Residual Effects of Selected Organic Mulches on Soil Physico-chemical Properties and Yellow Pepper (*Capsicum chinese*) Yield in Awka, South-Eastern Nigeria

Onunwa, A. O., Amutaigwe, N. N. and Ude, E. C.*
Department of Soil Science and Land Resources Management, Faculty of Agriculture, NnamdiAzikiwe University, Awka, Anambra State.

KEYWORDS

Capsicum chinese,
Soil properties,
Organic mulches,
Growth,
Yield

***CORRESPONDING AUTHOR**

nmesomachiezeobi@gmail.com
09035431250

ABSTRACT

A study on the residual effects of selected organic mulches on soil physico-chemical properties and yield of yellow pepper (Capsicum chinese) was conducted in the Department of Soil Science and Land Resources Management (LRM) Research farm, Nnamdi Azikiwe University, Awka. Oil palm fiber (OPF), rice husks and neem leaves (Azadirachta indica A. Juss.) were used as mulching materials and the residual effects were evaluated on the second year. The experiment was laid out in Randomized Complete Block Design (RCBD) with five replications. Data collected were subjected to Analysis of Variance (ANOVA) and means were separated using Least Significant Difference at 5% level of probability. The physical properties of the plots mulched with oil palm fiber had the least value for moisture content (22.98), hydraulic conductivity (14.4) and total porosity (49.54) among the mulched plots, while the least value for bulk density was found in soils mulched with Neem leaves (1.30). The soil mulched with neem leaves tended towards neutrality (pH = 6.2) compared to the others; had the highest values for available phosphorus (24.14), nitrogen (0.33), calcium (9.02), magnesium (4.46), effective cation exchange capacity (15.7) and base saturation (93.59) and the least values for aluminum (0.32) and hydrogen (0.64), which are indicators of a healthy and productive soil. The plots mulched with rice husk produced the highest value (2.2kg/2m) on yield among the mulched plots. Among the organic mulches tested in this work, neem leaves and rice husk proved to be better for the production of yellow pepper.

INTRODUCTION

The word Mulch was derived from the German word *molsch* meaning "easy to decay,". Mulching is referred to as spreading various covering materials on the surface of the soil to minimize moisture losses, weed population and enhance crop yield (Iqbal *et al.,* 2020). With the worldwide interest in sustainable farming, mulching is increasingly gaining greater relevance (Marble *et al.,* 2017). The use of Organic mulch effectively reduces soil salinity or induce soil desalinization by enhancing water retention in soil and reducing evaporation which is helpful in reclaiming saline soils (Iqbal *et al.,* 2020). Mulching has a positive influence on crop productivity; it reduces greenhouse gas released from the soil and increases organic carbon content in the soil, especially where organic mulching materials are used (Chan *et al.,* 2020). Organic Mulches like Leaves of arborvitae, eucalyptus, pine, and poplar have been discovered to be a good source of removing heavy metals from the soil solution (Iqbal *et al.,* 2020).

Wang *et al.* (2020) discovered the function of Organic Mulches in moderating soil temperature by insulating the soil, reducing fluctuations that can negatively affect microbial activity and root development. They help to retain soil moisture by acting as a barrier against direct sunlight, and reducing evaporation (Zhang *et al.,* 2019). Furthermore, as organic mulch decomposes, it releases essential nutrients such as nitrogen,

phosphorus, and potassium, which improves soil fertility (Xie *et al.,* 2021). Lal (2019) found out that organic mulch reduced the impact of raindrops on soil, consequently minimizing surface runoff and soil erosion. Organic mulch buffers soil pH over time by neutralizing extremes, creating a more suitable environment for plant growth (Yakovchenko *et al.,* (2017). They also improve stability of soil structural aggregates, nutrient availability as well as porosity and water infiltration (Abiven *et al.,* 2017).

The production of pepper in Nigeria (yellow pepper inclusive) is on the decline such that Nigeria imports pepper to make up for the low production (Abubakar, 2015). The estimated yield of 9t/ha obtained on the farmers field is low compared with the estimated yields of 15t/ha obtained in developed countries or those obtained from research field in Nigeria (Jaliya and Sani, 2006). From an output of 740, 000 metric tons from 82,000 hectares in 1991, pepper production declined to 715,000 metric tons from 90,000 hectares in 2002 (FAO, 2003). Between 2007 and 2009 despite the increased hectrage from 22.5 hectares to 26.92 hectares of land, the yield was not commensurate (5532 tons to 6063 tons). The decline according to Abdulmalik *et al.* (2012), and Jaliya and Sani (2006), have been attributed to biotic and abiotic factors like weeds, pests, diseases and environmental stress.

Yellow Pepper *(Capsicum chinense)* is a woody, perennial, small shrub that belongs to the *Solanacea* family (Sintayehu *et al.,* 2015) and native to the tropical regions of Central and South America, particularly the Amazon Basin (Bosland and Votava 2012). *Capsicum chinense* is a significant crop due to its culinary, medicinal, and economic benefits. It is popularly used as ingredients in dishes because of its pungent flavor. It contains capsaicinoid compounds which provides a characteristic heat (Bosland and Votava, 2012). *C. chinense* possess the ability to boost metabolism and thereby manage conditions such as arthritis, neuralgia and obesity (Reyes-Escogido *et al.,* 2011). Its capsaicin has anti-inflammatory, analgesic and antioxidant properties. It is also a rich source of vitamins, (especially A, C and E); it contains thiamine, vitamin B_6, beta carotene, and folic acid (Nadeem *et al.,* 2011). *C. chinense* provides income for farmers and plays a role in the agro-based industries for producing spices and pharmaceuticals (Bosland and Votava, 2012). *Capsicum chinense*, allows increasing aeration, water infiltration, and nutrient uptake due to its taproot system, thereby improving soil health. (Huang *et al.,* 2013). The yellow pepper plant provides a home and sustainability for various beneficial insects, such as bees and butterflies, (Potts *et al.,* 2010).

