Effect of Different Mulch Materials on Soil Properties, Growth and Yield of Tomato (*Lycoperiscon esculentum* mill) at Awka, Southeastern Nigeria

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K E Y W O R D S

Mulch materials,
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Plastic mulch,

A B S T R A C T

The experiment was conducted at Soil Science and Land Resources Management Research Farm, Nnamdi Azikiwe University, Awka, to study the effect of different mulch materials on selected soil properties, growth and yield of tomato. The treatment consisting of four mulch materials (sawdust, rice husk, plastic mulch, dry grasses and a control) were evaluated with Randomized Complete Block Design (RCBD) in four replications. Padma 108 f1 hybrid east west tomato seeds were used in the investigation. Data collected were subjected to Analysis of variance (ANOVA) and the means separated using Fishers Least Significant Difference (FLSD) at 5% level of significance. The results of the study indicated that using plastic mulch to grow padma 108 f1 hybrid east west seeds variety for tomato production in the area gave higher yield compared to other treatments. Therefore, application of plastic mulch for tomato production using padma 108 f1 hybrid east west seeds is recommended for tomato producers in the study area. Observations were made on plant height, number of branches, number of leaves, % flowering, % fruiting, which increased on mulched plots than on the control. Soil laboratory results showed that soil pH, soil organic carbon content, available phosphorus and exchangeable cations (Ca, K, Mg, and Na) increased as a result of increase in organic matter with the application of the mulch. Organic mulch precisely Dry Grasses improved the physical properties of the soil.

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INTRODUCTION

Mulching is used to regulate and control the soil temperature, moisture and nutrient content (Aldefer, 2005), weeds, pests and diseases (Unger *et al* 2001). It is known that plant development and yield increase occur with balanced soil temperature; mulching play great role in increasing yields, promoting early harvest, reducing fruit defects, reducing evaporation from the soil surface in vegetable production (Splittstoesser, 2005). The effectiveness of mulching depends on the type of mulching materials used. Mulches can be categorized as organic or inorganic (Forge *et al*. 2002), depending on the composition of the mulch, and their different effects on the growing medium. Effects of mulching include increase in specific mineral such as N, K, Mg, Ca, etc. in the soil as the mulch decomposes as well as changes in soil pH. Areas with sandy soils, which are more acidic than heavier soils, can thus benefit from the use of mulch as a possible contribution of organic material to the biological component of the soil environment (Forge *et al*. 2002). In addition, some mulches buffer changes in moisture, which will also have an influence on the soil micro-organisms (Autio *et al*. 1991; Brown and Tworkoski, 2003; Arancon *et al*. 2006). Mulching inhibits direct contact of the plants leaves and fruits with the soil, thereby producing cleaner crops with less decay potential.

Tomato is one of the major vegetables in Nigeria, hence, its use as a test crop in this study. Successful tomato cultivation largely depends on the cultural optimum efficient use of available soil moisture, spacing, time of planting, management practices etc. Tomato has best yields when grown in well-drained loam soils, rich in organic matter and plant nutrients with a pH range of 6 to 7.

Paucity of documented information on mulching and its influence on soil properties and tomato production especially in southeastern Nigeria has necessitated this study to be designed to focused on the positive effects of mulches in increasing the organic matter content in the soil (Arancon *et al*. 2006), increase soil moisture, moderate soil temperature (Treder *et al*. 2004), and improve root growth (Acharya and Sharma 1996). Mulches differ significantly in terms of the above mentioned positive attributes (Walsh *et al*. 2005).

The objective of this study is to examine the effect of the different mulching materials on selected soil properties, growth and yield of tomato in Awka.

MATERIALS AND METHODS

Description of the Experimental Site

The experiment was carried out at the Soil Science and Land Resources Management Research Farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka in the year 2015/2016. Awka is located at latitude 7^{o}00 and 7^{o}10^{I}N; longitude 6^{o}5$^{!}$ and 6^{o}15^{I}E at an elevation of 447 m above sea level. The site is characterized by heavy rainfall which is bimodal and high humidity (70 – 80%) (Ezenwaji *et al*., 2014).

