Effect of Different Live Mulches on Soil Physicochemical Properties and Yield of Okra in Nnamdi Azikiwe University, Awka, Nigeria

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KEYWORDS

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ABSTRACT

This experiment was carried out in the Department of Soil Science and Land Resources Management Research Farm, Faculty of Agriculture, Nnamdi Azikiwe University Awka, to determine the effect of different live mulches on physico-chemical properties of soil and yield of okra. Treatments include cowpea + Okra (CO), Melon + Okra (MO), pumpkin + Okra (PO), Wild ground nut + Okra (WgO) and the control (O). The experiment was laid in a Randomized Complete Block Design (RCBD). Plant height, number of leaf and leaf area index were collected at 4, 6 and 8 weeks after planting. Soil samples were collected, air dried, sieved and analyzed for physical and chemical properties using outlined standard and scientific methods in the laboratory. Data collected from field and laboratory was subjected to Analysis of Variance while significant means were separated using Fishers Least Significant Difference at 5%. Results indicated that live mulches conserved soil moisture and reduced bulk density of the soil while increasing soil pH, Organic matter, nitrogen, phosphorus and most basic cations (Ca, Mg, K, Na) tested. It also improved growth and development of the crop (okra). Among the live mulches tested, Calopogonium mucunoides(wild ground nut) had better capability of improving soil properties and the growth of okra when compared to other live mulches.

INTRODUCTION

Mulch is either organic or inorganic material that is spread on the surface of the soil to reduce moisture and nutrient losses due to evaporation. Live mulches are cover crops that are sown either before or with a main crop and are maintained as living ground cover throughout the growing season (Hartwig and Ammon, 2002). Application of mulch on the soil prevents surface evaporation thereby, conserving water (Patil *et al*., 2013). The word mulch was derived from the German word 'molsch' meaning 'easy to decay' and mulches have been used for vegetable production (Lightfoot, 1994). Mulches have the potential of minimizing runoff, improving the infiltration capacity of the soil and restraining the amount of weed through shading (Rathore *et al*., 1998). According to Tanavud *et al*. (2001) mulching materials are useful in the protection of soil from erosion by both water and wind, reduce soil compaction which could adversely affect the growth and development of crops. Live mulch helps in providing good soil conditions for the main crop to thrive. Although, soil quality is affected by the type of live mulch used. Food and feed living mulches improve soil organic carbon (OC), total nitrogen (TN), available phosphorous (AP), microbial biomass and soil bacterial structure and function better in legume live mulches than non-legume live mulches (Duda *et al*. (2003). Live mulches also improve soil moisture, infiltration, soil bulk density, temperature and erosion when compared to non-living mulch plots (DeVetter *et al*. (2015)

Okra (*Abelmoschus esculentus*, L) is known in many English-speaking countries as lady's finger, bhindi in India, okro plant, ochro. Okoro, gombo, kopi arab, kacangbendi and bhindi in Southeast Asia (Ndunguru, and Rajabu, 2004). Okra is a nutritious vegetable which is widely cultivated throughout the year in the tropics. It plays an important role in meeting the demand of scanty vegetables in the market (Ahmed *et al*., 1995). The aim of this study was to determine the effect of different live mulche on the physicochemical properties of soil and the yield of okra.

MATERIALS AND METHODS

Description of Experimental Area

This study was conducted at the Department of Soil Science and Land Resources Management Research Farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State. The latitude of Awka is 6.210528 and longitude is 7.072277. Awka is in the tropical rainforest zone of Nigeria and experiences two (2) distinct seasons of heavy rainfall between April and July accompanied by dry season November- March marked by a harmattan wind (Wikipedia). The average annual temperature is 26.8 ^{o}C and rainfall around 1589mm per year (https:en.climate-data.org).

