Sawdust is a wood waste containing a very rich carbonaceous component that can be used as soil amendment. Sawdust may be beneficial due to its rich carbonaceous nature, but it may also affect nitrogen availability for the same reason. They are considered to be slow decomposers, as their tissues are rich in lignin, suberin, tannins, and other decomposition-resistant, natural compounds. Thus, wood chips supply nutrients slowly to the system; at the same time, they absorb significant amounts of water that is slowly released to the soil (Khan *et al.*, 2005).

The coconut fruit yields 40% coconut husk which contain 30% fiber with dust making up the rest. Typical Composition of coconut husk (%): Nitrogen 0.26, Organic carbon 29, C: N ratio 100:1, Ph 5.5-6.8, Lignin 31, Cellulose 27, Hemicellulose 47, Potassium 0.78, Phosphorus 0.01, Iron (ppm) 0.07, Reducing sugar 4 (Prasad and Roeber,1997). Dried Guinea grass is rich in energy, vitamins and minerals hence can be used both as mulch and forage crop. It decomposes easily. One kilogram of guinea grass contains 0.29g Phosphorus, 3.90g Potassium, 0.49g

Calcium, 0.22g Sodium, 0.25g Magnesium; 66.67mg Iron, 43.89mg Manganese, 6.43g Copper, 25.68g Zinc (Eroarome, 2001).

Mulch has a great role in soil moisture conservation through modification of microclimatic soil conditions. It helps to reduce weed growth, reduce evaporation, and increase infiltration of rain water during growing season (Ibekwe *et al.*, 2003). Mulch provides numerous benefits to crop production by improving the physical, chemical, and biological soil properties (Jordan *et al.*, 2015). Constant application of inorganic fertilizer under intensive cropping also had resulted in yield reduction through leaching of soil nutrients. This has made most farmers to grow crops with little or no fertilizers thereby reducing their crop yield (Onwueme and Sinha, 19991). Therefore, the use of organic materials is encouraged to reduce the declining soil condition, enhance soil nutrient, and improve soil structure and aeration for better root growth, development and crop yield. The objective of this study is to determine the effect of the selected mulches; Coconut husk, Dried Guinea grass, Sawdust on the growth and yield performance of FARO 57 variety of *Oryza sativa* in Port Harcourt, Rivers state.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the Teaching and Research Farm of the University of Port Harcourt, Choba, Rivers State, Nigeria during the wet season between May and September 2019. The experimental site is located at latitude $04^0$3” N to 5^0 N and longitude 6^0 45” E to 7^0E with an elevation of 17m above sea level. It has an average temperature of 27^0C, relative humidity of 78% and an average rainfall that ranges from 2500-4000mm (Nwankwo and Ehirim, 2010).

Soil Analysis

Prior to planting, soil was collected randomly at a depth of 0-15cm from each plot with the use of soil auger. Physio-chemical properties were determined by standard laboratory procedures. The Kjeldal method was used to determine total nitrogen as described by Bremner and Mulvaney (1982). Available phosphorus was determined by rapid Perchloric acid digestion method. Exchangeable potassium was extracted using ammonium acetate and was determined using the flame photometer. The soil pH in 0.01M calcium chloride (CaCl) was determined using a glass electrode.

Sources of Planting Material

The upland rice variety used for this experiment was Federal Agricultural Research *Oryza* 57 (FARO 57) and was obtained from the University Agra rice unit. Sawdust mulch was collected from a sawmill at Rumuosi in Port Harcourt. Guinea grass was harvested before flowering at the University farm, Coconut husk was sourced from a local trader in Uruan Local Government Area in Akwa Ibom State.

Experimental Design and Treatment

The experimental land area was cleared manually, stumps and debris were removed without burning. The Experiment was laid out in a Randomized complete block Design (RCBD) and the treatments (Sawdust, Coconut husk, Dry guinea grass and Control - No mulch) were replicated four times. The gross plot was 9.5m by 13.5m consisting of 16 plots and each plot measured 3m by 2m with alley ways of 0.5m between rows and replicates. The planting distance between and within rows was 30cm by 30cm. Three seeds were planted per hole and later thinned to one seedling per plant at two weeks after planting. The treatments consisted of three mulching materials and a control where no mulch was used. The mulch materials were dried and applied at the rate of 2kg per plant using the ring method of application three weeks after planting (3WAP). Hoe weeding was carried out on the planted plots.