Research conducted by Sintayehu *et al (*2015) showed that dry coffee husk and dry vetiver grass mulches combined with Melka Awaze variety have a potential to increase the yield of yellow pepper (*Capsicum chinese*). The literature reviewed showed that the effects of organic mulches have been addressed (Antonio *et al.,* 2010; Marwan 2021; and Mingming, *et al.,* 2010). However, limited number of studies in which residual effects of different Organic mulches on the physicochemical properties of soil, growth and yield of yellow pepper *Capsicum chinese* have been comprehensively done. This study is therefore designed to determine the residual effect of selected organic mulch materials on some soil physico-chemical properties and the yield of yellow pepper (*Capsicum Chinese*) in Awka, Anambra State, after one year of the application with specific objectives as to determine the:

Residual effects of organic mulch (Rice husk, Neem leaves and oil Palm fiber) on the soil physico-chemical properties and the yield of yellow pepper in the second year.

MATERIALS AND METHODS

Description of the study area

This experiment was conducted at Soil Science and Land Resources Management demonstration farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State. Awka is located within latitude 6 º 24’ N and longitude 7º 11’E with an altitude of 422m and an average rainfall of 1650mm to 2000mm per annum, a mean minimum and maximum temperatures of 27º C and 30 ºC respectively and a relative humidity of 75 - 80% (Ezenwaji *et al*., 2014). There are two season within the location which are rainy season and dry season. The rainy season starts from April to October with a break around August known as August break. The dry season begins from November to March.

Weeds such as *Sida acuta, Senna occidentalis, Sclerocarpus africanus, Asystasia gangetica, Imperata cylindrical, Nelsomia canescens, Aspilia Africana, Mimosa pudica* were predominant in the experimental farm.

Methodology, Experimental Design and Layout

This study was conducted in an already established experimental field of 11m by 7m ($77m^2$) planted to yellow pepper at a spacing of 30cm x 60cm; containing 20 plots of 1m by 1m each, laid out in Randomized Complete Block Design (RCBD); having four treatments and each replicated five times.

Each of the plots received equal amount of treatment which is 4kg per plot (40 tonnes/ hectare) of:

T1- Oil palm fiber
T2- Rice husk
T3 – Neem leaves
T4 – control (No mulch)

Soil Sampling and Preparation

Soil samples were collected at different locations from the experimental plot, a total of 20 samples were collected using auger at the depth of 0-15cm. The samples were air dried and passed through a 2mm sieve.

Laboratory Analysis

The collected soil samples were analyzed in the laboratory for the following selected chemical and physical properties thus:

Particle size Distribution

Particle size distribution was determined by the Bouyoucus hydrometer method (1965) using Calgon as the dispersant. Textural class was determined using textural triangle

Soil pH

The pH of the soil samples was determined in a 1:2.5 soil: water ratio, using glass electrode method as modified by Jones (2001).

Exchangeable Acidity

The hydrogen and aluminum ions were determined by the titrimetric method of Mclean, (1982) using 1% phenolphthalein as an indicator as outlined by Udo *et al.*,(2009).

Organic Carbon

Organic carbon was determined by Walkley and Black wet oxidation method using barium solution as indicator as outlined by Nelson and Somner (1996).

The organic carbon was calculated as:

$$\text{Organic carbon in soil} = \frac{\text{Me } K_2Cr_20_7 - \text{MeFS}0_4 \text{ x } 0.003 \text{ x } 100 \text{ (F)}}{\text{Mass of air dried soil used}}$$

Where F = correction factor

Me = Normality of solution x volume used.

Organic matter was calculated by multiplying organic carbon value with Van Bemmelen factor of 1.724.

Exchangeable bases

Exchangeable bases (K^+, Ca^{2+}, Na^+, and Mg^{2+}) were determined as demonstrated by Jones, (2001) using Thomas, (1982) method. The amount of Ca and Mg were determined using Ethylene Diamine Tetra-Acetic (EDTA) titration method while potassium and sodium were determined by flame photometer (Rhoades, 1982)

Available phosphorus

This was determined using Bray 2 method according to Bray and Kurtz (1945). Available phosphorus was measured using a spectrophotometer.

Total nitrogen

Total nitrogen in the soil sample was determined by the Macro- Kjeldahl method (Udo *et al.,* 2009). Nitrogen was determined by titration using standard HCl.

Effective Cation Exchange Capacity (ECEC)

This was calculated as the summation of exchangeable cations measured in the soil with an estimate of the exchangeable acidity obtained from the buffer pH ie (Exchangeable Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) + Exchangeable acidity.

