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Tillage and Mulch Effect on Growth and Yield of Cucumber (*Cucumis sativus*) on an Ultisol in Nsukka, South-Eastern Nigeria

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Abstract

Objectives: Despite the global success of minimal tillage and plastic-film mulching since the 1950s, their application remains limited in sub-Saharan Africa. This study evaluated the effects of two tillage systems and four mulch types on the growth and yield of cucumber (*Cucumis sativus*) in the typical paleosol soil of South-Eastern Nigeria.

Method: A field experiment was conducted between June and September 2020 using a 2 x 4 factorial arrangement in a Randomised Complete Block Design (RCBD) with three replicates. Treatments consisted of two tillage levels (conventional and minimal) and four mulch types (no mulch, black plastic, transparent plastic, and grass). Growth traits, including vine length, branch number, and Leaf Area Index (LAI), were measured alongside maturity yield components. Data were analysed using GenStat.

Result: Statistical analysis showed no significant difference ($p \geq 0.05$) between minimal and conventional tillage, though minimal tillage produced numerically superior results, such as a longer vine length (98.7 cm) and larger LAI (200.4) compared to conventional tillage (75.5cm and 165.5), respectively, at 42 days after planting (DAP). At harvest (53 DAP), the highest yield of 1.72 t/ha was achieved using black plastic mulch. Overall, yields were consistently higher in minimal-tillage plots than in conventional-tillage plots.

Conclusion: The findings suggest that mulched plots, particularly those using black plastic, provide a superior soil environment for cucumber production. Furthermore, minimal tillage provides a more favourable edaphic environment than conventional methods in this region, making it a viable strategy for enhancing vegetable production in South-Eastern Nigeria.

Keywords: *Cucumis sativus*, plastic-film mulching, minimal tillage, South Eastern Nigeria, sustainable intensification

Introduction

Plants are a basic source of food and energy. Cucumber (*Cucumis sativus*) is an important vegetable crop believed to have originated in India and is widely grown in both the temperate and tropical zones of the world. The crop belongs to the family Cucurbitaceae, which comprises

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about 130 genera and 900 species. The plants in this family are grown around the tropics and in temperate areas, where those with edible fruits were among the earliest cultivated plants in both the Old and New Worlds. Economically, it ranks fourth in Asia, after tomatoes, cabbage, and onions (Orluchukwu & Amadi, 2022), and is the second-most-important vegetable crop in Western Europe after tomatoes. In tropical Africa, the crop has not been ranked because of limited use.

The production of cucumbers in Nigeria is very low due to limited use and seasonal factors. They are mainly produced in the northern states of Nigeria (Saleh et al*.,* 2024). Cucumber is rich in fibre and vitamins, aids in weight loss, reduces the risk of cancer, repels mouth odour, keeps the body hydrated, aids digestion, makes the skin smooth and young, breaks kidney stones, stabilises cholesterol level, cures diabetes, regulates blood pressure, and many other important factors.

Cucumbers grow shallow and wide. Only a limited number of roots can penetrate up to a depth of 5.0 meters. Vegetables generally grow slowly under no-till cultivation. Zero- or minimal-tillage systems affect soil properties, which, in turn, can influence nutrient uptake and plant chemical composition (Singh et al*.,* 2020). A minimal tillage system is also an effective technique for halting soil erosion and making food production truly sustainable. Other advantages of minimal tillage include: reduced fuel consumption and nitrate leaching, preservation of soil structure, and the presence of earthworms and other soil fauna (Bista et al., 2019). The tillage system helps with root penetration, anchorage, nutrient and moisture uptake in cucumber crops.

Mulching serves many purposes and may be composed of various materials. The main benefit of mulching is raising soil temperature in the seedbed zone, which promotes faster crop growth and earlier harvest. Mulching is a technique used by vegetable growers for many years and may involve organic and inorganic materials. This use of organic or inorganic mulching materials can conserve and sustain the beneficial effects of water retention, soil aggregation, and soil fertility. Organic mulch includes rice husk, grass, sawdust, wood shavings, cassava peels, wheat straw, peat, compost, peat moss, wood chips, paper, and others, while inorganic mulch materials comprise black, white, and other-coloured polythene plastic crop covers. However, the response of crops to mulch depends on the crop species, prevailing climate, production system and the type of mulch. Mulches primarily affect the field microclimate by modifying the surface radiation budget and suppressing soil water evaporation. These microclimate factors strongly affect soil temperature and moisture in the root region, which, in turn, influence plant growth and productivity.

