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EFFECT OF SELECTED MULCH MATERIALS ON YIELD PERFORMANCE AND VISCOSITY OF OKRA (*Abelmoschus esculentus* L.) IN OWERRI, SOUTH EASTERN NIGERIA.

OGU, C.E.,
Department Of Agricultural Education
Alvan Ikoku University Of Education, Owerri
Email: Christian.ogu@alvanikoku.edu.ng/ oguchrisx@gmail.com

OSUAKU, S.K
Department of Agricultural Education
Alvan Ikoku University of Education, Owerri.

EKOJA, I.O
Department of Agricultural Education
Alvan Ikoku University of Education, Owerri.

&

ONOGU, B.
Department of Agricultural Education
Alvan Ikoku University of Education, Owerri.

Abstract
This study was conducted in 2021 and 2022 early cropping seasons at the teaching and research farm of School of Agriculture and Agricultural Technology, Federal University of Technology owerri, to investigate the effect of selected mulch materials on the performance and viscosity of okra (Abelmoschus esculentus L.) in Owerri. The experiment was layout in a Randomized Complete Block Design with five (5) treatments, each replicated four (4) times. The treatments were palm bunch waste (PBW), palm kernel shell (PKS), dry banana leaf (DBL), Chromolenaena odorata leaf (COL) and unmulched (UM). The treatments were applied three weeks after planting. Growth and yield parameters measured include; weed fresh weight, plant height, leaf area, leaf abscission, number of fruits per plant, percentage moisture content, and fresh fruit co-efficient of viscosity. The result showed that plots mulched with PKS significantly ($p<0.05$) reduced weed growth compared with other mulch treated plots. In both seasons, PBW plots enhanced okra growth and yield significantly ($p<0.05$) compared with other treatments. Okra fruits from PBW plots had the highest value of co-efficient of viscosity (901.60), followed by COL (705.60), while the least value of 360.64 was recorded in the UM (control) plots.
Keywords: *Mulch materials, Okra, Yield, viscosity.*

Introduction
Okra (*Abelmoschus esculentus* L. Moench) is one of the most important vegetable crops cultivated in tropical and subtropical regions, and believed to have originated in Africa (Islam, 2019). Okra is grown across Nigeria, where it serves a major component of local diets and source of income for smallholder farmers. The crop is valued not only for its edible green pods but also for its rich nutritional composition; including vitamin, minerials, dietary fibre (Basnet *et al*., 2023), and a characteristic mucilage that contributes to its culinary and medicinal importance. This mucilaginous property is widely utilized in soups and has been reported to possess health benefits such as cholesterol reduction and pharmaceutical applications (Gemede, *et al*., 2016).

Despite its importance, okra production in Nigeria is still constrained by several agronomic challenges, particularly low soil fertility, poor moisture retention and suboptimal crop management practices (Kihara *et al*., 2023). These factors contribute to relatively low yields compared to the crop's potential. Enhancing soil conditions, limiting interference and

improving soil moisture are therefore critical for increasing both the production and quality of okra. Mulching is effective agronomic practice for improving soil physical and chemical properties, conserving soil moisture, suppressing weed, and regulating soil temperature (Lal, 2019). Various mulch materials (organic or inorganic) have shown to be significant in influencing crop growth and yield.

For example, studies conducted in Nigeria indicate that different mulch types can lead to variations in okra performance (Adeleke and Olaleye, 2020; Ogu *et al*., 2019), with some materials (like polythene mulch) enhancing yield and overall crop quality through improved moisture conservation and soil condition. The type of mulch applied can affect not only the vegetative growth and yield of okra but also its quality attributes, including the mucilaginous content of the pods. Since mucilage is an important quality parameter influencing consumer preference and industrial use, understanding how mulching practices impact this trait is essential for optimizing production.

Mulching can influence availability of soil nutrient and plant physiology, which in turn may alter biochemical properties such mucilage content. Given these considerations, this study aims to evaluate the effect of selected mulch materials on yield performance and viscocity of okra in Owerri, Southeastern Nigeria.

