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EFFECT OF MULCHING ON GROWTH OF GINGER IN ISHIAGU, EBONYI STATE, NIGERIA

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ABSTRACT
The paper investigates effect of mulching on growth of ginger in ishiagu, ebonyi state, Nigeria. The experiment was carried out at the experimental farm of Federal College of Agriculture, Ishiagu, Ivo LGA of Ebonyi State, Nigeria, during the 2009 and 2010 cropping seasons, using ginger as test crop. In 2009, there was less than 40% sprouting of ginger at 4 WAP but all the mulched plots were significantly higher than the control. In 2010, there was also significant difference (P < 0.05) in sprouting at 4 WAP but not at 6 and 8 WAP. At 6 WAP there was 50 to 62% sprouting across the treatments. However, at 8 WAP, there was 80% or more sprouting across the treatments. Number of leaves per plant showed that at 6 WAP on average, the organic mulch materials produced higher number of leaves when compared with either the control plot or the black polythene mulched plot. No significant differences occurred between the treatments at 8 WAP. In both years, the dry grass mulch resulted in significantly higher leaf area than the saw dust mulch. The mean leaf area for 2009 and 2010 was in the magnitude of dry grass >rice husk> saw dust > black polythene > control. There was increase in plant height from 4-12 WAP in 2009 and 2010. The organic mulches available were suitable for ginger production in the study area and the test crop UG1 is well adaptable to Ishiagu Environment. It is therefore concluded that mulching is imperative for ginger production and variety UG1 could be used to maximize production at Ishiagu environment. Dry grass and rice husk mulches should be used in Ishiagu environment.

Keywords: mulch, growth, ginger, rice husks

INTRODUCTION
The agricultural land area of the world is limited and is composed of a layer of top soil that averages only about 18 centimeters over the earth's surface. This mantle should be exploited with care. The conservation and replenishment of this mantle is important to support the survival of increasing human population (Lal, 1994). Among other methods, the use of mulch takes prime place in conservation and replenishment of the top soil. Most other methods like the application of fertilizer do add nutrients to the soil but do not conserve the soil. Modern soil conservation is based on the result of definite research and on farmer's experience from all over the world. The application of soil conserving practices, such as mulching, results in increased hectare production and decrease per unit cost of production. To the farmer, such practices not only result in an increase in farm profits, but also help to lower the cost of food and clothing to people living in cities. Mulching continues to be an important soil management practice in many parts of the world, (Lal, 1995a; Juo and Lal, 2001; Opara-Nadi and Lal 1997; Salau *et al*; 2002). These and other studies show that protecting the soil surface with mulches help to improve the

soil environment which is important for optimal crop growth and yield. Mulches may be defined as insulating substance spread over the surface of the soil (Jules, 1999). Most mulching materials consist of plant refuse or by-products: leaves; straw, sawdust, rice husk, corn cobs, peat, tobacco stems, wood chips or paper. Inorganic substances such as rook wool, plastic or gravel can also be used as mulches. Ginger is a tropical monocotyledonous herbaceous perennial plant (Pulseglove, 2005) with leafy shoots and grows to a height of 30- 100cm tall, depending on the cultivars and growing environment. Purseglove (2005) added that the plant resembles the common alligator pepper, which is often grown as a compound crop. The rhizome is thick, hard and palmately branched about 15-25mm in diameter. The production of ginger (*Zingiber officinale* Roscoe) in Nigeria started since 1929, as recorded by Anad, (2000). Nigeria produced about 110,000 MMT of ginger in 2005 even though internally it had the largest area of land under cultivation. China and India are the world's largest producers. Between 1960 and 1969, Nigeria ranked second after India, as world largest exporter of ginger (Anad, 2000). Between 1967 and 1986, Nigeria exported a total of 56,224, 519 tonnes of ginger valued at $618,812 to European and North American countries (Eluagu and Ugwu, 2008). Ginger (*Zingiber officinale* Roscoe) is a spice crop, for millions of people in these regions providing an important source of carbohydrate, protein, minerals and vitamins than is commonly assumed (Adodo, 2004).