Experimental Design

The experiment was laid out in Randomized Complete Block Design (RCBD), having 5 treatments with 5 replications. The treatments include Cowpea and okra (CO); Melon and okra (MO); Pumpkin and okra (PO); wild ground nut and okra (WgO); Control (sole okra) (O)

Field Operations and Land Preparation

A field size of 16m by 22m was marked out using measuring tape, rope, and peg. The Land was cleared, ploughed, harrowed, and ridged at 4m x 2m. The blocks were 1m apart. Poultry manure was applied on each ridge at the rate of 10 t/ha and was left to cure for one week before planting. The test crop was okra and was soaked overnight and drained before planting to speed up the germination. Seeds were sown at the recommended spacing of 0.6m by 0.9m at two seeds per hole which was later thinned down to one plant/stand. Weeding was done manually at week four using hoe to reduce weed competition

Materials and Sources

Okra seeds (Cajun delight - Dwarf green pod) was sourced from Agricultural Development programme in Awka. Melon, cowpea, and pumpkin seeds were sourced from seed vendors in Awka while wild ground nut was s sourced from the Faculty of Agriculture Unizik, Awka.

Soil Sampling

Soil samples were randomly collected before planting from within the experimental field at a depth of 0-15cm using a soil auger. Soil samples were collected after harvest from stipulated points and tagged separately. Core samplers were used to collect undisturbed soil samples at the experimental field. Both samples were taken to the laboratory for the analysis. Soil samples for analysis were collected before and after the experiment.

Laboratory Analysis

The following parameters were analyzed for: Particle Size Distributions was determined using Bouyoucus hydrometer method as described by Bouyoucus (1962). Bulk density was determined using core method (Blake and Hartge, 1986). Soil pH was determined in H_2O and KCL using glass electrode pH meter at a soil liquid ratio of 1:2.5 as modified by Udo *et al*. (2009). Soil Organic Carbon was determined by Walkley *and* Black wet oxidation method as modified by (Nelson and Sommers, 1996). Total Nitrogen was determined by Kjeldhal digestion method (Bremmer and Mulvaney (1996). Available Phosphorus was determined by Bray 2 method as described by Bray and Kurtz (1945). Exchangeable bases were extracted using 1.0N ammonium acetate (NH_4OA_c) (Black and Hartge, 1986). K and Na^+ were determined using flame photometer while Ca and Mg were determined using EDTA titration method. Exchangeable acidity was determined using 1.0N KCl solution and 1.0N sodium fluoride (NaF) titrated with 0.05M HCl. The effective cation exchange capacity (ECEC) was calculated as the sum of exchangeable bases (Ca, Mg, K and Na) and exchangeable acidity (Al^{3+} and H^+).

Data Collection on Okra

The data collected are growth and yield of the okra, plant height, number of pods, number of leaves and leaf area index.

Statistical Analysis

Data collected was subjected to Analysis of variance (ANOVA) for Randomized Complete Block Design (RCBD) using Genstat Release 12.1, 3rdedition and significant means were separated using the Fishers least significant difference (LSD) at 0.05 probability level.

RESULTS AND DISCUSSION

Table 1 showed the physicochemical properties of the initial soil sample. The textural class of the experimental plot is Sandy loam, strongly acidic and low in moisture content.

Table 1: Physicochemical properties of the initial soil sample (0-15 cm)

Soil properties	Average values
Sand (%)	70.30
Silt (%)	15.20
Clay (%)	14.50
Soil texture	Sandy
loam	
Moisture content (%)	14.10
Bulk density (gcm-3)	1.44
pH	5.3
Available phosphorus (mg/kg)	15.8
Nitrogen (%)	0.108
Organic Carbon (%)	1.21
Ca2+ (cmol/kg)	4.30
Mg2+ (cmol/kg)	1.6
K+ (cmol/kg)	0.151
Na+(cmol/kg)	0.105
Al3+ (cmol/kg)	0.52
H+ (cmol/kg)	1.06
Exchangeable acidity	1.58
ECEC (cmol/kg)	7.74

Source: field data

Effect of different live mulch on the physical properties of the soil

Table 2 showed the effects of different live mulches on soil physical properties. The results obtained showed that there was no significant difference between the treatments and soil texture. Bulk density between the treatments differed significantly and was in this order: O (1.48) > MO (1.43) > PO (1.39) > CO (1.36) > WgO (1.32), for soil moisture content, there was a significant difference which was in the order: WgO (26.68) > CO (18.22) > MO (17.5) > PO (16.28) > O (12.9). An increase in moisture content agrees with Nurudeen *et al*. (2022) who observed an increase in the moisture content when cowpea was used as a live much compared to control. Sharma *et al*. (2010), Wiggan *et al*. (2012) and De Vetter *et al*., (2015) also observed that live mulches improved moisture content, infiltration rate and bulk density. Nurudeen *et al.* (2022) recorded a decrease in the bulk density of cowpea live mulch ($p< 0.05$) when compared to the control.