Materials and Methods

The study was carried out at the teaching and research farm of the School of Agriculture and Agricultural Technology (SAAT), Federal University of Technology Owerri, Imo State, during the 2021 and 2022 cropping seasons respectively. Owerri is located in the humid forest zone of Southeastern Nigeria, with a minimum and maximum annual ambient temperature of 20 ^{0}C and 32 ^{0}C respectively, a mean annual rainfall of 2500 mm, and humidity of 92 percent (Nwosu and Adeniyi, 1980). The okra variety (Pusa sawam) used for this experiment was obtained from National Horticultral Research Institute (NIHORT), Ibadan. The experiment was a Randomized Complete Block Design (RCBD), with five treatments, each replicated four times. The treatments comprised, palm kernel shell (PKS), palm bunch waste (PBW), *Chromolaena odorata* leaf mulch (CLM), dry banana leaves (DBL), and unmulched (control) (UM).

The palm kernel shell and palm bunch waste were obtained from Umugwoma village in Ohaji Egbema Local Government Area, while dry banana leaves and *Chromonaena odorata* were within the experimental site. Fifteen tons per hectare (15 t/ha) of each of these treatments were applied three weeks after planting (3WAP) in each of the plot measuring 2 m x 2 m. Sowing was done on April 28 and 24th in 2021 and 2022 cropping seasons respectively, two seeds were sown directly into the soil with a spacing of 30 cm x 60 cm. the seedlings were later thinned down to one to give the required population density. Weeding was done at three, six and nine weeks after planting.

Growth and yield measurement taken include plant height, leaf area, number of leaf abscission, number of fresh fruits per plant, fruits moisture content, and viscosity (mucilaginous quality). The viscosity was measured in the laboratory using viscometer, while co-efficient of viscosity was assessed by the method described by Nelkon and Parker (1979) using the stoke formula.

$$\text{Co-efficient of viscosity} = \frac{2ga(e-0)}{gvo}$$

Data collected were subjected to analysis of variance (ANOVA) according to the procedures of a randomized complete block design as described by Obi, (2002), while mean separation was done by the use of least significant difference (LSD) at 5% probability level.

Results and Discussion

Table 1: Effect of mulching on weed fresh weight (g/m^2)

	2021 SEASON	2022 SEASON

Treatments	6 WAP	9 WAP	6 WAP	9 WAP
Palm kernel shell	1.04	5.17	2.12	1.75
Palm bunch waste	1.52	2.76	1.84	2.34
***Chromolaena odorata* leaf**	2.68	7.62	5.18	7.61
Dry banana leaf	1.78	6.04	2.37	4.35
Unmulched(control)	11.75	16.27	12.99	14.08
$LSD_{0.05}$	2.73	3.76	6.04	3.84

The weed populations were generally low in the mulched plots, while the unmulched plots had the highest weed population in both seasons. The fresh weed weights were significantly ($p<0.05$) higher in unmulched (UM) plots followed by plots mulched with *Chromolaena odorata* leaf (COL), dry banana leaf (DBL), palm bunch waste (PBW), and palm kernel shell (PKS) (Table 1). There was no significant difference in weed weight between palm bunch waste and palm kernel shell at 6 and 9 weeks after planting (WAP) in 2021 and 2022 seasons. Plots mulched with COL were not as effective as plots mulched with PKS, PBW, and DBL in suppressing weeds in both years.

The highest weed population was discovered in the UM plots. This may be due to the fact that the weed seeds in the UM plots enjoyed favourable environmental conditions that enable them to germinate. This agreed with Essien *et al.* (2009) who observed that unmulched maize plot produced the highest weed population due to the fact that the soil was bare and the weed species received adequate growth resources.

Table 2: Effect of mulching on okra plant height (cm)

TREATMENTS	3WAP	4WAP	5WAP	6WAP	7WAP	8WAP
	2021 SEASON					
Unmulch	4.25	5.18	5.98	6.10	7.13	7.43
Palm bunch waste	4.80	7.35	9.60	11.93	14.58	17.20
Chromolaena odorata	4.55	6.45	7.35	8.93	10.23	11.55
Dry banana leaf	4.78	6.70	7.65	8.63	9.70	10.30
Palm kernel shell	3.93	4.73	5.55	6.68	8.80	11.40
$LSD_{0.05}$	Ns	1.53	1.74	3.15	3.67	4.21
	2022 SEASON					
Unmulch	4.05	4.75	5.60	6.10	7.03	7.28
Palm bunch waste	4.33	5.70	6.73	8.45	10.60	13.18
Chromolaena odorata	4.40	5.80	6.60	7.08	8.28	9.10
Dry banana leaf	4.28	5.20	5.58	6.25	7.33	8.25
Palm kernel shell	3.78	4.33	4.80	5.45	6.75	8.08
$LSD_{0.05}$	Ns	0.94	1.30	1.65	1.99	2.57

The effect of mulching on okra plant height is shown in Table 2. Okra plant heights were significantly ($P<0.05$) influenced by the different mulch materials. At 3WAP, okra mean plant heights in both seasons were statistically the same. At 4 and 5 WAP, there were significant differences in okra plant heights in both years, the plots treated with PBW produced the tallest plant heights (9.6 cm and 6.8 cm) respectively, while the lowest (4.8 cm and 4.33 cm) were recorded in plots treated with PKS in both seasons respectively.