Over 90 percent of West African ginger comes from Nigeria (Okwuowulu, 1995). Ginger accounts for 10 percent of the output of spice and tuber spice crops (AERLS, 1997). In Sub-Saharan Africa, ginger accounts for 30 percent of the total spice crops and exported crops, to USA, Sierra Leone, West Germany, the Netherlands and United Kingdom (AERLS, 1997). Nigeria accounts for 52 percent of the world hot and peppery ginger and 22 percent production. Nigeria produces about 0.40 metric tons of ginger per annum. (Adodo, 2004). Major ginger producing states in Nigeria include Kaduna, Niger, Nasarawa, Plateau and Abia (FMANR, 2005). There are three varieties of ginger namely, the white "Tafin Giwa", the yellow "Yatsun Biri", and foreign which is referred to as mainland china. Subsequent trials have established superiority of Tafin Giwa over others (Erinle, 2001).

Ginger is a tuber crop highly valued in Nigeria because of its enormous potentials in food, beverage and pharmaceutical industries. It is a crop grown especially for its spicy and medicinal values. The loss of top soil due to wind and water is a national problem which needs urgent attention. According to Lal (1994), mulches can effectively check erosion provided the slope does not exceed 15%. Soil conservation through mulching yields immediate reward in terms of plant growth and must be considered the basis of sound soil management.

Ginger requires application of mulch for its growth and yield. Mulch reduces direct evaporation and thereby conserves soil moisture. It controls weeds and mulching with maize stover significantly increased both grain and straw yield (Okigbo 2002). Mukharsingh *et al.*, (2000) on their studies on different mulches in Punjab reported significant increase in yield and that rice husk was the best. Lal (1996), Nogueira *et al.*, (2003), and Okigbo (2002) also reported similar results. The beneficial effect of mulching have been attributed to improvement in soil physical, chemical and biological properties (Lal and Kang, 1992; Opara-Nadi and Lal, 1997; Salau *et al.*, 2002) as well as to the shading effect of the mulch and prevention of soil erosion (Lal, 1995). Application of mulches helps to regulate soil temperature. The temperature stabilizing effect of dry season mulches is due to insulation, heat absorbing and shading, and this appears to increase nutrient availability and ultimately plant growth. Besides conserving soil moisture by reducing evaporation rate, mulches also retard erosion by protecting the soil against the beating force and splashing action of rain. Run-offs are also effectively checked (Lal 1994, and Falayi *et al.*, 1999). Mulches also increase the infiltration of water through the soil and control weed by smothering weed growth and cutting off light from the soil surface (Vlees-Chauwer *et al.*, 1998). In his experiment at IITA in 1994, Lal also observed at 8 weeks after planting that earth-worm activity was influenced by mulching. He also reported that mulched plots maintained their initial infiltration rate as compared to significant decline in infiltrability of the unmulched plots. In addition, mulches may be sources of organic matter and nutrient to the soil and the physical condition of soil is largely conditioned by the amount of organic matter it contains as reported by Jonkovic *et al.*, (2000). There is scarcity of fertile land for ginger production due to demographic pressure and non-agricultural uses of land. Consequently, intensification, ecological adaptation trials, mechanization of ginger production to reduce drudgery and improve processing and marketing, will boost ginger production and export in Nigeria. Mulches favour ginger production in the following ways (N.R.C.R.I Bulletin, 2004):-

- Increasing the uniform infiltration of rain water by protecting the soil structure;
- Reducing the direct evaporation of water from the soil surface and thereby conserving soil moisture;
- Controlling weeds;
- Modifying soil temperature and controlling erosion;
- Adding plant nutrients to the soil through the decomposition of plant residue used for mulching;
- Promote soil aeration (soil air)
- Increasing organic matter and soil biotic population.

