Influence of Sawdust Mulch on Soil Properties, Growth and Yield Performance of Okra *abelmoschus esculentus* (l.) Moench in an alfisol

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Abstract

Sawdust, a byproduct of the saw-milling, pulp, paper, and wood processing industries, is composed of small waste particles. When used as mulch, sawdust can impact soil structure, aeration of heavy soils, evaporation losses, soil moisture, soil temperature, and ultimately, the distribution of soil elements within the plant growth profile. To investigate these effects, a field experiment was conducted at the Teaching and Research Farm of the Federal College of Forestry in Jericho, Ibadan. The objective of this study was to assess the influence of sawdust mulching on selected soil properties, as well as the growth and yield performance of okra (Abelmoschus esculentus (L) Moench). The experiment followed a Randomized Complete Block Design (RCBD) and consisted of four treatments (Control, 10 tons/ha, 20 tons/ha, and 30 tons/ha), each replicated four times, resulting in a total of sixteen experimental units. Six mulch treatments were applied, and data were collected on plant height (cm), stem girth (cm), number of leaves per plant, number of branches per plant, and pod yield. The results revealed that the application of sawdust mulch reduced bulk density, increased total porosity, and enhanced the growth and yield of okra compared to the control plot, particularly from 4 weeks to 8 weeks after planting. In conclusion, the study suggests that the application of sawdust mulch at a rate of 20 tons/ha significantly promotes the growth and yield (kg/ha) of okra, while also improving soil properties in the study area. Therefore, it is recommended that farmers in the study area consider adopting sawdust mulching at a rate of 20 tons/ha to optimize pod yield in okra production.

KEYWORDS: Okra, Sawdust, Soil Properties, Alfisol, Mulching.

INTRODUCTION

Mulching plays a crucial role in protecting soil against the impact of raindrops, thereby reducing water and soil loss rates in diverse environments, including agricultural lands and rangelands (Blavet *et al*., 2009; Cook *et al*., 2006; Fernández *et al*., 2012; Jordán *et al*., 2010; Massimo *et al*., 2016; Morgan, 1986; Sadeghi *et al*., 2015). It effectively mitigates overland flow generation rates and velocity by increasing surface roughness, leading to a decrease in sediment and nutrient concentrations in runoff (Cerdà, 1998; Cerdà, 2001; Jordán *et al*., 2010; Poesen and Lavee, 1991). Moreover, mulching improves infiltration capacity and enhances water intake and storage in the soil profile (Cook *et al*., 2006; Jordán *et al*., 2010).

Sawdust, which is the fine powder-like residue produced during wood cutting (Hornby, 1998), primarily originates from saw-milling, pulp and paper, and wood processing industries. In regions like southern Nigeria, sawdust often accumulates in heaps and is predominantly burned, causing environmental pollution (Adegoke and Mohammed, 2002). Sawdust is a carbonaceous organic substance with a high carbon to nitrogen ratio estimated at approximately 300:1 (Tran, 2005). Application of sawdust mulch has been found to increase soil oxygen diffusion rate, promote a more uniform soil temperature, reduce surface crusting and soil bulk density, and improve aeration porosity and soil moisture content (Elliot and Robichaud, 2001; Khan *et al*., 2000; Tran, 2005).

Sawdust mulch enhances soil structure, improves aeration in heavy soils, enhances water absorption and penetration, and conserves moisture through weed control and reduced evaporation. In Nigeria, okra (Abelmoschus esculentus) is a widely consumed crop, both in fresh and dried forms, due to its nutritional importance (Fatokun and Chedda, 1981; Odoh *et al*., 2017). Small-scale farmers are increasingly interested in commercial okra cultivation for income generation and other opportunities (Selleck and Opena, 1985; Odoh *et al*., 2017). However, achieving optimum yields of 2-3 t/ha in tropical countries like Nigeria has been challenging, partly due to ongoing soil fertility decline. To improve okra production, various organic and inorganic materials, such as fertilizers, organic manure, and bio-fertilizers, have been employed to enhance the physical, chemical, and biological properties of soils.