Soil mulching with plastic films has its benefits because cucurbits, including cucumber, are shallow-rooting and do not like being hoed. These mulch materials help the plant conserve water, control weeds, and control soil-borne diseases and pests, while keeping the soil moist and warm. In vegetable crop production, plastic (synthetic/polythene) sheets are widely used as mulch materials to improve agricultural production.

This project involves the growing of cucumber in tilled and non-tilled plots on an inherently low-fertility coarse-textured soil, which was amended with the use of organic (poultry manure, wood ash) and inorganic (NPK 15:15:15) fertilisers at the University of Nigeria, Nsukka, southeastern Nigeria, and the use of different mulch materials, namely: grass straw and polythene sheets. The aim of this field study, conducted in this humid tropical region, was to

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determine the effects of tillage and mulching with different mulching materials on cucumber growth. The specific objectives for this experiment include:

- To determine the effect of tillage systems on the production of cucumber.
- To ascertain the effect of different mulching materials on cucumber production.

Materials and Methods

Study Location

The experiment was carried out at the Teaching & Research Farm of the Faculty of Agriculture, University of Nigeria, Nsukka, between June 2020 and September 2020. The experimental site is located at latitude 06° 52'N and longitude 07º 24'E. The study is located in the Derived Savanna agroecological zone of southeastern Nigeria. The climate is humid tropical with two distinct seasons, the rainy season (usually April to October) and the dry season (usually November to March). The area's climate is characterised by a mean annual rainfall of about 1600 mm, with a bimodal distribution, typically peaking in July and October. The mean minimum and maximum daily temperatures are 21 and 31ºC, respectively. Relative humidity can vary year to year, often in the range of 55-90%.

The soil at the experimental site, sandy loam, is brownish-red, coarse-textured and hence well-drained. The key physicochemical properties of the top-(0-20 cm) soil from a nearby field some 100 m away have been presented elsewhere (Obalum et al*.,* 2017); showing sand, silt and clay contents of 750, 70 and 180 g/kg, respectively, acidic pH of 4.8, organic carbon concentration of 17.88 g/kg, total nitrogen of 0.56 g/kg, and cation exchange capacity of 12.40cmol/kg.

Field Study

The experiment was laid out as a 2×4 factorial in a randomised complete block design (RCBD), replicated thrice. The field study started on the 5th of June 2020. Two experimental factors were studied: tillage and mulching. Factor A is two tillage systems: conventional and minimal tillage. Factor B is mulching, including organic and inorganic mulch materials. The organic mulch used was grass, while the inorganic mulch was black, transparent polyethene, and the control plot contained no mulching material. The treatments were replicated three times in a randomised complete block design (RCBD), resulting in a total of 24 experimental plots. The experimental plot for the study measured 18m x 7.5m. The site was manually cleared and demarcated into plots for the treatment using bunds. Each plot was 1.5m x 1.5m, and a 0.75m space was left between adjoining plots in a block. The separation between the three blocks was 1.5m. Soil analysis was carried out, and soil amendments: ash and air-dried poultry manure were applied at a rate of 3t/ha and 10t/ha, respectively. Each plot, measuring 2.25 m^2, received 2.25kg of poultry and 0.65kg of lime (ash).

Observation and data collection

Growth parameters were assessed at 2, 4 and 6 weeks after planting (WAP). For this data collection, the three middle plants in a plot were used. Data were collected on several growth parameters, including the number of leaves and branches per plant. At maturity and harvest, yields were assessed on a whole-plot basis, with data collected on fruit yield (fruit weight per plot, g). Data were collected on some yield components, including the mean fruit length and the mean fruit girth. Others were marketable yield per plot, number of fruits per plot, and marketable number of fruits per plot.

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Results

Table 1: Soil Physiochemical Properties Prior to Planting

Parameters	Values obtained
Clay	14.00
Silt	13.00
Fine sand	29.00
Coarse sand	44.00
pH (H_2O)	4.80
pH (KCl)	4.00
Textural class	Sandy loam
Organic Carbon (%)	1.14
Organic matter (%)	1.97
Nitrogen (%)	0.11
Available Phosphorus (ppm)	9.46
Exchangeable cations (cmol/kg)	
Na^+	0.04
K^+	0.09
Ca^{2+}	0.60
Mg^{2+}	1.20
CEC (cmol/kg)	20.40
Exchangeable acidity	
Al^{3+}	0.40
H^+	19.20
Base saturation (%)	9.46