Odedina *et al.*, (2002) concluded in their experiment on the use of siam weed mulch for improving maize nutrient content and yield that Siam weed residue is useful for improving availability of nutrients and yield of maize. Ahaiwe and Okwusi (2010) in their study on effect of agroforestry prunings on seed yam yield and size of seed yam found that application of *Spondias mombin* mulch resulted in the highest number of tubers having weights greater than 200g, while the least number of seed yams weighing less than 200g was obtained with the control. They also concluded that application of prunings (mulches) resulted in significantly higher seed yam yield over the control (no application) in both 2000 and 2001 cropping seasons. Ginger requires moderate to high levels of soil fertility (Njoku *et al.*, 1999). Okwuowulu (1998) reported that compound fertilizer (N.P.K 15:15:15) applied by broadcasting at the rate of 700kg/ha before mulching was effective for ginger production. Purseglove (2005) suggested supplying 60-100kg/ha of Nitrogen and NPK (12:14:10) at the rate of 750kg/ha for good ginger growth. NRCRI (2001) recommended NPK (15:15:15) compound fertilizer applied 6-8 weeks after planting at the rate of 350-400kg/ha for ginger. The objective of the study is to determine the effect of mulching on growth of ginger at Ishiagu, Ebonyi State.

MATERIALS AND METHODS

Study Area

The experiment was carried out at the experimental farm of Federal College of Agriculture, Ishiagu, Ivo LGA of Ebonyi State, Nigeria, during the 2009 and 2010 cropping seasons, using ginger as test crop. Ishiagu is made up of 17 villages and covers an area of about 120 km^2 with a population of about 40,000 people (Ajah, 1998; NPC, 1996). The community is blessed with natural resources such as marble, lead and zinc (Onu, 1995). The area lies between latitudes 5^0 and 6^0 North of the Equator and longitudes 7^0 and 8^0 East of the Equator with annual rainfall of about 1,200 mm to 1,600 mm per annum and temperature range of about $27^{o}C$ to $33^{o}C$ (Onu, 1995). Ishiagu is located in Southwest of Ebonyi State and is bordered in the North by Awgu and Aninri Local Government Areas (LGAs) of Enugu State, in the east by Akaeze in Ivo LGA of Ebonyi State. In the south, the area is boarded by Acha and in the west by Uturu all in Isukwuato LGA of Abia State (Anyata, 1996).

The vegetation is derived savannah in the southeast agro– ecological zone of Nigeria. The area has two seasons, namely the rainy and the dry seasons. The former lasts about seven months; commencing most often from April to October with a short break normally in the month of August called August break. The latter lasts about five months from November to March. The underlying geology is sedimentary rock derived from successive marine deposits of the Cretaceous and Tertiary Imo (shale) formation (Lekwa *et al*., 1995). The soil is hydromorphic and classified as Typic Haplustult by the Federal Department of Agricultural Land Resources (FDALR, 1985), the soil temperature regime of the study area is about $32.2^{o}C$ (Nwite *et al.*, 2008). Chukwu (2007) stated that soils of Ishiagu are derived from shale parent material. He described the soils as deep, matured and characterized by lessivage and redoximorphic features at a depth of ≥ 56 cm. The soils are classified as Aquic Haplustalf (USDA) and correlated with Gleyic Acrisol (FAO/UNESCO) (Chukwu, 2007).

Land Preparation

The experimental site in 2009 was 10m away from the site in 2010 cropping seasons. Cropping history showed that the sites were previously occupied by *Panicum maximum* (guinea grass), *Imperata cylindrica* (spear grass), *Axonopus compressus* (carpet grass), *Centrosema pubescens, Calopogonium mucunoides, Pueraria phaseoloides, Euphorbia spp* (milk weed) and *Ageratum conyzoides* (goat weed). Each year the site was mechanically prepared with the aid of tractor. Land preparation was done by clearing, ploughing, harrowing and making of beds.

Field Experiment

The experimental design was a randomized complete block design (RCBD) with four replications. The plot size was 4 m x 2 m (8 m^2) with an alley of 0.5 m between plots and 1m between replicates. The field layout is shown as Figure I. Treatments comprised four types of mulch and a control without mulch. The treatments were saw dust (SD), rice husk (RH), dry grass (DG) (dominated by *Axonopus compressus* and *Eleusine indica*), black polythene (BP) and control (no mulch)

Planting

The test crop was ginger (*Zingiber officinale* Roscoe) var UG1 (yellow ginger) obtained from Ginger Research Programme of the National Root Crops Research Institute, Umudike, Abia State, Nigeria. The rhizomes were cut into plantable sett size of 5g. Care was taken to ensure that each sett contained at least two buds. Seed treatment involved dipping the rhizomes into a solution of ethoxyethyl mercuric chloride for about one minute in the evening of the day preceding planting. The treated ginger setts were air - dried overnight. The setts were planted in shallow holes of 4 cm deep at a spacing of 20 cm x 20 cm to give a plant population of 250, 000 plants/ha.