At 6, 7 and 8 WAP the results of mean plant height followed the same pattern of plant growth as in week five; with PBW treated plots was highly significant (P<0.05) among all the treatments in both seasons. At 8 WAP, plots treated with PBW recorded the highest mean plant heights of 17.2 cm and 13.2 cm respectively in both years, while UM plots recorded the lowest mean plant height of 7.4 cm and 7.3 cm in both seasons respectively. Rasheed and Olubade, (2009) reported that competition of weeds with okra from 4 - 8 WAP significantly reduced the height. All the mulch treated plots recorded taller plant height compared to the unmulched plot (control).

While PBW was highly significant among the treatments, COL, PKS and DBL were statistically the same, but significantly (P<0.05) differed with the UM (control) plots. The better plant height witnessed in PBW could be as a result of its ability to checkmate weed competition, and slowly decompose to add nutrients to the soil; impacting on plant growth. This result agreed with Ndagana *et al*. (2024) that mulching for effective weed control practices improved okra growth and yield performance by reducing weed competition and conserving soil nutrients. The result also agreed with Essien *et al.* (2009) who reported that fast decomposers provide large amount of nutrients in the early stage of crop growth which contributed to the mutual supply of plant nutrient which affected other growth and yield parameters.

Table 3: Effect of different mulch materials on leaf area of okra (cm^2)

TREATMENTS	3WAP	4WAP	5WAP	6WAP	7WAP	8WAP
			2021 SEASON			
Unmulch	4.25	4.68	5.43	5.43	6.98	10.68
Palm bunch waste	4.85	19.63	36.35	57.35	89.05	101.53
Chromolaena odorata	4.48	12.50	18.55	25.40	31.57	38.63
Dry banana leaf	4.55	5.65	7.63	9.53	14.90	18.18
Palm kernel shell	5.18	8.70	12.98	16.85	22.93	23.55
$LSD_{0.05}$	Ns	8.27	15.84	28.60	33.28	34.03
			2022 SEASON			
Unmulch	4.93	6.58	8.75	13.73	18.15	19.20
Palm bunch waste	5.50	10.40	20.58	36.55	49.93	51.48
Chromolaena odorata	4.63	6.58	8.95	16.35	23.58	27.48
Dry banana leaf	4.95	7.00	9.95	15.73	23.95	22.20
Palm kernel shell	5.00	6.33	9.00	17.43	28.95	34.43
$LSD_{0.05}$	Ns	1.97	6.05	8.74	16.18	15.57

The effects of different mulch materials on okra leaf area are shown in Table 3. The leaf area varies with the growth period and with different mulch materials applied in both 2021 and 2022 cropping seasons respectively. At 3 WAP the leaf area of okra in all mulched plots were similar in both seasons. In 2021, at 4, 5, 6 WAP, leaf area in plots mulched with PBW were highly significant (P<0.05) among the treatments except plots mulched with COL which was statistically the same but with higher leaf area. Plots mulched with *Chromolaena odorata* leaf were also statistically the same with PKS, DBL and UM treatments, but had higher leaf areas at 4, 5 and 6 WAP. Whereas, in 2022, plots mulched with PBW at 4, 5 and

6 WAP was highly significant (P<0.05) among all the treatments, while other treatments remained statistically the same (Table 3). At 7 and 8 WAP, plots mulched with PBW significantly recorded the largest leaf area (89.05 cm^2, 101.53 cm^2 and 49.93 cm^2, 51.48 cm^2) while the smallest leaf (6.98 cm^2, 10.68 cm^2 and 18.15 cm^2, 19.20 cm^2) was recorded in unmulched (control) plots in 2021 and 2022 cropping seasons respectively.