Sawdust, considered a waste product from timber-industrial activities, is produced in substantial quantities annually in Nigeria, with most of it being burned. However, an increasing amount is being utilized as mulch by horticulturists, small fruit growers, and nurserymen. It is also finding application as litter in barns and feedlots, suggesting its potential as a valuable commodity for agricultural utilization and soil conservation. While the use of sawdust mulch has predominantly relied on trial and error, it has generally yielded positive results.

This study aims to investigate the effects of sawdust mulch on the growth and yield of okra, as well as its impact on soil properties. By exploring the influence of sawdust mulch application, valuable insights can be gained to optimize okra production and promote sustainable agricultural practices.

METHODOLOGY

The experiment was conducted at the Teaching and Research Farm of the Federal College of Forestry, Jericho, Oyo State (latitude 07°54'N, longitude 03°34'E), Ibadan, Oyo State, Nigeria. The region experiences a bimodal pattern of annual rainfall, with a total of 1400 mm. The mean monthly temperature ranges from 32°C to a maximum of 35.5°C.

Prior to tillage, soil samples were collected from each plot at a depth of 0-15 cm. The samples were bulked together, air-dried, crushed in a mortar to break up soil clods, and sieved using a 2 mm sieve to remove large particles, debris, and pebbles. Particle size analysis was performed using the Bouyoucos hydrometer method (Bouyoucos, 1962). Soil bulk density was determined using the core method described by Blake and Hartage (1986). Saturated hydraulic conductivity was determined following the procedure outlined by the Soil Science Society of America (2002). Soil pH was measured using a glass electrode pH meter in a 1:1 soil-to-water ratio (Udo and Ogunwale, 1986).

Organic carbon content was determined using the Walkley Black wet oxidation method (Udo and Ogunwale, 1986). Total nitrogen content was analyzed according to the method described by Kjeldahl (1883). Available phosphorus was determined using the Mehlich III extraction method (Mehlich, 1984) and analyzed with a spectrophotometer. Exchangeable cations (K, Ca, Na, and Mg) were extracted using ammonium acetate, and potassium and sodium were quantified using a flame photometer, while calcium and magnesium were analyzed using an Atomic Absorption Spectrophotometer. Extractable micronutrients (Fe, Mn, Cu, and Zn) were extracted with 0.1N HCl solution and quantified using an Atomic Absorption Spectrophotometer.

A subsample of sawdust weighing five (5) mg was collected for total nitrogen, phosphorus content, and cation (potassium (K), sodium (Na), magnesium (Mg), and calcium (Ca)) analysis, following standard procedures used for plant samples (Tran, 2005).

The experimental field was manually cleared and tilled using a cutlass. The entire field was divided into 16 experimental plots, each occupying a total land area of 235 m2. The experiment was designed as a Randomized Complete Block Design (RCBD) with four replications. The treatments consisted of: Control (no sawdust application on the soil surface), 10 t ha-1 (equivalent to 5.4 kg per plot), 20 t ha-1 (equivalent to 10.8 kg per plot), and 30 t ha-1 (equivalent to 16.2 kg per plot). The sawdust treatments were evenly spread on the soil surface two (2) weeks before planting.

Okra seeds (variety 47-4) were planted at a rate of two seeds per hole and subsequently thinned to one plant per stand, with a spacing of 60 x 45 cm, resulting in a total of 37,037 plants per hectare. The okra seeds were directly planted at a depth of 3 cm. Twelve okra seedlings were planted per experimental unit, amounting to seventy-two seedlings per plot per replication. Two okra plants from the mid-row of each experimental unit were selected for data collection on plant height, stem girth, number of leaves, number of branches, and yield parameters. Soil temperature was measured using a soil thermometer between 12:00 and 13:00 hr (1 pm) local time before harvesting the okra pods.