Table 2. Effects of different Live Mulch on Soil Physical Properties

Treatment	Sand %	Silt %	Clay %	Tex	MC %	BD g/m^3
Cowpea + okra (CO)	70.5	15.1	14.4	SL	18.22	1.36
Wild ground nut + okra (WgO)	70.3	15.2	14.3	SL	26.68	1.32
Pumkin + okra (PO)	70.7	15.0	14.3	SL	16.28	1.39
Melon + okra (MO)	70.5	15.1	14.4	SL	17.5	1.43
Control (sole okra) (O)	70.3	15.2	14.5	SL	12.9	1.48
Mean	70.46	15.12	14.42	SL	17.52	1.39
LSD$^{(0.05)}$	NS	NS	NS		0.38	0.02

Note: tex = texture, Mc = moisture content, BD = Bulk density, LSD= least significant difference

Effects of different live mulches on soil chemical properties

Table 3 showed the effects of live mulch on Soil chemical properties. Exchangeable bases were observed to significantly vary at ($p>0.05$). Calcium was highest in WgO (6.44) and lowest in the control (3.8), magnesium was in this order: WgO (3.62) > CO (3.04) > MO (2.80) > PO (2.38). Similarly, this study has shown that all values of the live mulch on exchangeable acidity are higher than the control plot. This corroborates with the findings of Awopegba *et al*. (2017) who observed a significant increase in the exchangeable bases in the soils covered with herbaceous mulch treatment of *Calopoganum* and Moringa, he recorded an increase in Ca level in plots with moringa (3.90 cmol/kg) and Calopoganum (3.20 cmol/kg) When compared to the control, also an increase in Mg level with *Calopoganum* (1.40cmol/kg) was recorded. Again, *Calopogonum* and moringa increased potassium level significantly (1.62 and 1.93 cmol/kg) when compared to the control. There was a significant difference in sodium as influenced by the live mulches. This finding agreed with the findings of Awodun *et al.* (2007) that legumes are sources of utilizable N, P, K, Ca, Mg and organic matter. There was a significant difference in all the treatments at (p>0.05). This study showed that for $H^{+,}$ control was the highest (1.19) while wild ground nut was the lowest (0.52). For $Al^{3+,}$ control has the highest value (0.77) while wild groundnut was the lowest (0.32).

Results obtained showed that there is a significance difference between the treatments at (p>0.05). The ECEC was in the order: WgO (11.56) > CO (11.09) > MO (10.02) > PO (9.51). ECEC was higher in mulch plots than in the control plot.

The plot with wild ground nut had the highest pH (6.12) and lowest value on the control plot, this agrees with Awopegba *et al.* (2017) that recorded a significant increase in pH on the plots with live mulch when compared to control. The increase in the soil pH might be because of chopped herbaceous mulch which tends to improve the soil exchangeable bases while reducing exchangeable acidity thereby reducing soil acidity; this also was experienced by Egbe *et al*. (2012).Organic carbon showed a significant difference between treatments at (p>0.05), WgO was highest (1.66) while the lowest was control (1.06). Organic carbon was in the order: WgO (1.66) > CO (1.56) > PO (1.51) > MO (1.44) > control (1.06). This is evidence that mulch materials used increased the organic carbon content of the soil when compared with the control; this is in line with Awopegba *et al*. (2017) who recorded a significant increase in the soil organic carbon with *Calopoganum mucunoides* (1.99g/kg) recording the highest soil organic carbon when compared to other mulch materials and the control. This study report corroborates with the findings of Tejeday *et al*. (2007) who observed that the application of leguminous residues had a positive effect on soil physical, chemical and biological properties. There was a significant difference among the treatments at (p>0.005) as far as nitrogen is concerned. CAO had the highest value of nitrogen (0.154%) while the lowest was observed in control (0.092%). Awopegba *et al*. (2017) had a similar result though Gliricidia sepium had the highest N ((7.18%)) when compared to calopogonum (5.10%).