Mulch Application

All mulching materials were applied immediately after planting. The organic mulches were evenly spread on the raised beds at the rate of 20 t/ha. The black polythene mulch was perforated to allow passage of rainwater into the soil. It was held firmly on the plots by covering about 8 cm of the tips with soil along the edges of the beds. The black polythene was perforated with about 5 cm opening to avoid impeding the sprouting of the rhizomes.

Agronomic Data Collection

Plant height was measured at 2 weeks intervals using meter rule. Leaf area was calculated according to Anteneh et al., (2008) formular as follows: LA = L x W x K; where LA = leaf area, L = leaf length, W = leaf width and K = 1.426 (constant for ginger).

Statistical analysis

Data collected were subjected to statistical analysis. The agronomic data were analyzed using analysis of variance (ANOVA). According to steel and Torrie (1990), differences between treatment means were detected using least significant difference (LSD). Combine analysis was done to compare the mean yield of treatments after two years of cropping.

RESULTS AND DISCUSSION

Effect of Mulching On Ginger Growth

Sprout count

In 2009, there was less than 40% sprouting of ginger at 4 WAP but all the mulched plots were significantly higher than the control (Table 1). However, at 6 WAP, 50% or more sprouting was observed on plots mulched with rice husk (50.0%) and dry grass (52%). Sprouting on plots mulched with saw dust, black polythene and the control was 48, 48 and 43%, respectively. Percentage sprouting in 2009 was statistically different among the treatments at 4 but not at 6 and 8 weeks after planting.

In 2010, there was also significant difference ($P < 0.05$) in sprouting at 4 WAP but not at 6 and 8 WAP. At 6 WAP there was 50 to 62% sprouting across the treatments. However, at 8 WAP, there was 80% or more sprouting across the treatments. The results buttressed the importance of mulching in ginger production. Ohiri and Njoku (1997) emphasized that mulching enhanced early sprouting in ginger, through its effect in moderating soil temperature to about 32°C required for optimum ginger production. This result is in line with their findings.

Table 1: Effect of mulching materials on sprouting of ginger at 4, 6 and 8 weeks after planting (WAP).

	Sprouting Count (%) in 2009 Cropping Season		
	Weeks after planting		
Treatments	4	6	8
Dry Grass	36.5	52.0	85.0
Rice husk	35.0	50.0	84.0
Saw dust	33.0	48.0	84.0
Black polythene	31.0	48.0	82.0
Control	18.5	43.0	80.0
LSD(0.05)	**10.5**	**NS**	**NS**
	2010 Cropping Season		
Dry Grass	40	62	88
Rice husk	42	54	85
Saw dust	38	50	81
Black polythene	35	50	80
Control	20	50	80
LSD	**7.20**	**NS**	**NS**

NS = Not Significant

Number of leaves of ginger

Number of leaves per plant showed that at 6 WAP on average, the organic mulch materials produced higher number of leaves when compared with either the control plot or the black polythene mulched plot (Table 2). No significant differences occurred between the treatments at 8 WAP (Table 3). Probably, mineralization of organic mulches increased the soil nutrient pool available for the ginger plants to absorb and produce more leaves than in the control and black polythene mulched plots. The result is similar to the report by Amadi *et al.*, (2010) on ginger in high altitude environment of Jos Plateau. They evaluated two ginger varieties (UG 1 and UG2) and found that the number of leaves per plant ranged from 34.8 to 43.0 for variety UG 1 and 35.2 to 45.4 for variety UG 2 in 2009 and 2010 cropping seasons. The relatively higher number of leaves recorded at 8 WAP at Ishiagu than in Jos could be due to differences in environments.