The better leaf area in plot mulched with PBW could probably be as a result of its ability to protect the soil, smother weeds, and gradually decomposed to boost the soil nutrient which impacted on vegetative growth of okra plant. Lal (2019) reported that on decomposition, plant residues increase humus content of the soil and this improved soil physical properties. This finding agrees with Rosi *et al*. (2024) that organic mulches improve soil quality, conserve moisture, reduce erosion, and gradually release nutrients that support plant growth.

Table 4: Effect of mulching on number of okra fresh fruits per plant

	2021 SEASON			2022 SEASON		
TREATMENTS	**9WAP**	**10WAP**	**11WAP**	**9WAP**	**10WAP**	**11WAP**
Unmulch	2.50	3.50	3.50	0.75	3.25	3.75
Palm bunch waste	6.75	9.75	7.25	6.755	9.75	6.75
Chromolaena odorata	5.00	7.75	5.25	4.50	7.50	5.25
Dry banana leaf	4.00	5.50	4.75	2.50	5.00	4.25
Palm kernel shell	5.25	7.50	5.00	3.50	5.50	4.75
$LSD_{0.05}$	2.04	2.00	0.99	1.13	1.56	0.69

The result of different mulch materials on okra fruit yield were shown in Table 4 above. Okra yield differed significantly with the type of mulch material used. In both 2021 and 2022 cropping seasons, all the mulched plots had greater pod yield than the unmulched (control). Plots mulched with PBW recorded the highest number of fruits (9.75) per plant at 10 WAP in both 2021 and 2022 cropping seasons respectively, while the lowest number of fruit yield (3.50 and 3.25) per plant was obtained in UM plots at 10 WAP in 2021 and 2022 cropping seasons respectively. The UM plots had the lowest number of pod yield in both seasons apparently due to poor crop growth and development which might be as a result of low soil nutrient and weed competition. It was observed that PBW improves growth and yield significantly over other mulch treatments.

Demo and Bogale (2024), reported that mulch offer tremendous potential for increased crop production through its marked effect on weeds and soils physical and chemical environment, which increases crop growth and yield. Mulch greatly affects soil improvement, suppresses weed growth and boosts the growth and yield of okra. These probably accounted for the higher cumulative pod production and yield in the mulched treated plots than the unmulched plots. This result agrees with Ndagana *et al.* (2024) who reported that mulching and effective weed control practices improved okra growth and pod yield by reducing weed competition and conserving soil nutrients.

Table 5: Effect of mulching on moisture content and viscosity of okra fruits

Treatments	% moisture content	Time (sec)	co−efficient of viscosity
Unmulch	71.13	72	360.64
Palm bunch waste	77.26	176	901.60
Chromolaena odorata	73.63	140	705.60
Dry banana leaf	73.00	80	407.17
Palm kernel shell	73.89	120	664.37

The results on moisture content shows that okra fruits from PBW had the highest percentage moisture content of 77.26 % compared to other treatments, while lowest percentage moisture content of 71.13 % was recorded in UM plots (Table 5). The result on co-efficient of viscosity for okra fruits as influenced by different mulch materials indicates a higher difference existing between the PBW treated plot and other treatments.

The results showed that okra fruits from mulched plots were more viscous than the unmulched plots. Co-efficient of viscosity varied with different mulched materials used. Okra fruits from PBW treated plots had the highest value of co-efficient of viscosity (901.6), this was followed by COL (705.6), PKS (664.37), DBL (407.17), and the lowest value of 360.64 was recorded in the UM plots (control) (Table 5). The higher viscosity recorded in fruits mulched with PBW could be as a result of improved and favourable soil conditions that benefited plant growth and yield. This finding agrees with Otuaro *et al.* (2024) who stated that mulching significantly improved okra growth parameters, pod yield, and overall crop quality.

Conclusion and Recommendations

Based on the findings of the study, it can be concluded that mulched materials have great potentials of improving okra growth and yield. All the mulched plots increased growth and fruit yield through modification of the crop growing environment by reducing weed infestation and maintaining soil nutrients. Mulching with Palm bunch waste increased okra growth and yield parameters significantly ($p<0.05$) higher than other mulch materials. Also, okra fruits from palm bunch waste recorded the highest value of co-efficient of viscosity compared to other treatments. Palm bunch waste mulch has shown to be best amongst the treatments in terms of okra growth, yield, and viscosity performance.

Therefore, for effective weed control, and high quality and quantity yield of okra, palm bunch waste should be recommended at 15 ton/ha at three weeks after planting, and proper care should be taken to ensure the mulch materials are applied properly at the base of the plants.

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