CEC - Cation Exchange Capacity

Table 2: Chemical Composition of the Poultry Manure Used for This Study

Parameters	Values obtained
pH (H_2O)	8.9
pH (KCl)	8.5
Organic Carbon (%)	35.11
Organic matter (%)	50.53
Nitrogen (%)	0.29
Available Phosphorus	0.64
Exchangeable cations (meq)	
Na^+	0.37
K^+	0.51
Ca^{2+}	7.20
Mg^{2+}	9.21

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The results presented in Tables 1 and 2 show the values of some soil properties prior to the experiment and the chemical composition of the poultry manure used for soil amendment. The soil was extremely acidic with a pH in KCL (4.00). The low carbon and total nitrogen levels, compared with the critical minimum for Nigerian soils (Shaibu et al., 2018), could be attributed to continuous cropping without additional nutrient supply. The low pH and nutrient levels indicate high acidity and low fertility, necessitating the use of soil amendments such as poultry manure, whose nutrient composition differs slightly from that reported by Agbede (2021) in Table 2.

Table 3: Main Effect of Tillage and Mulch Type on Leaf Area, Number of Leaves, and Vine Length at Certain Growth Stages of the Cucumber Variety Used for the Study

	Leaf area cm^2			Number of leaves			Vine length (cm)		
Treatment	2	4	6	2	4	6	2	4	6
Tillage									
Conventional	36.8	146.8	165.5	3.6	6.2	11.8	3.7	32.1	75.5
Minimal	45.1	168.5	200.4	4.2	9.4	15.1	3.7	32.9	98.7
FLSD (*p = 0.05*)	20.7	77.2	84.5	1.1	3.11	4.7	1.2	16.2	38.9
Mulch Type									
Control	40.6	188.4	215.5	3.6	6.9	7.2	4.2	28.2	64.4
Transparent	43.8	161.7	182.2	3.9	9.4	12.2	3.8	36.7	80.3
Black	44.4	198.4	218.5	4.2	7.9	13.3	3.6	37.4	84.0
Grass	35.1	141.4	175.4	3.7	7.6	10.6	3.2	27.7	69.6
FLSD (*p = 0.05*)	29.2	109.1	119.5	1.6	4.4	6.6	1.74	22.9	55.0

The main effect of tillage and surface mulching on the leaf area, number of nodes and vine length at the selected growth stages of the cucumber variety used for the study are presented (Table 3). The results show that the main effects of tillage were consistently non-significant ($p > 0.05$). At 6 WAP, the minimal tillage had a higher LAI (200.4) than conventional tillage (165.5), as shown in Table 3. The result also shows that black mulch has a higher LAI (218.5) than the other mulch types throughout the experiment. The cucumber plants showed no significant difference ($p > 0.05$) between the conventional tillage and the minimal tillage. However, minimal tillage produced a higher vine length (98.7cm) than conventional tillage (95.5cm). The results also show that, among the mulch types, plastic mulch had the greatest number of leaves per plant.

Table 4: Main Effect of Tillage and Mulch Type on Number of Branches, Number of Nodes, and Number of Internodes

	Number of branches			Number of nodes			Number of internodes.		
Treatment	2	4	6	2	4	6	2	4	6
Tillage									
Conventional	2.0	2.1	2.5	1.3	6.9	12.2	0.9	6.7	11.4
Minimal	2.0	2.2	2.8	1.3	7.8	15.1	0.9	7.5	14.1

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Treatment	Number of branches			Number of nodes			Number of internodes.		
	2	4	6	2	4	6	2	4	6
Tillage									
FLSD (*p = 0.05*)	1.4	0.8	0.9	0.5	2.9	4.9	0.1	2.6	4.7
Mulch Type									
Control	1.5	1.6	2.6	1.2	6.5	12.9	0.8	6.6	11.9
Transparent	2.2	2.2	2.7	1.5	7.5	12.9	0.9	7.5	12.2
Black	2.1	2.2	2.8	1.3	9.1	17.5	0.9	8.1	16.5
Grass	2.0	2.1	2.7	1.3	6.3	11.1	0.9	6.2	10.3
FLSD (*p = 0.05*)	1.9	1.8	1.9	0.6	4.2	6.9	0.2	3.7	6.7

The results presented in Table 4 showed that the main effects of tillage and mulch type were on the number of branches, nodes, and internodes. The results showed that both tillage systems had 2 branches at 2WAP, while the mean value of 2.8 and 2.2 was recorded for minimal tillage and conventional tillage at 6WAP, respectively. The same trend was also observed for the number of nodes and internodes. The result also indicated that black plastic mulch had the highest number of branches at 6WAP, with a similar trend observed for the number of nodes (12.9) and internodes (12.2).