At the time of harvesting, post-experimental soil samples were taken from each treatment plot and analyzed for selected physical and chemical properties. Statistical analysis of the collected data was performed using the Genstat Statistical Software package, and the results were subjected to analysis of variance. Means were separated using the least significant difference (LSD) test at a significance level of 5%.

RESULTS AND DISCUSSION

The soil classification of the experimental site identified the soils as Alfisols, characterized by specific features (Smyth and Montgomery, 1962). The data presented in Table 1 further support this classification and provide insights into the soil's properties. The soil samples exhibited moderate levels of organic carbon (11.14 g/kg), total nitrogen (1.8 g/kg), available phosphorus (16.0 mg/kg), potassium (0.38 cmol/kg), and zinc (1.7 mg/kg), falling within the critical ranges for these parameters (Adeoye and Agboola, 1985; Akinrinde and Obigbesan, 2000). Additionally, the soil displayed a nearly neutral pH of 6.57, indicating its suitability for okra production.

The bulk density of the soil was determined to be 1.54 g/cm3, indicating a loamy sand texture. This value suggests that the soil has favorable porosity for root penetration and water movement. Moreover, the saturated hydraulic conductivity of 14.48 cm/hr indicates good drainage properties, which are essential for optimal okra growth.

Chemical analysis of the sawdust used as mulching material before application is presented in Table 2. The results reveal relatively low nutrient concentrations in the mulching material, specifically in total nitrogen (0.07%), total phosphorus (0.014%), calcium (0.421%), potassium (0.030%), and sodium (0.012%). These findings provide valuable information regarding the soil and mulching material characteristics, laying the foundation for understanding the impact of sawdust mulch on the growth and yield of okra.

Table 1: The physical and chemical properties of the soil (0-15 cm depth) before the experiment

Soil parameters	Content in soil
pH (H2O)	6.57
Organic Carbon (g/kg)	11.14
Total Nitrogen (g/kg)	1.8
Available Phosphorus (mg/kg)	16
Exch. Acidity (cmol/kg)	0.35
Exch.H+	0.25
Exch.Al+++	0.10
Exchangeable Cations (cmol/kg)	
Ca	2.68
Mg	0.82
K	0.38
Na	0.24
Extractable Micronutrients (mg/kg)	
Mn	88.26
Fe	121.10
Cu	1.46
Zn	1.74
Particle size distribution (g/kg)	
Sand	810.00
Silt	110.00
Clay	80.00
Textural class	Loamy Sand
Bulk density (g/cm3)	1.54
Saturated Hydraulic Conductivity (cm/hr)	14.48
Total porosity (%)	41.89

Plant height increases appreciably across treatment. Plant height differs significantly $P<0.05$ across treatment at 4th and 8th weeks after planting, but not significantly different at 2nd week after planting. Increasing the amount of saw dust mulch was seen to have significantly increased plant height (Table 3). This finding is in agreement with the findings of Guo and GU (2000) that showed that mulching raises soil temperature thereby promoting faster crop development and increase yield.

Table 2: Selected chemical analysis of sawdust used before application

Parameters	Contents
Total Nitrogen (%)	0.07
Total Phosphorus (%)	0.014
Ca (%)	0.421
Mg (%)	0.030
K (%)	0.076
Na (%)	0.012
Mn (mg/kg)	5.50
Fe (mg/kg)	189.90
Cu (mg/kg)	2.35
Zn (mg/kg)	33.75

Table 3: Influence of sawdust mulching on plant height (cm) of Okra (*Abelmoschus esculentus*) from 2 to 8 weeks after planting (WAP)

Treatments	2	4	6	8
	Weeks after planting (WAP)			
Control	9.33	20.83	34.3	40.8
10t/ha	8.50	22.33	36.5	42.2
20t/ha	8.61	21.50	37.7	45.7
30t/ha	8.86	25.17	39.2	45.7
LSD P < 0.05	3.24ns	3.94*	8.18*	8.99ns

Number of leaves increases appreciably across treatment. Number of leaves differs significantly P < 0.05 across treatment at 2nd to 6th week after planting but not significantly different at 8th week after planting. At 8th weeks after planting, 10 t/ha of sawdust mulch plot (19.17) had the highest number of leaves (Table 4).