ECEC = TEB + TEA

Percentage Base saturation

This was calculated using:

TEB/ECEC × 100/1

Where TEB = total exchangeable bases

ECEC = Effective Cation Exchange Capacity

Yield Data Collection

Four middle plants of each plot was tagged and used as experimental unit for data collection. The data was collected on the following parameters: number of fruits and fruit yield.

Statistical Analysis

Data collected was subjected to analysis of variance (ANOVA) for Randomized Complete Block Design (RCBD) using Genstat 4th edition (2011); significant means were separated using Fisher's Least Significant Difference (F-LSD) at 0.05 probability level.

RESULTS AND DISCUSSIONS

Nutrient Composition of the Mulch Materials and Poultry manure used in the experiment

The nutrient composition of the mulch materials and poultry manure used in this study are presented in table 1.0 which showed the value of soil pH, Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Sodium, Organic matter and C/N ratio of the samples.

Table 1: Nutrient Composition of Mulch Materials and Poultry manure used in the study

Nutrient	PM	OPF	RH	NL
pH	8.8	5.7	6.2	5.8
Nitrogen (%)	3.6	1.52	1.34	2.98
Phosphorus (mg/kg)	2.22	1.86	0.88	1.10
Potassium(cmol/kg)	1.4	0.97	0.91	1.28
Calcium (cmol/kg)	0.88	0.60	0.52	0.66
Magnesium(cmol/kg)	0.52	0.40	0.38	0.44
Sodium(cmol/kg)	0.33	0.24	0.22	0.29
Organic matter (%)	38.02	37.64	31.43	36.47
C/N ratio	10.6	24.8	23.5	12.2

Source: Uko et al., 2021
PM = Poultry Manure; OPF = Oil Palm Fibre; RH = Rice Husk; NL = Neem Leaves

Effect of Organic Mulch on Soil Physical Properties

Particle size

Result of selected soil physical properties is shown in Table 2. Sand particles ranged from 73.2 to 73.8 %; silt particles ranged from 11.4 to 11.6 % while clay particles ranged from 14.8 to 15.4 %. The result showed that particle sizes were not significantly affected by mulching. This is in agreement with Jinshi *et al*. (2018), who observed lesser soil loss to sedimentation with higher application rate of organic mulch. Although Zhang *et al.* (2019), discovered that Organic Mulch can increase silt clay fractions and reduce sand fraction.

Moisture Content

Moisture content of the soil ranged from 18.8 to 28.92 %, plot mulched with rice husk had the highest moisture content (28.92%) followed by plot mulched with Neem leaves (24.4%) and plot mulched with rice husk (22.98%); while control plot had the lowest value (18.8%). The result (Table 2) showed that organic mulch had a significant effect on moisture content ($p \leq 0.05$). This observation is in accordance with the findings of Goitom *et al,* (2017) who reported an increase in soil moisture as a result of increasing rate of organic mulch in potato production in agro-ecological zone of central highlands of Kenya.

Bulk Density (BD)

The result (Table 2) showed that bulk density ranged from 1.30 g/cm^3 to 1.42 g/cm^3. The highest bulk density (1.42 g/cm^3) was recorded in the control plot followed by oil palm fiber (1.34 g/cm^3) while plots with rice husk and Neem leaves recorded 1.32g/cm^3 and 1.30 g/cm^3 respectively. The increase in pore space observed in this study as a result of reduced bulk density may be attributed to the ability of organic mulch to reduce the compactness of the soil and protect soil surface from direct hit of raindrop. The findings for bulk density is in line with the assertions of Rafia *et al.,* (2022) who reported an improved bulk density and increase in pore spaces due to increasing soil Organic matter and aggregate stability.

Total Porosity (TP)

Total porosity ranged from 50.94 - 46.19% (Table 2). The highest porosity was recorded in plot mulched with Neem leave (50.94%) followed by plot mulched with rice husk (50.28%) and then plot mulched with Oil palm fibre (49.54%) while the lowest value of Total Porosity was recorded on plot with no mulch (46.19 %). Total porosity also showed a significant ($p < 0.05$) increase across the mulched plots when compared to the control. This report is also in tandem with the report of Li *et al.* (2020) on soil porosity.

Hydraulic Conductivity (Ksat)

Hydraulic conductivity ranged from 9.4 to 17.4 cm^3/hr with a significant increase ($p \leq 0.05$) across the plots mulched with different organic materials when compared to the control plot. Highest value of Ksat (17.4 cm^3/hr) was recorded in plot with Neem leave mulch, followed by rice husk mulch (16.22 cm^3/hr), then Oil palm fibre (14.4cm^3/hr) while the lowest (9.4 cm^3/hr) was recorded in the control. The increase in hydraulic conductivity observed in this study may be attributed to the ability of organic mulch to decompose and create more space for easy and more water passage through the soil pores. Nwosu *et al.* (2016) reported similar result where organic mulch increased soil porosity which in turn led to significant improvement in the saturated hydraulic conductivity.