Table 5: Main Effect of Tillage and Mulching on Fruit Weight (g), Fruit Length (cm), and Fruit Circumference of Cucumber.

Tillage	Fruit weight(g)	Fruit length(cm)	Fruit circumference(cm)
Conventional	321.7	21.9	16.2
Minimal	300.9	22.6	15.5
FLSD (*P = 0.05*)	123.0	19.5	11.5
Mulch Type			
Control	334.1	24.2	15.4
Transparent	369.9	28.3	16.1
Black	386.6	29.9	16.0
Grass	354.7	26.6	15.9
FLSD (*P = 0.05*)	154.0	19.8	14.4

The results shown in Table 5 represent the main effects of tillage and mulching on cucumber fruit weight, length, and circumference. The result shows that there was no significant ($p < 0.05$) difference in the main effect of tillage on the cucumber plants; however, conventional tillage gave the higher mean value for some of the yield parameters over the minimal tillage. Minimal tillage, however, produced a higher fruit length than conventional tillage. The mulch

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effect on the yield parameters (fruit length, weight and circumference) recorded no significant ($p < 0.05$) effect. However, the black mulch recorded the highest across the yield parameters.

Discussion

The LAI in conventional tillage did not significantly differ from that in minimal tillage or in the plastic mulched plots during the period under review. According to Gaddam et al. (2017), LAI in plastic film-mulched plots was higher than in unmulched plots, indicating that plastic film mulches influence the microclimate around the rhizosphere, providing optimal conditions for plant growth. These results imply that the effect each treatment had on vine length definitely affected the plant's overall growth. The result is consistent with those of Iqbal et al. (2020), who found that the no-mulch plot had the lowest LAI throughout the period of their tomato experiment. Since LAI is an indicator of crop growth, the least suitable edaphic conditions for crop growth were found in the no-mulch, conventionally tilled plots. Minimal tillage resulted in longer vine length than conventional tillage. This result differs from that of Singh et al. (2021), who reported that the maximum plant height was observed in wheat grown with minimal tillage.

The black mulch used produced the highest vine length at 4 and 6WAP, the result is in line with the results obtained by Iqbal et al. (2020), who reported that plastic film mulch reduces leaching of nutrients, reduces weed problems (especially black film mulch), reduces evaporation of soil water and reduces soil compaction. Plastic-film mulch also helps maintain optimum soil moisture, aids seed establishments and promotes excellent crop growth throughout the season. All these are positive productivity indicators. A greater number of leaves per plant was recorded in plots with plastic mulch. This could be due to the retention of nutrients and water that would otherwise have been lost through evapotranspiration from the plant and soil surfaces, and to almost complete weed control in the plots with plastic mulch.

This agrees with the report of Kanthaswamy et al., (2020) who evaluated the effect of white, silver and black plastic mulch and bare soil (as control) on the growth and yield of chilli pepper (*Capsium annuum* L) and reported that the number of leaves, plants heights, stem base diameter, number of primary branches and yield were better in the plants grown on plastic mulch. Conventional tillage yielded more than minimal tillage; this is consistent with the study by Etok et al. (2025), who found that conventional tillage is more suitable for planting cucumber in the rainforest zone.

The higher percentage yield advantage shown by plastic film mulch plots over the control may be due to differences in the colour of the plastic mulch used. Black-coloured plastic film mulch absorbs more radiant energy from the sun, reduces weed competition, and improves the overall edaphic conditions for plants, resulting in better yields. This is in line with the findings of Adewoyin et al. (2022), who reported that staked cucumber plants mulched with black polythene mulches had the highest yield of cucumber fruit compared to other mulch materials.

Conclusion

The results presented in this study have shown that plastic mulch and tillage technique significantly affect the growth, characteristics and yield indices of cucumber. The colour of the plastic mulch used could influence leaf area (LAI), vine length, and yield. Black plastic mulch treatment had the highest fruit yield of 386.6g ≈ 1.72 tons/ha, whereas no mulch had a fruit yield of 334.1g ≈ 1.48 tons/ha. This means that plastic film mulch treatments provided a better

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edaphic environment for the crop than other treatments used in the study. Plastic film mulch and tillage techniques can be used to manipulate the soil environment for profitable cucumber production in tropical climates.

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