Data Collection

Data were collected at weekly intervals starting from 4 weeks after planting (4 WAP) until 12 WAP. Three (3) plants per plot were tagged for data collection out of 21 plants per plot. The parameters recorded on growth were: plant height **(**this was measured with a graduated meter rule taken from the soil surface to the tip of the longest leaf of the plant); leaf area (the leaf area was determined by K(L × W), where L is the leaf length, W is the maximum width of leaf) with a correction factor of 0.5 (which is used as K); leaf area index (LAI) was calculated using the formula (Hunt, 1978): LA/P, where LA = total leaf area and P = land area occupied by plant. Leaf area used in leaf area index calculation was determined by the disc method according to the procedure of Kelm *et al.*, (2001); number of leaves (this was determined by counting at weekly interval starting from 4WAP); number of tillers; (this was also determined by counting the tillers at weekly interval starting from 4WAP). Yield Parameters recorded: were weight of tillers (weight of tillers was taken fresh and dried. The fresh weight was gotten by cutting the tillers from the base of the plant and weighed. The tillers were sundried for about two weeks and dry weight was taken); Weight of panicles (this was taken after threshing. The panicles were sun-dried and weighed using a sensitive weighing balance. Grain yield (the grains were threshed and weighed using a sensitive weighing balance).

Statistical Analysis

Data collected was subjected to statistical analysis of Variance (ANOVA) using GenStat Release, version 12.1 and significant treatment means were compared using least significant difference (LSD) at 5% probability level.

RESULTS

Soil Physio-chemical Properties

The chemical properties of soil at the experimental site before planting is presented in Table 1. The result of the soil analysis shows that the soil was low in total organic matter (2.27), available phosphorus (3.0), and nitrogen (0.57) but adequate in exchangeable potassium (6.5). The pH of the soil was slightly acidic (7.0), while the soil texture was sandy loam.

Table 1: Physio-chemical properties of the soil at the Experimental site before Planting

Soil Properties	Value
Nitrogen (g/kg)	0.57
Potassium (cmol/kg)	6.5
Phosphorus (mg/kg)	3.0
Total organic carbon (%)	1.4
Organic matter (%)	2.27
pH	7.0
Sand	70.4
Silt	9.4
Clay	20.2
Soil texture	Sandy loam

Plant height

The effect of mulching materials on plant height (cm) is presented in Table 2. There was significant difference among treatments. There was steady increase in plant height throughout the observation period, the control treatment (CO - no mulch) showed a constant increase in plant height as compared to other treatments. The tallest plant at 11WAP and 12 WAP (72.2 cm and 77.9cm respectively) was produced with the treatment Dried guinea grass mulch followed by the treatment Control (no – mulch) with 71.6cm and 75cm within the same period. Also, in 11WAP and 12 WAP, coconut husk had a plant height of 69.cm and 72.7cm respectively. The least plant height was recorded in the sawdust plot (61.4 cm) at 12WAP compared to other treatments.

Table 2: Effect of mulching materials on Plant Height (cm) of upland rice in Port Harcourt

	Weeks After planting								
Treatment	4	5	6	7	8	9	10	11	12
Coconut Husk	37.1	44.1	46.7	52.8	54.4	63.4	65.5	69.2	72.7
Dry Guinea Grass	39.2	45.7	52.8	57.9	62.2	67.7	69.9	72.2	77.9
Saw Dust	34.7	37.3	43.6	45.2	49.2	58.8	59.1	61.6	61.4
Control	43.6	50.0	54.6	58.5	63.0	69.0	70.6	71.6	75.0
LSD (0.05)	NS	12.06	NS	NS	13.15	NS	NS	NS	NS

NS= Not-significant

Leaf Area (cm^2)

The effect of mulching material on the leaf area of Upland rice is presented in Table 3. There were significant differences in the leaf area recorded at 4, 6 and 7 WAP. The largest leaf area was recorded with the treatment Coconut husk mulch (46.0 cm^2 at 12WAP). The least leaf area was recorded with the treatment, sawdust (35.1 cm^2 at 12WAP).