Table 2: Effect of Organic Mulch on Soil Physical Properties

Treatment	Sand %	Silt %	Clay %	Texture	MC %	BD g/cm^3	TP %	Ksat cm^3/hr
Oil Palm fiber	73.6	11.6	14.8	SL	22.98	1.34	49.54	14.4
Rice husk	73.8	11.4	14.8	SL	28.92	1.32	50.28	16.22
Neem leaf	73.4	11.4	15.2	SL	24.4	1.30	50.94	17.4
Control	73.2	11.4	15.4	SL	18.8	1.42	46.19	9.4
LSD $_{(0.05)}$	NS	NS	NS		0.26	0.02	0.74	0.39

MC = Moisture Content; BD = Bulk density; TP = Total porosity; Ksat = hydraulic conductivity; LSD = Least Significant Difference; NS = Not significant

Effect of Organic Mulch on selected Soil Chemical properties

Soil pH

Soil pH (Table 3.0) ranged from 4.8 to 6.24. Plot mulched with Neem leave had the highest pH (6.24) followed by oil palm fiber (5.98), then Rice husk (5.76) and the least was the control (4.8). The mulched plots showed significant difference ($p \leq 0.05$) as influenced by the organic mulches. The increase in pH recorded in this study may be attributed to mineralization and release of nutrient from mulch materials, used in this study. This is in line with the report of Patil *et al.,* (2013) who observed a significant increase in pH and most soil nutrient as a result of using rice husks as mulch materials.

Available Phosphorus (Av.P)

Different organic mulches had positive and significant effects on available phosphorous (Table 3). Available phosphorus ranged from 13.32 to 24.14mg/kg, neem leaves had the highest (24.14 mg/kg), followed by oil palm fiber (22.5 mg/kg) and then rice husk (21.46 mg/kg); while the least was the control (13.32 mg/kg). The significant difference ($p \leq 0.05$) observed in available phosphorus across mulched plots may be due to the high level of phosphorus released from the gradual decomposition and mineralization of the organic materials used as mulch. This observation on the available phosphorus is in line with Li *et al.* (2021) who reported an increase in phosphorus on plots mulched with straw.

Total Nitrogen (TN)

Total nitrogen ranged from 0.07 to 0.33%. Plot mulched with Neem leaves had the highest (0.33%) followed by oil palm fiber (0.31 %) and then rice husk (0.29 %) while control plots had the lowest value (0.07 %). The Total Nitrogen increased significantly ($p \leq 0.05$) among the mulched plots when compared to the control. Increase in nitrogen as a result of using organic mulch may be attributed to the gradual decomposition of the organic mulches thus releasing nitrogen to the soil. The significant difference on total nitrogen among the mulched plots as observed in this study is in agreement with the report of Li *et al.* (2021) and Roohallah, (2024) who observed similar increase and reduction in transport of nitrogen in plots under Organic mulch respectively.

Organic Carbon (OC)

Organic carbon ranged from 0.76 to 2.79% (Table 3). The mulched plots showed significant ($p \leq 0.05$) effect on organic carbon as influenced by organic mulches. Plots mulched with rice husk had the highest value (2.79 %) followed by oil palm fiber (1.76 %) while the least among the mulched plots was Neem leaves (1.59 %); meanwhile, the control plot had 0.76 % organic carbon. The increase in organic carbon among the mulched plots may be due to availability of organic material on the soil surface as also observed by Pazhanivel *et al.* (2024) who reported a significant positive effect in organic matter on plots treated with rice husk mulch compared to no mulch.

Calcium (Ca^{2+})

Calcium result (Table 3.0) indicated that the highest value of calcium was recorded in plots with Neem leave mulch (9.02 cmol/kg), followed by plot with oil palm fiber (7.94 cmol/kg) while the least value among the plots mulched with different organic mulch was observed in rice husk (7.22 cmol/kg). Ca^{2+} was significantly ($p \leq 0.05$) affected by the organic mulches. Meanwhile, the control was the least with the value of 2.64 cmol/kg. The increase in Ca^{2+} recorded in the mulched plots may be attributed to the gradual decomposition and mineralization of organic mulch materials used in the experiment. The observation of increased content of Ca^{2+} is similar to the report of Patil *et al.* (2013) who observed an increase in most soil nutrients as a result of using organic mulch which induced early maturity in tomato.

Magnesium (Mg^{2+})

Magnesium result (Table 3) showed that highest value of magnesium weas observed in plots mulched with neem leaves (4.46 cmol/kg), followed by plots with oil palm fiber (4.04 cmol/kg) while the least value among the plots mulched with organic mulches was recorded in rice husk (3.18 cmol/kg) Mg^{2+} was significantly ($p \leq 0.05$) affected by the organic mulches. Meanwhile, the control was the least with the value (0.56 cmol/kg). The increase in Mg^{2+} recorded in the mulched plots may be attributed to the gradual decomposition and mineralization of organic mulch materials used in the experiment. The observation of increased content of

Mg^{2+} is similar to the report of Edward (2018) who observed an increase in most soil nutrients as a result of using organic mulch which improved maize crop performance.

Potassium (K^+)

Potassium values ranged from 0.07 to 0.34 cmol/kg while sodium values ranged from 0.07 to 0.31 cmol/kg (Table 3). The highest value of K^+ was recorded in plots mulched with oil palm fibre (0.34cmol/kg) followed by plots with Neem leave mulch (0.331cmol/kg). The lowest value was in the control (0.07cmol/kg). It was observed that plots with organic mulch significantly ($p \leq 0.05$) increased in a positive dimension over the control. Observation of mulch significant effect on potassium (K^+) is similar to the findings of Bingpeng *et al.* (2019), who reported an increase in the amount of available K^+ under mulched experiment.