Table 4: Influence of sawdust mulching on number of leaves of Okra (*Abelmoschus esculentus*) from 2 to 8 weeks after planting (WAP)

Treatments	2	4	6	8
	Weeks after planting (WAP)			
Control	4.00	7.00	12.17	15.00
10t/ha	4.00	7.17	11.50	19.17
20t/ha	4.17	7.00	12.17	16.17
30t/ha	4.17	8.00	11.83	13.18
LSD P < 0.05	0.86*	1.75**	4.46ns	5.00ns

Influence of mulching on stem girth of Okra (*Abelmoschus esculentus*) from 2nd to 8th weeks after planting is as presented in Table 5. Stem girth increases appreciably across treatment from 2nd to

8th weeks after planting. At 8th weeks after planting, sawdust mulch plot (5.97 cm) had the highest stem girth followed by 30 t/ha sawdust mulch plot (5.97 cm) and least was recorded from by control plot (4.28 cm).

Table 5: Influence of sawdust mulching on stem girth (cm) of Okra (*Abelmoschus esculentus*) from 2 to 8 weeks after planting (WAP)

Treatments	2	4	6	8
	Weeks after planting (WAP)			
Control	1.17	2.70	3.67	4.28
10t/ha	1.25	3.25	4.42	5.00
20t/ha	1.42	3.17	3.92	4.90
30t/ha	1.33	3.47	4.92	5.97
LSD P < 0.05	0.47*	0.55*	1.25*	1.28*

Influence of mulching materials on number of branches of Okra (*Abelmoschus esculentus*) from 2nd to 8nd weeks after planting (WAP) is as presented in Table 6. Number of branches increases appreciably across treatment from 2nd to 8th weeks after planting. At 8th weeks after planting, 20 t/ha sawdust mulch plot had the highest number of branches followed by 30 t/ha sawdust mulch plot (7.67) and least by control plot and 10 t/ha sawdust mulch plot (7.50).

The temperature of the soil was recorded from 2nd to 6th weeks after planting. At 6th week after planting, the average temperature of the soil after planting was 30.39^{o}C (Table 7).

Table 6: Influence of sawdust mulching on number of branches of Okra (*Abelmoschus esculentus*) from 2 to 8 weeks after planting (WAP)

Treatments	2	4	6	8
	Weeks after planting (WAP)			
Control	3.67	7.00	6.33	7.50
10t/ha	4.00	7.17	6.83	7.55
20t/ha	4.33	7.00	8.00	8.17
30t/ha	3.83	8.00	7.33	7.67
LSD P < 0.05	0.838**	1.20*	1.38*	1.56ns

Table 7: Influence of mulching materials on soil temperature (^{o}C)

Treatments	2	4	6
	Weeks after planting		
Control	29.10	29.13	30.32
10t/ha	28.92	29.42	30.27
20t/ha	28.75	29.38	30.20
30t/ha	29.35	29.22	30.78
LSD P < 0.05	0.854*	0.60ns	0.89**

Number of Pods and weight of pods differ (P<0.05) significantly and increases across treatments. 20t/ha Sawdust mulch plot had the highest number of pods (50.00) and weight of pods (908.00

kg/ha), followed by 30t/ha sawdust mulch plot (47.70 and 894.00 kg/ha), and the least were recorded by control plot (34.70 and 781.00 kg/ha) (Table 8).