Table 3: Effect of mulching materials on the Leaf area (cm^2) of upland rice in Port Harcourt

	Weeks After planting								
TREATMENT	4	5	6	7	8	9	10	11	12
Coconut Husk	9.2	17.5	22.2	22.3	29.8	34.5	37.4	40.5	46.0
Dry Guinea Grass	10.9	20.2	24.4	24.7	30.9	33.2	38.5	32.5	42.6
Saw Dust	11.6	16.1	16.0	18.0	25.6	25.4	52.0	39.4	35.1
Control	19.3	23.5	27.7	27.5	30.5	32.8	39.5	39.0	43.2
LSD (0.05)	8.72	7.53	11.66	11.59	NS	NS	NS	NS	NS

NS= Not-significant

Leaf area index

In Table 4 the maximum leaf area index at 12 WAP was obtained in control- no mulch (4.15) followed by coconut husk (3.60). However, the minimum leaf area index was recorded in sawdust (2.55). The leaf area index was comparable in different organic mulching material from 4-12WAP. There was steady increase in leaf area index throughout the sampling period. There was a significant difference at 4WAP.

Table 4: Effect of mulching materials on the Leaf area Index of upland rice in Port Harcourt

	Weeks After Planting								
TREATMENT	4	5	6	7	8	9	10	11	12
Coconut	0.080	0.267	0.499	0.51	1.07	1.66	2.13	2.53	3.60
Dry Guinea Grass	0.092	0.323	0.576	0.58	1.28	1.78	2.39	2.78	3.41
Saw Dust	0.107	0.213	0.325	0.33	0.79	1.15	2.45	2.20	2.55
Control	0.377	0.616	0.643	1.01	1.58	2.54	3.00	3.42	4.15
LSD (0.05)	0.2822	N	N	N	N	N	N	N	N

NS = Not-significant

Number of leaves

The effect of mulch materials on number of leaves is presented in Table 5. There was significant difference on leaf production at 4, 5, and 7 WAP. The plot without mulch (control) had the highest number of leaves (18.3, 25.2, 35.7) at 4 WAP, 5 WAP and 7 WAP respectively compared to other treatments. There was a steady increase in leaf production throughout the observing period. The highest number of leaves was also recorded under the treatment control – no mulch (96.7) at 12WAP followed by the treatment - Dry guinea grass (88.3). The minimum number of leaves was observed with Sawdust mulch (63.0) at 12 WAP.

Table 5: Effect of mulching materials on the Number of Leaves in upland rice in Port Harcourt.

	Weeks After Planting								
TREATMENT	4	5	6	7	8	9	10	11	12
Coconut Husk	10.9	16.8	23.8	24.0	37.7	51.5	60.8	67.7	79.5
Dry Guinea Grass	9.2	17.8	52.8	25.6	45.0	58.5	69.8	77.3	88.3
Saw Dust	9.0	14.7	43.6	16.8	28.5	39.4	50.8	58.8	63.0
Control	18.3	25.2	54.0	35.7	68.4	77.3	81.7	89.5	96.7
LSD (0.05)	8.94	14.97	NS	18.65	NS	N S	NS	NS	NS

NS = Not-significant

Number of Tillers

The effect of mulch on the number of Tillers is presented in Table 6. There was significant difference in the number of tillers produced at 4, 5 and 7 WAP. The control treatment had the highest number of tillers (4.42, 5.50, 8.48) compared to other treatments in 4, 5, and 7 WAP respectively. The maximum number of Tiller was recorded under the control– no mulch (20.7) at 12WAP and the minimum was recorded in sawdust (14.6). The number of tillers increased steadily over the period of observation from as low as 1.25 to as high as 20.7.