Sodium (Na^+)

Sodium values ranged from 0.07 to 0.31cmol/kg (Table 3). It was observed to be the highest in the plot mulched with oil palm fibre (0.31cmol/kg) followed by Neem leave (0.30cmol/kg), while the lowest value was in the control (0.07cmol/kg). It was observed that plots with organic mulch significantly ($p \leq 0.05$) increased in a positive dimension over the control which is in agreement with the findings of Sales *et al.*, (2015), who discovered an improved sodium absorption ratio, significantly mitigating soil salinity and sodicity level in an experiment under organic mulch such as grape vine pruning residue.

Hydrogen (H^+)

Table 3 showed that the application of different organic mulch had positive effect on the hydrogen of the studied soil. H^+ ranged from 0.64 to 1.43cmol/kg while aluminum ranged from 0.32 to 0.82 cmol/kg. Highest H^+ was recorded in the control plot (1.43cmol/kg) followed by rice husk (0.85cmol/kg) and oil palm fiber (0.71cmol/kg), then (0.64cmol/kg) as observed in plots with Neem leave mulches. The significant difference ($p \leq 0.05$) recorded on hydrogen among the treatments may be attributed to the ability of the organic mulch to improve soil pH which in turn decreased hydrogen ion by adsorption through basic cations in the organic mulch. These observations on hydrogen concentrations in the soil is in line with the findings of Uko *et al.*, (2021) who reported a significant decrease in H^+ concentrations on plots mulched with oil palm fiber.

Aluminum (Al^{3+})

Application of organic mulch positively affected the aluminum of the soil under study. Aluminium ranged from 0.32 to 0.82 cmol/kg (Table 3). Highest Al^{3+} was recorded in control plot (0.82cmol/kg); followed by rice husk (0.42cmol/kg) and oil palm fibre (0.35cmol/kg). The lowest value was recorded in plots with Neem leave mulch (0.32cmol/kg). The significant difference ($p \leq 0.05$) recorded on aluminium among the treatments may be as a result of the ability of the organic mulch materials to adsorb basic cation thereby decreasing the aluminum ion concentrations thereby improving the soil pH. This observation is in agreement with the findings of Patil*et al.* (2013) who discovered a decrease in the amount Al^{3+} under mulched experiment.

Effective Cation Exchange Capacity (ECEC)

Table 3 showed that ECEC ranged from 5.59 to 15.07cmol/kg. Plot mulched with Neem leave had the highest value (15.07cmol/kg), followed by plots mulched with oil palm fibre (13.69cmol/kg), rice husk mulched plots (12.27cmol/kg) and the lowest (5.59cmol/kg) was obtained in the control. Effective cation exchange capacity was significantly ($p \leq 0.05$) affected by the different organic mulches. This result is in agreement with Uko *et al.*, (2021) who reported an increase in ECEC as a result of using neem leaves and oil palm fiber mulch in their experiment.

Base Saturation (BS)

Base saturation values ranged from 59.66 - 92.25% (Table 3). Plots with Neem leave mulch had the highest value (93.59%) followed by oil palm fiber mulched plot (92.25%), while the lowest (59.66%) was recorded in plots without mulch (control). The significant difference ($p \leq 0.05$) observed on plots with Organic mulches may be as a result of the ability of the organic mulch materials to decompose and release nutrients like calcium, magnesium, and potassium, thereby raising the cation exchange capacity of the soil and allowing it to hold more positively charged ions, leading to a higher base saturation percentage. This is in tandem with the observation of Akpan and Iliyasu (2018) who recorded an increase in the basic cations in Acid sands as a result of Organic mulch application.

Table 3. Effect of Different Organic Mulch on selected Soil Chemical properties

Mulch material	pH	Av.P mg/kg	N %	OC %	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	H^{+} Al^{3+}		ECEC	BS %
					…….cmol/kg …….							
Oil palm fiber	5.98	22.5	0.31	1.70	7.94	4.04	0.34	0.31	0.71	0.35	13.69	92.25
Rice husk	5.76	21.5	0.29	2.71	7.22	3.18	0.31	0.29	0.85	0.42	12.27	89.63
Neem leave	6.24	24.14	0.33	1.59	9.02	4.46	0.33	0.30	0.64	0.32	15.07	93.59
Control	4.8	13.32	0.07	0.76	2.64	0.56	0.07	0.07	1.43	0.82	5.59	59.66
LSD (0.05)	0.14	0.51	0.002	0.19	0.34	0.15	0.004	0.005	0.09	0.06	0.41	1.36

Note: Av.p = Available phosphorus, TN = Total nitrogen, OC = Organic carbon, Ca^{2+} = Calcium, Mg = Magnesium, K = Potassium, Na = Sodium, H^{+} = Hydrogen, Al^{3+} = Aluminum, ECEC = Effective Cation Exchange capacity, BS = Base saturation, LSD = Least Significant Difference

Total number of fruits

The total number of fruits at harvest (Fig. 1) ranged from 156 to 375, the plot mulched with rice husk had the highest number of fruits (375) followed by oil palm fiber (333) while plots mulched with neem leave had 324 which is the lowest among the mulched plots but was higher than the control (156). The increase in number of fruits recorded in mulched plots may be attributed to the gradual release and supply of nutrients from the different organic mulch materials applied in the farm. This result agrees with Goitom *et.al*. (2017), who worked on the effect of organic mulching on Soil Moisture, Yield, and Yield contributing components of Sesame.