Design and Layout of the Experiment

A total land area of 5000m^2 was manually cleared, ploughed and harrowed by tractor and the beds raised according to specifications. Tomato seedlings were transplanted at a spacing of 60 by 50 cm. The experiment was laid out in Randomized complete block design (RCBD), having five treatments and four replicates. The treatments were: Black plastic mulch (M2); Rice husks (M5); Dry grasses/hay (M4); Saw dust (M3); Control (M1), which were replicated 4 times

Cultural and Management practices

Mulch Materials were applied at a thickness of 0.2mm per plot. Pyramidal staking was done 18 DAT; NPK (15:15:15) was applied at 1 week after transplanting (WAT); weeding operation was carried out at 2 weeks interval. The crops were harvested at intervals of two days

Soil Sample Analysis

Six initial Soil samples were collected at 0-15 cm depth and composited. At harvest (8-12 weeks after application of mulch), soil samples were collected at designated points, air-dried, ground, passed through 2 mm sieve and stored in plastic bottles, ready for analysis. The samples were analyzed for pH using pH meter (McLean, 1982), Soil texture was determined by Bouyoucos hydrometer method (Gee and Bauder, 1986); Soil moisture was determined by gravimetric method (Jalota *et al*., 1998), bulk density was determined using core method (Blake and Hartge, 1986), soil organic carbon was determined using Walkley and Black wet oxidation method (Nelson and Sommers, 1982); Total N by Bremner and Mulvancy (1982). Phosphorus (P), calcium (Ca^{2+}), magnesium (Mg^{2+}) and potassium (K^+) were extracted with 1.0N NH4OAc. Available P was measured using spectrophotometer (Nelsen and Sommers, 1982), K was determined using flame photometer (Richards, 1954). Ca and Mg were determined using the EDTA filtration method.

The following growth and yield parameters were collected:

Plant height was measured using meter rule; Number of Branches and Number of the Leaves by visual counting and observation.

Data Analysis

Data collected were subjected to analysis of variance (ANOVA) following the routine procedure for RCBD experiments using GenStat 2008 edition (GenStat, 2008). Mean separation was done using Fisher's least significant difference (F-LSD) at 5% probability level.

RESULT AND DISCUSSION

Table 1 showed the results of initial soil sample to assess the soil fertility status. Soil organic carbon was 1.23%. Available phosphorous was 20.6 (ppm) while soil Ca^{2+} and Mg^{2+} were 10.9and 5.44 (meq 100 g–1 of soil) respectively. The soil was slightly acidic with a pH of 6.2. The soil texture was sandy loam.

Table 1: Pre-planting soil physico-chemical properties of the experimental site

Soil property	Values
(%) Sand	69.22
(%)Clay	4.54
(%)Silt	26.24
pH	6.2
Bulk density mg/ cm^3	1.61
Moisture content (%)	11.49
Total porosity (%)	39.25
Organic carbon (%)	1.23
Available P (ppm)	20.6
Exchangeable K (meq 100 g^{-1} soil)	10.83
Exchangeable Ca (meq 100 g^{-1} soil)	10.9
Exchangeable Mg (meq 100 g^{-1} soil)	5.44
Exchangeable Na^+(meq 100 g^{-1} soil)	14.0
Exchangeable H^{2+} (meq 100 g^{-1} soil)	8.0
Exchangeable Al^{3+} (meq 100 g^{-1} soil)	9.0

Table 2 showed the effect of mulch treatments on soil chemical properties. Organic carbon, $Ca^{2+,}$ Mg^{2+} and H^+were not significantly different from the control. This result is expected, because plastic mulch promotes the respiration of roots and soil microorganisms, accelerates the decomposition of organic matter, and increases the concentration of carbon dioxide in soil thereby increasing available P content (Gu *et al*., 2018; Zhang *et al*., 2020).