Table 6: Effect of Mulching materials on the Number of Tillers in upland rice in Port Harcourt

	Weeks After Planting								
TREATMENT	4	5	6	7	8	9	10	11	12
Coconut Husk	2.08	3.08	4.41	4.25	7.1	10.5	12.2	14.6	18.6
Dry Grass	2.00	3.08	4.45	5.58	9.6	12.8	13.7	15.8	19.0
Saw Dust	1.25	1.75	4.22	3.17	6.1	8.1	9.7	11.0	14.6
Control	4.42	5.50	4.66	8.48	12.6	16.0	18.1	19.8	20.7
LSD (0.05)	3.10	3.45	NS	4.751	NS	NS	NS	NS	NS

NS = Not-significant

Yield Parameters

The data presented in Table 7 shows that the effect of mulch treatments on fresh weight of tillers were numerically different at all the stages of crop growth. The maximum fresh weight of tillers (4,750kg/ha) was recorded under the treatment of coconut followed by dry guinea grass (4,583kg/ha), the minimum Fresh weight of tillers was observed with sawdust (2,333.33kg/ha). The effect of mulch on dry weight of tillers is also presented on Table 7. There was a significant difference in dry weight. The highest dry weight was obtained in coconut (2333.33kg/ha) while the lowest was in control - no-mulch plot (1,250kg/ha). In panicle weight, dried guinea grass produced the highest panicle weight (45.5kg/ha) and the lowest in control (25.83kg/ha). Coconut husk mulched upland rice plants produced significantly higher grain yield of 142.16kg/ha compared to other treatments, while control (no-mulch) had the lowest yield of 65.16kg/ha. The same trend of yield production followed in 1000 grain weight.

Table 7: Effect of Mulching materials on the Yield (kg/ha) of upland rice in Port Harcourt

Treatment	Fresh weight of tillers	Dry weight of tillers	Weight of panicles	Grain Yield	1000 Grain Weight
Coconut Husk	4,750	2,333.33	45.30	142.16	35.16
Dry Guinea Grass	4,583	2,250	45.50	122.66	15.83
Saw Dust	2,333.33	1,375	27.33	72.33	13.33
Control	4,250	1,250	25.83	65.16	11.00
LSD (0.05)	NS	NS	NS	16.67	NS

NS = Not-significant

DISCUSSION

The low organic matter and Nitrogen (N) level recorded could be as a result of continuous cropping on the experimental site, excessive rainfall leading to soil erosion, leaching of nutrients which might have led to nutrient removal from the soil.

In vegetative growth, control performed better in leaf area, leaf area index, number of leaves and number of tillers, this showed that nutrients status in the experimental plot was relatively suitable for rice production. Jordan *et al*., 2015 reported a slow rate of decomposition of mulch materials leading to reduced plant growth. According to Master Gardener (2007), water stress and changes in pH in decomposing mulch material also cause low release of nutrients resulting in low plant growth. Time of mulch application is also one of the factors to be considered for the performance of control over mulch in these parameters. The increasing plant height was due to favorable soil moisture and a favorable temperature condition for proper plant growth (Yu, *et al.,* 1981). Maximum plant height and number of leaves have also been observed in mulched plot (Khan *et al*., 2005). Sawdust also enhanced soil fertility, but the enhancement was slow due to slow release of nitrogen as a result of its high Carbon/Nitrogen ratio (C:N) but according to

Johnson, *et al*., (2004) Sawdust may negatively affect crops by drying up soil Nitrogen due to a wide C:N ratio. Result showed that Dry guinea grass mulch has a faster decomposition rate which facilitated the quicker release of nutrient to plants as compared to Coconut husk and Sawdust. Although control (no-mulch) performed better during vegetative period, while Dry guinea grass and Coconut husk mulched plots gave a better yield attribute. Higher grain yield was observed under mulched conditions as compared to no-mulch, this is in agreement with Lehar, *et al.,* (2017) and Arash (2013). Sawdust had the lowest figures in both vegetative and yield parameters compared to other mulch materials, this is as result of its high C:N ratio. Application of Dry guinea grass mulch is recommended due to its low C:N ratio which facilitate faster decomposition and quicker release of nutrient for plant growth. Coconut husk is also recommended and more research should be carried out on it to know the best rate of application of the mulch. In conclusion application of Coconut husk and Dry guinea grass at the rate of 2kg per plant in each case is recommended for rice cultivation in the study area.

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