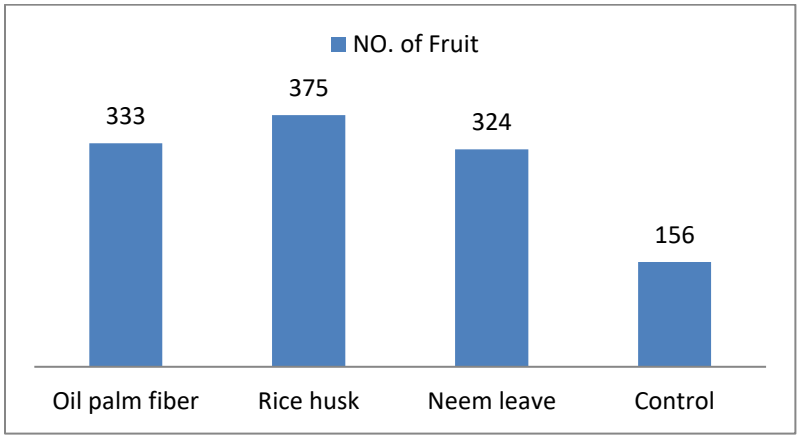

Fig. 1: Total Number of Fruits

Total yield of pepper

The result in Figure 2 showed that total pepper yield ranged from 0.76 kg/plot to 2.2 kg/plot as a result of applying different organic mulches and allowing it for about one year without further application of mulch materials. Highest yield was recorded in plots mulched with rice husk (2.2 kg/plot) followed by plots mulched with oil palm fiber (1.83 kg/plot) while the least among the mulched plots was recorded in plots mulched with neem leave (1.55 kg/plot). Total yield significantly varied ($p>0.05$) when compared with the control (0.76 kg/plot). The increase in yield recorded in this study may be attributed to the high nutrient content of the organic materials used as mulch. This is in tandem with the report of Vanella *et al.* (2024), who observed increase in orange yield as a result of using different organic mulch under Mediterranean climate.

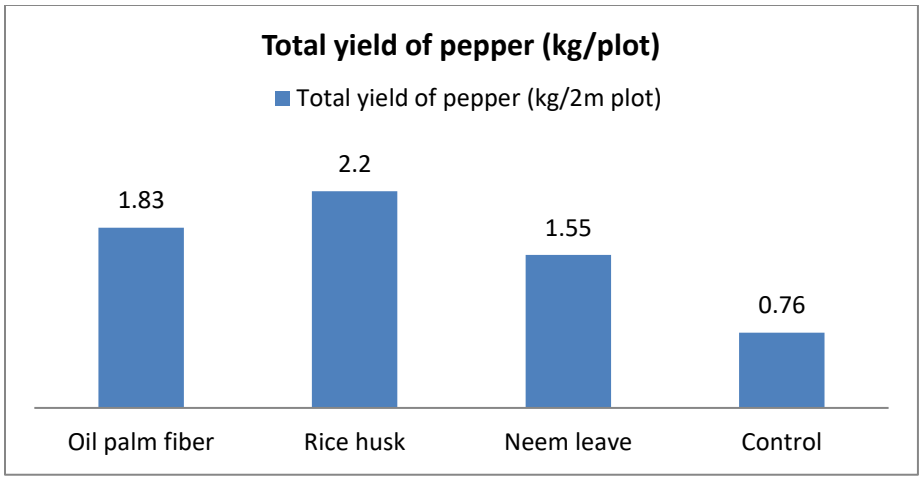

Fig. 2: Total yield of pepper (t/ha)

Figure 2. Effect of different mulch material on total yield of pepper

Mulch material	**(t/ha)**
Oil palm fiber	1.83
Rice husk	2.2
Neem leave	1.55
Control	0.76
Mean	1.59
LSD (0.05)	0.59

CONCLUSIONS AND RECOMMENDATIONS

Different Organic Mulches vary in their effects on both the soil physico-chemical properties and the yield of yellow pepper (*Capsicum chinese*) on the second year without mulch application to ascertain the residual effects of that applied the previous year. The application of Organic Mulches has been found to improve the soil physicochemical properties such as soil moisture content, total porosity, and soil N.P.K etc, thereby enhancing sustainable organic agriculture as well as increase the yield of yellow pepper, with the highest number of fruits recorded in plots mulched with rice husk followed by neem leaves, and also the highest N, P and K were recorded in plots mulched with neem leaves. Based on the overall performance and observations, this study recommends that rice husk and neem leaves be used as mulch materials in the production of yellow pepper (*Capsicum chinese*) because it is economical and readily available. Most importantly, because of its ability to increase yellow pepper yield and improve soil health.

REFERENCES

Abdulmalik, M. M, Olarewaju, J. D, Usman, I. S. and Ibrahim, A. (2012). Effects of moisture stress on flowering and fruit set in sweet pepper (Capsicum annum L.) Cultivars. PAT June, 2012; 8 (1): 191 -198; ISSN: 0794 5213. Journal Publication of Nasarawa State University, Keffi

Abiven, S., Menasseri-Aubry, S., and Angers, D. A. (2017). Impact of organic mulch on soil health. *Agriculture, Ecosystem and Environment.* 236,137-145.