The pH differed significantly and followed the order: rice husk (5.8)> saw dust (5.6)> plastic mulch (5.4)>dry grasses (5.2)>control (4.8). The increase observed in soil pH value could probably be due to significant improvement in soil organic matter and exchangeable cations. Available Phosphorus was in the order: Black plastic (0.060 ppm)>Dry grasses (0.042 ppm)>Saw dust (0.025 ppm)>Rice husk (0.036ppm)>control (0.24 ppm). A report by Hundal *et al*. (2000) indicated that available phosphorus was significantly affected by mulching. The increase in available P in the mulched plots could be attributed to the increase in soil organic matter. Sanchez (2001) observed that maintaining organic matter could affect phosphorus level. However, the decline in available P in the control could be as a result of plant uptake and P-fixation without replacement because many studies have demonstrated that mulching significantly affected the available P in different soil depths and surfaces (Thankamani *et al*., 2016). Qu *et al*. (2019) indicated that available phosphorus content was significantly affected only by the organic mulches. K was observed to vary significantly among the treatments. Plots mulched with Plastic and dry grasses were significantly different from control which was statistically the same with rice husk and saw dust. K decrease under control could be attributed to removal through plant uptake and losses through leaching. The increase in K with time on mulched plots could be a result of the increase in organic matter derived from mulching.

Na^+ was observed to vary significantly among the treatments. Plastic mulch, Rice husk and saw dust were significantly different from the control which was statistically the same as dry grasses. Meanwhile, Saw dust had the highest value (1.8) while plastic mulch had the least (0.18).

Table 2: The effect of mulch treatments on soil chemical properties

				Exchangeable bases					
Treatment	**Org. C %**	**pH**	**Ava. P (ppm)**	K^+	Ca^{2+}	Mg^{2+}	Na^+	Al^{3+}	H^+
				(meq 100 g–1 of soil)					
Plastic mulch	1.24	5.4	0.061	2.21	17.1	8.6	0.18	0.7	0.4
Dry grasses	1.53	5.2	0.042	2.20	18.2	9.1	0.29	0.2	0.4
Saw dust	1.89	5.6	0.025	1.28	15.7	7.8	1.8	0.5	0.4
Rice husk	1.32	5.8	0.036	1.41	18.0	9.0	0.19	0.1	0.3
Control	1.30	4.8	0.024	1.39	15.5	7.8	0.22	1.4	0.6
LSD0.05	NS	0.011	0.02	0.03	NS	NS	0.041	0.037	NS

P value <0.05; NS means Not Significant

Table 3 showed the effect of mulch treatments on soil physical properties. Mulch significantly affected soil moisture content. Dry grasses (14.94) varied significantly with control (11.85) which was statistically the same as Plastic (12.88), saw dust (12.79), Rice Husk (12.49). It was observed that Soil moisture content improved considerably due to the decreased temperature in plots mulched with dry grass. The result agrees with the findings of (Adeoye, 1984; Agele *et al*., 2000) who reported the effect of mulching on soil moisture conservation and reduction in soil temperature regimes. Organic mulch precisely, Dry Grasses reduced evaporation of soil moisture and thus improved soil moisture retention (Hernandez *et al*., 2016). Other studies from agricultural fields in the humid tropics had shown that mulching ameliorates soil moisture deficits and regulates temperature regimes, improves water infiltration, reduce evaporation and run–off as well as improve soil structure (Olasantan, 1988) This is in agreement with Smith *et al*. (2000), findings; Liu *et al*. (2002) and Khurshid *et al*. (2006) who observed that mulching improved the ecological environment of the soil and increased soil water content.