Table 2: Number of leaves/plants of ginger as influenced by the treatments at 6 weeks after planting (WAP)

	Number of leaves at 6 WAP		
Treatments	**2009**	**2010**	**Mean**
Dry grass	43.0	50.0	46.5
Rice husk	45.0	48.0	46.5
Saw dust	36.0	45.0	40.5
Black polythene	33.0	38.0	35.5
Control (No mulch)	34.0	36.0	35.0
LSD (0.05)	**7.00**	**10.00**	**5.50**

Table 3: Effect of mulch treatments on the number of leaves of ginger at 8 weeks after planting (WAP)

Number of leaves at 8 WAP			
Treatments	**2009**	**2010**	**Mean**
Dry grass	52	54	53.0
Rice husk	49	56	52.5
Saw dust	50	51	50.5
Black polythene	48	50	49.0
Control (No mulch)	49	50	49.5
LSD (0.05)	NS	NS	NS

Leaf length

The effect of mulching materials on the leaf length is presented in Table 4. Results showed that in 2009 leaf length increased progressively from 4 weeks after planting to 12 weeks after planting (WAP) in all treatments. In 2009, dry grass gave a higher significant ($P < 0.05$) leaf length relative to other treatment at 4 WAP. However, there was no significant difference in leaf length among the plots that were mulched with black polythene, rice husk, saw dust and the control. From 6 WAP up to 12 WAP, all the mulched plots (irrespective of mulch type) had higher significant leaf length than the control plot. From 8 to 12 WAP, plots mulched with dry grass consistently resulted in highest significant ($P < 0.05$) leaf length compared to other treatments. In 2010, dry grass mulch resulted in 42, 32.9 and 24.0% higher significant ($P < 0.05$) leaf length than the control, black polythene and Saw dust treatment, respectively at 4 WAP. However, there was no significant difference in leaf length between plots that were mulched with dry grass and Rice husk. As was observed in 2009, length of ginger leaf increased progressively from 4 WAP to 12 WAP. At 12 WAP plots mulched with dry grass gave the highest leaf length of 34.1cm which was 59.3 and 36.4% higher than the control and black polythene mulched plots (Table 4.16). The increase in leaf length with time, up to 12 WAP suggests that the maximum growth stage of ginger was not attained.

Table 4: Leaf length (cm) of ginger as influenced by mulches at 4,6,8, 10 and 12 weeks after planting (WAP)

Weeks after planting

	4	6	8	10	12
Types of mulch			**2009**		
Dry Grass	9.00	15.0	22.6	28.3	33.6
Rice husk	8.25	15.6	21.0	27.0	31.2
Saw dust	8.20	14.6	20.4	25.0	30.0
Black polythene	8.00	14.1	19.0	25.0	29.0
Control	8.00	13.0	18.0	23.6	28.1
Mean	8.29	14.46	20.2	25.8	24.1
LSD(0.05)	**0.82**	**0.13**	**0.60**	**0.80**	**1.27**
Types of mulch			**2010**		
Dry Grass	9.30	14.8	21.0	29.0	34.1
Rice husk	8.70	16.0	20.0	25.4	30.0
Saw dust	7.50	15.0	20.5	23.8	28.6
Black polythene	7.00	14.5	18.4	20.6	25.0
Control	6.55	13.7	16.0	19.0	21.4
Mean	7.81	14.8	19.2	23.6	27.8
LSD(0.05)	**1.50**	**1.20**	**1.17**	**1.50**	**1.48**

Leaf Area of Ginger

Effects of treatments on leaf area of ginger showed that across the treatments, leaf area ranged from 45.5cm^2 in the control to 53.7cm^2 in the dry grass mulch in 2009 (Table 5). The same trend was observed in 2010 because the leaf area ranged from 47.4cm^2 in the control to 56.2cm^2 in the dry grass mulch. Application of organic mulches, irrespective of type resulted in higher ($P < 0.05$) leaf area relative to polythene mulch and the control. However, there was no significant difference in leaf area between plots mulched with dry grass and rice husk. In both years, the dry grass mulch resulted in significantly higher leaf area than the saw dust mulch. The mean leaf area for 2009 and 2010 was in the magnitude of dry grass >rice husk> saw dust > black polythene > control.