Table 3. Effects of live mulch on soil chemical properties

	Soil chemical parameters										
Treatment	**pH**	**OC %**	**TN %**	**Av.P mg/kg**	**Ca2+**	**Mg2+ cmol/ kg**	**K+ cmol/ kg**	**Na+ cmol/ kg**	**H+ cmol/ kg**	**Al3+ cmol/ kg**	**ECEC cmol/ kg**
Cowpea + okra	4.84	1.56	0.138	18.6	5.8	3.04	0.294	0.255	1.14	0.56	11.09
Wild ground nut + okra	6.12	1.66	0.154	20.96	6.44	3.62	0.355	0.31	0.52	0.32	11.56
Pumkin + okra	5.2	1.51	0.131	18.58	5.08	2.38	0.246	0.202	1.08	0.51	9.51
Melon + okra	5.74	1.44	0.124	20.18	5.48	2.8	0.279	0.23	0.81	0.42	10.02
Control (sole okra)	4.12	1.06	0.092	14.58	3.8	0.96	0.095	0.075	1.19	0.77	6.89
Mean	5.2	1.44	0.128	18.58	5.32	2.6	0.254	0.214	0.95	0.52	9.81
LSD (0.05)	0.19	0.05	0.005	0.62	0.12	0.14	0.014	0.013	0.05	0.02	0.24

ECEC = Effective Cation Exchange Capacity; BS = base saturation; LSD= least significant difference; Av. P= available phosphorous; TN= total nitrogen; OC = organic carbon

Effects of live mulch on plant parameters

The plant height at four weeks after planting, showed a significant difference such that WgO (31.81a) and PO (31.88a) varied significantly from Control (24.79b) which was statistically different from MO (30.47ab) which was statistically the same with CO (30.09ab). At six weeks and eight weeks after planting there was no significant difference among the different treatments and the control. Number of leaves as well as the leaf area index were not significantly different at the 4th, 6th and 8th WAP.

Table 4a: Effects of different live mulches on plant height

Treatment	**Plant height 4 WAP**	**Plant height 6 WAP**	**Plant height 8 WAP**
Cowpea + okra (CO)	30.09ab	78.8a	111.7a
Wild ground nut + okra (WgO)	31.81a	77.4a	116.0a
Pumkin + okra (PO)	31.88a	72.8a	112.1a
Melon + okra (MO)	30.47ab	72.8a	107.9a
Control (sole okra)	24.79b	74.0a	106.4a
Mean	**29.81**	**75.1**	**110.8**
LSD (0.05)	**NS**	**NS**	**NS**

WAP: weeks after planting, LSD= least significant difference, NS= not significant

For the number of flowers at 4WAP, there was a significant difference in this order: PO (5a) = MO (5a) > CO (4ab) = WgO (4ab) = Control (4ab). At six weeks, the pods have developed and so instead of numbering the leaves, the pods are numbered which varied in this order: PO (10a) > CaO (9ab) = MO (9ab) > (8b) = Control (7b). At the 8th week, there was no significant difference.

Table 4b: Effects of Different Live Mulches on number of flowers and number of Pods

Treatment	Number of flowers 4 WAP	Number of Pods 6 WAP	Number of Pods 8 WAP
Cowpea + okra (CO)	4ab	8b	13a
Wild ground nut + okra (WgO)	4ab	9ab	12a
Pumkin + okra (PO)	5a	10a	13a
Melon + okra (MO)	5a	9ab	13a
Control (sole okra)	4ab	7b	12a
Mean	4	9	13
LSD (0.05)	NS	1.52	NS

WAP= Weeks after planting, LSD= least significant difference, NS= not significant

CONCLUSION

From the results, it could be observed that mulch materials had significant impacts on organic matter content, nitrogen, exchangeable bases, and pH. The acidity of the soil was reduced with the live mulch from Al^{3+} (0.77 cmol/kg) and H^{+}(1.19 cmol/kg) on the control plot to Al^{3+}(0.32 cmol/kg) and H^{+} (0.52 cmol/kg) WgO which was used as a live mulch, and this gave rise to the increase on pH of the soil. In comparison with the different mulch materials used, there was a steady flow or pattern with which the different mulch materials affected or influenced the soil physical and chemical properties, *Calopoganum Mucunoides* and okra plot differed significantly from other mulch materials, hence it can be concluded that wild ground nut is a better live mulch when compared to cowpea, melon and pumpkin. It would be recommended that for proper maintenance and sustainability of soil fertility, *Calopogonium* should be used as live mulch in the study area.

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