Abubakar.S. (2015). Nigeria imports vegetables. Accessed from (http://www.fepsannigeria.com/index.php?option=com_contentandview=articleandid=216: Nigeria-imports-vegetables-andcatid=57: frontpage) on 19th Jan 2015

Akpan, G. U., and Iliyasu, M. (2018). Effect of Organic Mulches on Soil Productivity and Microbial Activities in Acid Sands of Uyo, Nigeria. *International Journal of Agricultural research and food production.* ISSN: 2536-7331 (print):2536-734x. Retrieved from http://www.casirmediapublishing.com.

Antonio J., Lorena M. Z., Juan G. (2010). Effects of Mulching on Soil Physical Properties and Runoff under Semi-arid Conditions in Southern Spain. *Catena* 81 (1), 77-85, 2010. https://doi.org/10.1016/j.catena.2010.01.007. Retrieved from www.sciencedirect.com.

Bingpeng Q., Yuanxin L., Xiangyang S., Suyan L., Xinyu W., Kaiyi X., Binghui Y., Hua Z. (2019). Effect of Various Mulches on Soil Physico—Chemical Properties and Tree Growth (Sophora japonica) in Urban Tree Pits. *PLoS One*. 2019 Feb 6;14(2):e0210777. doi: 10.1371/journal.pone.0210777. Retrieved from www.pmc.ncbi.nim.nih.gov.

Bosland, P. W. and Votava, E. J. (2012). Peppers: Vegetable and spice capsicums. *Crop Production Science in Horticulture 12. Cab International Publishing*, Wallingford, England, UK, 204.

Bosland, P. W. and Votava, E. J. (2012). Peppers: Vegetable and spice capsicums (2nd ed.). *Cabi digital library Publishing*. ePDF:eISBN : 978-1-84593-784-3.

Bouyoucos, G.F. (1965) Hydrometer Method Improved for Making Particle Size Analysis of Soils. Soil Science Society of America Proceedings, 26, 464-465. https://doi.org/10.2134/agronj1962.00021962005400050028x

Bray, R.H and Kurtz L.T. (1945). "Determinalion of Total Organic and Available Forms of Phosphorus in Soils.

Chan G., Xufei L., and Debarati B. (2020). Effect of soil mulching on agricultural greenhouse gas emissions in China: A meta-analysis. *National Library of Medicine.* 10.1371/journal.pone.0262120. Retrieved from Pmc.ncbi.nlm.nih.gov.

Edward A.A. (2018).Influence of Organic Mulches on Soil Physico-Chemical Properties and Maize (Zea Mays L.) Crop Performance. *Journal of Agricultural Studies* 6 (2), 1, 2018. Retrieved from www.researchgate.net.

Marble, S. C., Koeser, A. K., Hasing, G., McClean, D. and Chandler, A. (2017). Efficacy and estimated annual cost of common weed control methods in landscape planting beds. *Hort. Technology, 27*(2), 199-221.

Ezenwaji, E.E., Phil-Eze, P.O., Enete, I.C. and Osuiwu, B.O, (2014). An analysis of the cycle and Pericity of Annual Rainfall Over Awka Region, Nigeria. *Atmospheric and climatic sciences*, 4: 665-671.

F.A.O, Food and Agricultural Organization (2003). Bulletin of statistics, Rome Italy. 4 (2):98-99.

Genstat. (2011). Discovery Edition 4. Genstat Release 10.3DE (pc/windows)

Goitom, T., Alemtsahay, T., Berhanu, A. (2017). Effect of Organic Mulching on Soil Moisture, Yield, and Yield Contributing Components of Sesame (Sesamum indicum L.).*International Journal of Agronomy.* Issue 1 476750. https://doi.org/10.1155/2017/4767509.

Huang, Y., Li, W., and Wang, Y. (2013). Effects of Pepper Root on Soil Physical Properties. *Journal of Soil Science and Plant Nutrition*, 13(2), 257-266.

Iqbal, R., Raza, M.A.S. and Valipour, M. (2020). Potential agricultural and environmental benefits of mulches - A Review. *Bull Natl Res Cent* 44, 75. https://doi.org/10.1186/s42269-020-00290-3.

Jaliya, M..M and Sani, B.M. (2006). Pepper Production under irrigation. National Agricultural Extension Research Liaison Services, Ahmadu Bello University, Extension Bulletin No.206

Jinshi L., Gaoli Z., Jia W., Fangshi J., Ming-kuang W., Yanhe H. (2018). Mulching effects on erosion from steep slopes and sediment particle size distributions of gully colluvial deposits. *Catena* 160, 57-67, 2018. Retrieved from www.sciencedirect.com.

Jones, J.B, (2001). Laboratory Guide for Conducting Soil Tests and Plant Analysis. *Earth Science Environment and Agriculture.*1st edition., pg 384. eBook ISBN; 9780429132117. DOI; http://doi.org/10.1201/9781420025293. Retrieved from www.taylorfrancis,com

Lal, R. (2019). Soil erosion and its impact on ecosystem services. *Land Degradation and Development*, 30(16), 2336–2350. https://doi.org/10.1002/ldr.3429

Li, J., Zhang, F., Wang, X., and Zhao, Y. (2021). Effects of Organic Mulch on Soil Phosphorus Availability and Microbial Community Composition. *Journal of Soil Science and Plant Nutrition*, 21(2), 456-468.

Marble, S.C, Koeser, A.K, Hasing, G, McClean, D, and Chandler, A, (2017).