For bulk density, Dry grasses (1.30) varied significantly with control (1.48) which was statistically the same with rice husk (1.39), saw dust (1.36) and plastic mulch (1.38). From the result we observed that organic mulch reduced the bulk density of the soil when compared to the control. This agrees with the findings of Ghuman and Sur (2001) who concluded that mulching decreased bulk density of the surface soil. According to Aina (1979) organic mulch eliminates compaction in soils. According to Fergusen and Gumbs (2000), Mulching reduced bulk density, increased soil moisture, organic matter contents leading to suitable environment for **root penetration.**

Table 3: Effect of mulch treatments on soil physical properties

Mulch	Textural Class	BD mg cm^{-3}	Soil Porosity (%)	Moisture Content (%)
Plastic Mulch	Sandy Loam	1.38	40.09	12.88
Dry Grasses	Sandy Loam	1.30	37.63	14.94
Saw Dust	Sandy Loam	1.36	41.0	12.79
Rice Husk	Sandy Loam	1.39	40.93	12.49
Control	Sandy Loam	1.48	37.29	11.85
$LSD_{0.05}$	-	0.04	0.03	0.03

P value <0.05.

Table 4 showed the effect of the different mulching materials on tomato branches at 2, 4 and 6 weeks after transplanting (WAT). At 2 weeks, there was significant difference (p<0.05) among the mulched materials with respect to the number of branches produced by the tomato plants. Number of branches was in this order: black plastic (10.67)>Dry grasses (9.50) > Rice husk (9.33)>Saw dust (9.17) >control (7.92).

At 4 weeks, there was significant variation (p<0.05) in the number of branches produced. It was in the order: plastic mulch (24.67)> Rice husk (19.42)> Saw dust (17.67)> Dry grasses (17.17) and then control (12.75).

At 6 weeks, there was a significant difference in tomato branches. It followed this pattern: Plastic (39.42)>Dry grasses (31.75)> Rice husk (31.00)> Saw dust (29.42)> Control (22.42). This observation pattern at 6WAT is exactly the same with the observation at 2WAT. The number of branches per plant continually increased with plant age. All the mulches had positive effect on generating and retaining higher number of branches per plant. Generally, the highest number of branches per plant was observed in black plastic mulch. Control always showed the least number of branches. It was reported that mulched tomato plants had more branches than that of the control, which supported these results (Srivastava *et al*., 1994). The least number of branches recorded under control might be due to soil temperature difference among mulch materials. The increase in plant branches due to the various mulch materials has been reported by Taber and Smith (2009), which corroborates with our findings.

Table 4: Effect of mulching materials on number of tomato branches at 2, 4 and 6 weeks after transplanting

	Weeks after transplanting (WAP)		
Treatment	2	4	6
Plastic mulch	10.67	24.67	39.42
Dry grasses	9.50	17.17	31.75
Rice husk	9.33	19.42	31.00
Saw dust	9.17	17.67	29.42
Control	7.92	12.75	22.42
$LSD_{0.05}$	1.26	4.74	5.84

Table 5showed the effect of the different mulching materials on the number of leaves at 2, 4 and 6 weeks after transplanting. At 2 weeks after transplanting, there was a significant difference (p<0.05) in the number of tomato leaves. The order was: Black plastic (106.9)>Saw dust (99.2)>Dry grasses (88.3)>Rice husk (79.8) and then the control (75.8).

At 4 weeks after planting, the different mulching materials had a significant variation ($p<0.05$) on the number of leaves. Black plastic (223.8)>Dry grasses (213.5)>Saw dust (209)>Rice husk (200.7)>control (165.6).

At 6 weeks after transplanting, there was a significant difference ($p<0.05$) in the number of tomato leaves as a result of the different mulching materials used. Black plastic (272.1)> Dry grasses (255.1)>Saw dust (248.2)>Rice husk (241.6)>control (199.0).

The maximum number of leaves per plant was found on the plants mulched with black plastic at all growth stages, followed by the Dry grasses. The microclimate condition improved by the mulches might have provided a suitable condition for producing higher number of leaves in the plants. The effectiveness of plastic mulches for the production of leaves in maize was better than control as reported by Izakovic (1989). The number of leaves increased with increasing time after transplanting. The greater number of leaves might be due to the optimum soil temperature and higher soil moisture content at the root zone during the plant growing period.