Table 8: Influence of sawdust mulching on yield of Okra (*Abelmoschus esculentus*)

Treatments	Number of pods	Weight of pods (kg/ha)
Control	38.70	781.00
10t/ha	46.30	802.00
20t/ha	50.00	908.00
30t/ha	47.70	894.00
LSD $P < 0.05$	8.61**	291.9**

The application of sawdust mulch resulted in notable effects on soil properties. Specifically, the mulch application led to a reduction in bulk density and an increase in total porosity compared to the control (Table 9). The decrease in bulk density can be attributed to the decomposition of sawdust, which likely increased the organic matter content and improved the soil structure, consequently reducing the bulk density and enhancing soil porosity.

Table 9: Influence of sawdust mulching on soil physical properties after harvesting

Parameters	Control	10 t/ha	20 t/ha	30 t/ha
PH (H2O)	5.93	6.64	6.70	6.59
Organic carbon (%)	2.80	2.20	2.40	2.40
Total Nitrogen (%)	0.31	0.24	0.26	0.26
Available Phosphorus (mg/kg)	17.52	21.32	19.32	18.84
Exch. Acidity (cmol/kg)	0.30	0.30	0.35	0.32
Exch.H+ (cmol/kg)	0.30	0.30	0.35	0.32
Exch.Al+++ (cmol/kg)	0.00	0.00	0.00	0.00
Ca	3.12	3.07	3.36	3.16
Mg	1.04	0.89	0.94	1.01
K	0.43	0.48	0.41	0.38
Na	0.29	0.25	0.27	0.32
Mn	67.8	59.5	68.20	71.00
Fe	85.50	91.00	81.20	86.50
Cu	0.95	0.88	0.79	0.80
Zn	0.86	0.89	0.91	0.78
Sand	79.50	80.50	80.00	81 00
Silt	10.50	10.00	10.00	10.00
Clay	10.00	9.50	10.00	9.00
Textural class	Sandy loam	Loamy sand	Loamy sand	Loamy sand

These findings align with previous studies. Agele *et al*. (2010) conducted an experiment investigating the effects of mulch materials on soil improvements and sunflower (*Helianthus annus* L.) yield, and their results also demonstrated significant improvements in soil moisture and temperature regimes with mulch application. Similarly, Adekiya *et al*. (2015) evaluated different mulching materials and observed reduced bulk density and soil temperature, along with increased porosity and moisture compared to the control.

Numerous studies have consistently reported the beneficial impact of mulch application on soil properties. Olasantan (1988), Agele (2000), and Adekiya (2015) have documented that mulching effectively ameliorates soil moisture deficits, extreme temperature conditions, evaporation, runoff, and enhances soil structure.

Furthermore, the mulch treatments applied in this study resulted in increased plant height, stem girth, number of leaves, and pod yield compared to the control. These improvements can be attributed to the enhanced soil physical and chemical conditions associated with lower bulk density, increased soil moisture, elevated organic matter content, and improved total porosity in the mulch-applied plots, as compared to the control.

CONCLUSION

Incorporating sawdust mulch has proven to be effective in enhancing soil properties, as well as the growth and yield of Okra (Abelmoschus esculentus), particularly in the study area. The application of sawdust mulch resulted in a reduction in bulk density, an increase in organic carbon content, total porosity, and gravimetric moisture content of the soil. Among the various mulch treatments evaluated, the application of 20t/ha sawdust mulch consistently demonstrated excellent outcomes in terms of Okra growth and yield.

Based on the findings of this study, it is strongly recommended that farmers in the study area consider adopting sawdust mulching at a rate of 20t/ha to maximize pod yield in Okra production. Furthermore, farmers should be educated on the benefits of using mulch materials to improve soil conditions, which, in turn, will positively impact the growth and yield of their crops.

These results highlight the potential of sawdust mulch as a viable and sustainable soil management practice for Okra production. By implementing sawdust mulching, farmers can enhance soil fertility, optimize crop growth, and achieve higher yields. Continued research and outreach efforts are warranted to further explore the long-term effects of sawdust mulch application and its potential for wider adoption in Okra cultivation.

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