The results compared favourably with results obtained by Amadi *et al.*, (2014), who evaluated the leaf area of 16 ginger mutants at Umudike. They obtained a range of leaf area of 31.98cm^2 – 54.55cm^2. The higher leaf area in the organic mulched plots, suggested a higher photosynthetic activity on those plots. This, probably contributed in explaining the higher significant rhizome yields obtained on the organic mulched plots relative to black polythene mulched plots and to the control plots without any mulch, respectively.

Table 5: Effect of types of mulch on leaf area of ginger 8 WAP in 2009 and 2010.

Treatments	2009	2010	Mean
	leaf area in (cm^2)		
Dry grass	53.7	56.2	55.0
Rice husk	52.9	55.0	54.0
Saw dust	50.4	51.8	51.1
Black polythene	48.7	49.0	48.9
Control	45.5	47.4	46.5
Mean	50.2	51.2	
LSD (0.05)	1.54	1.67	

Plant height

Plant height measured at 4, 6, 8, 10 and 12 WAP is shown in Table 6. The plant height followed the same trend as in the length of leaves. In 2009, plant height increased in the following order: dry grass > rice husk> saw dust > black polythene > control at 4 WAP and 12 WAP. At 12 WAP, dry grass resulted in 16.2, 10.2 6.2 and 1.2°cm higher significant ($P < 0.05$) plant height than the control, black polythene, saw dust and rice husk mulched plots respectively.

In 2010, the plant height from 4 to 12 WAP ranged from 20 to 39 cm, 18 to 35 cm, 16 to 31 cm, 13 to 29 cm and 12 to 24 cm for plots that received dry grass, rice husk, saw dust, black polythene and control without mulch respectively. The pattern of increase in plant height from 4-12 WAP followed the trend obtained in 2009. The results obtained agree with Chukwu *et al.*, (2008) who obtained (32.3-35.5cm) on Arenic patendult at Umudike, in trials on low external-input in sustainable ginger production. The increase in plant height over time in organic mulched plots could also be attributed to the mineralization of the organic mulches and the release of more nutrients which the plants, probably utilized, to increase in growth.

Table 6: Effect of mulch types on plant height of ginger at 4, 6, 8, 10 and 12 weeks after planting (WAP)

Plant height (cm) in 2009

	Weeks after planting				
Treatments	**4**	**6**	**8**	**10**	**12**
Dry Grass	21.4	26.0	30.0	30.5	38.2
Rice husk	20.0	21.4	27.0	30.0	37.0
Saw dust	13.0	15.4	25.0	28.0	32.0
Black polythene	11.5	17.0	22.0	25.0	28.0
Control	9.50	15.0	20.0	21.0	22.0
LSD(0.05)	**1.30**	**1.14**	**1.30**	**2.5**	**1.80**

Plant height (cm) in 2010

Dry Grass	20.0	25.0	28.0	31.0	39.0
Rice husk	18.0	22.0	26.0	29.0	35.0
Saw dust	16.5	19.0	23.4	25.0	31.6
Black polythene	13.2	18.0	21.0	23.3	29.4
Control	12.1	16.0	19.3	20.0	24.0
LSD(0.05)	**1.60**	**1.20**	**1.25**	**2.1**	**2.5**

CONCLUSION AND RECOMMENDATIONS

The organic mulches available were suitable for ginger production in the study area and the test crop UG1 is well adaptable to Ishiagu Environment. It is therefore concluded that mulching is imperative for ginger production and variety UG1 could be used to maximize production at Ishiagu environment. In order to substantially improve soil physical and chemical properties and ginger rhizome yields, it is recommended that dry grass and rice husk mulches be used in Ishiagu environment. Rice husk is the most abundant mulching material in Ishiagu environment because it is a major rice growing area. Therefore, the use of rice husk as mulch could reduce environmental pollution arising from its current method of disposal by burning and also reduce weed infestation.

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