Marwan N.R. (2021). Yield and yield components of maize and soil physical properties as affected by tillage practices and organic mulching. *Saudi Journal of Biological Sciences* 28 (12), 7152-7159, 2021. Retrieved from www.sciencedirect.com.

Mingming Z, Yinghao X., Tuo J., Kai Z., Zhili Li, Chitao S., Qinghua M., Quanqi L. (2010). Effect of long-term biodegradable film mulch on soil physicochemical and microbial properties .*Toxics* 10 (3), 129, 2022.

Nadeem, M., Muhammad, F., Anjum, F. A., Khan, M.R., Saed, M. and Riaz, A. (2011). Antioxidant Potential of Bell Pepper (*Capsicum annum* L.). *Pakistan Journal of Food Science*, 21(14):45-51.

Nelson, D.W. and Somners, L.E. (1996) . Total Carbon, Organic Carbon, and Organic Matter. In: Sparks, D.L., *et al*., Eds., Methods of Soil Analysis. Part 3.Chemical Methods, *SSSA Book Series No. 5*, *SSSA and ASA, Madison*, WI, 961-1010.

Nwosu, M.O. and Eke-Okoro, O.N. (2016). Effects of Organic Mulch Materials on Soil Surface Evapouration. *Notulae Scientia Biologicae*, 8(1), 82-89

Patil S.S., Kelkar Tushar, S., and Bhalerao Satish, A. (2013).Mulching: A soil and water conservation practice. *Res. J. Agric. Forestry Sci.*, ISSN, 2320, 6063.

Pazhanivel, K.S., Krishnaveni, A., Pazhanivelan, S., Bharani, A., Arunkumar, V., Devaki, P., and Muthukrishnan, N. (2024). Carbon Economics for Different Agricultural Practices for Farming Soil. *arXiv preprint arXiv:*243.07530

Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O., and Kunin, W. E. (2010). Global pollinator declines: Trends, impacts and drivers. *Trends in Ecology and Evolution*, 25(6), 345-353.

Rafia, M., Muhammad, B. H., Hira T., Marina, Q. and Iqra T. (2022). MULCHES EFFECTS On Soil Physical Properties ie Prorsity, Aggregate Stability, Infiltration Rates, Bulk Density, Compaction. *Mulching in Agroecosystems: Plants Soil And Environment*, 41-58,2022. Retrieved from www.springer.com

Reyes-Escogido, M. L., Gonzalez-Mondragon, E. G., and Vazquez-Tzompantzi, E. (2011). Chemical and Pharmacological Aspects of Capsaicin. *Molecules*, 16(2): 1253–1270. https://doi.org/10.3390/molecules16021253.

Sales, R. (2015). Impact of organic matter on vineyard soil moisture, weed growth and yung vine growth. *Master's thesis,* Texas AandM University. https://oaktrust.library.tamu.edu/bitstream/handle/1969.1/154480/SALES-THESIS-2015.pdf.

Sintayehu, M., Ali M., Derbew, B. and Essubalew, G. (2015). Impact of Organic Mulch Materials on Yield and Yield Attributes of Hot Pepper Varieties at Jimma, Southwest Ethiopia. *American-Eurasian J. Agric. and Environ. Sci.,* 15 (11). DOI: 10.5829/idosi.aejaes.2015.15.11.12736. Retrieved from www Research gates.com.

Udo, E. J., Ibia, T. O., Ogunwale, J.A., Ano, A.A. and Esu, I. E. (2009). Manual of Soil, Plant and Water Analyses. *Sibon Books Limited.* Lagos, 31-33. Retrieved from scrip.org.

Uko, I., Onunwa, A.O., Obidigwe, N.A. and Okorie, C.H. (2021). Weed Management, Soil Physico-chemical Properties and Growth Response of Hot Yellow Pepper (Capsicum chinense N.) as Influenced by Different Organic Mulches. *African journal of Organic Agriculture and Ecology* 5: 9 - 18https://www.researchgate. net/publication/363272246

Vanella D., Guarrera S., Ferlito F., Longo-Minnolo G., Milani M., Pappalardo G.,Nicolosi E., Giuffrida A. G., Torrisi B., Las Casas G., and Consoli S. (2024). Effects of organic mulching and regulated deficit irrigation on crop water status, soil and yield features in an orange orchard under Mediterranean climate. *National Library of Medicine.* https://doi.org/10.1016/j.scitotenv.2024.177528.

Wang, Z., Fan, J., Zhang, F., and Li, Q. (2020). Effects of straw mulch on soil water and salt dynamics and sunflower yield in a saline field. *Agricultural Water Management*, 228, 105914. https://doi.org/10.1016/j.agwat.2019.105914

Xie, J., Hou, Y., Du, S., Liu, Z., and Zhang, J. (2021). *E*ffects of organic mulching on soil properties and crop yields: A meta-analysis. *Agriculture, Ecosystems and Environment*, 309, 107239. https://doi.org/10.1016/j.agee.2021.107239

Yakovchenko, V. P., Yakovchenko, N. V., and Tikhonova, E. V. (2017). Effects of Organic Mulching on Soil Properties and Plant Growth. *Journal of Environmental Science and Health.* Part B, 52, 342-349.

Zhang, Z., Zhou, W., and Liang, G. (2019). Effects of organic mulch on soil moisture, temperature, and seedling growth. *Plant and Soil*, 443(1), 123–135. https://doi.org/10.1007/s11104-019-04243-5