Table 5: effect of different mulching materials on the number of tomato leaves at 2, 4 and 6 weeks after transplanting

	Weeks after planting		
Treatment	**2**	**4**	**6**
Plastic mulch	106.9	223.8	272.1
Dry grasses	88.3	213.5	255.1
Rice husk	79.8	200.7	241.6
Saw dust	99.2	209.0	248.2
Control	75.8	165.6	199.0
$LSD_{0.05}$	19.06	41.03	40.93

Mulching also helps to balance soil temperature; this in turn affected soil microbial activities in the rhizosphere (Ayum *et al*., 2008). It prevents crops from rainwater splash thereby maintaining plant hygiene (Johnson *et al*., 2004). Enhanced microbial population increased plant growth parameters which eventually increased the yield of the plant (Bhagat *et al*., 2016).

Table 6 showed the effect of different mulching materials on plant height at 2, 4 and 6 weeks after transplanting. Observed results showed that there were significant differences ($p<0.05$) in the height of tomato plants at 2, 4 and 6 weeks after transplanting. Black plastic mulch (42.17cm)>Dry grasses (39.33cm)>saw dust (36.50cm)>Rice husk (32.67cm)>control (32.00cm).

At 4 weeks after transplanting, there was a statistically significant difference ($p<0.05$) in height of tomato plants. Black plastic mulch (81.3cm)>Saw dust ((72.6cm)>Rice husk (64.5cm)>Dry grasses (63.4cm)>control (55.6cm).

At 6 weeks after transplanting, significant differences ($p<0.05$) were also observed in tomato plant height. Black plastic (93.5cm)>Saw dust (86.8cm)>Rice husk (77.6cm) >dry grasses (74.6cm)>control (70.0cm).

Height of tomato was observed to be higher in mulched plots than in the control. This effect might be due to conservation of sufficient soil moisture which provided water to the plant. On the contrary, control did not have much height possibly due to volatilization of soil nutrient/moisture. The increase in plant height due to various mulch materials have been reported by various authors (Bhardwaj, 2011; Sarolia and Bhardwaj 2012). Synthetic mulches increased plant height over the control (Ekinci and Dursun 2009). The increased plant height in mulched plants was possibly due to better availability of soil moisture and optimum soil temperature provided by the mulches. Changes in the plant height of chilli have been observed by using different mulches and plastic mulch increased the plant height than other mulches (Shinde *et al*., 1999).

Table 6: Effect of different mulching materials on plant height (cm)

	Weeks after transplanting		
Treatment	2	4	6
Plastic mulch	42.17	81.3	93.5
Dry grasses	39.33	63.4	74.6
Rice husk	32.67	64.5	77.6
Saw dust	36.50	72.6	86.8
Control	31.00	55.6	70.0
$LSD_{0.05}$	6.184	11.24	12.80

Table 7 showed the effect of different mulching materials on the yield of tomato. Observed data showed that there was significant difference ($p<0.05$) in the yield of tomato. Plastic mulch had the highest tomato yield (5.08kg/plant)>Rice husk (4.50 kg/plant) >dry grasses (4.45 kg/plant)> Saw dust (4.77 kg/plant); the least yield was recorded in the control (3.10 kg/plant).

Table 7: Effect of different mulching materials on tomato yield

Treatment	Yield (kg/plant)
Plastic mulch	5.08
Dry grasses	4.45
Rice husk	4.50
Saw dust	4.77
Control	3.10
$LSD_{0.05}$	0.97

CONCLUSIONS AND RECOMMENDATION

This study showed that tomato (padma 108 f1 hybrid east west seeds) responded to mulching. Soil pH, organic carbon, available phosphorus, and exchangeable cations (Ca, K, Mg, and Na) increased as a result of increase in organic matter associated with the application of mulches. These attributes led to enhanced growth and yield of tomato. The advantages derived from mulching were reflected in plant height, number of leaves and number of branches. Among the mulching materials tested, black plastic mulch favored growth parameters and yield of tomato. The result of this study indicated that black plastic mulch displayed superiority over the other mulch materials used in this study. Therefore, application of black plastic mulch using padma 108 f1 hybrid east west seeds is recommended for tomato producers in the study area.

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