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Effects of Mulching and Staking on Cucumber Growth, Yield and Weed Suppression under Tropical Conditions in Southeast Nigeria

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ABSTRACT

Cucumber is a nutritious vegetable with high economic and medicinal value, but its growth and yield are constrained by biotic and abiotic factors. This study assessed the effects of mulching and staking on cucumber growth, weed suppression, and yield under tropical conditions in the derived savanna zone of southeast, Nigeria. Treatments included black polyethylene mulch, dry grass mulch, and no mulch, combined with table staking, trellising, and no staking in a randomized complete block design. Results showed black polyethylene mulch consistently enhanced growth, yield, and weed suppression. Integrating polyethylene mulch with staking is recommended for sustainable cucumber production.

1 Introduction

Cucumber (Cucumis sativus L.), a member of the gourd family Cucurbitaceae, is one of the oldest vegetable crops known to man and is believed to have originated in India (Haifa Group, 2024). Today, it is widely cultivated across tropical and subtropical regions of the world. Botanically, cucumber is a coarse, prostrate vine that climbs with the aid of spiraling tendrils. The plant bears large, triangular leaves and yellow unisexual flowers, with female flowers distinguished by the swollen ovary that develops into the edible fruit. The fruit is classified as a pepo (false berry), typically elongated and cylindrical, though size, shape, and surface texture vary with cultivar. Immature fruits are green due to chlorophyll, while mature fruits turn yellowish-white. Seeded cultivars produce well-developed seeds, whereas English cucumbers are generally seedless or contain rudimentary seeds (Haifa group, 2024).

Cucumber fruits are known for their high-water content, making them refreshing and hydrating. The plant has a strong taproot that may reach 1-m deep, but most of the root system is shallow and spreads laterally within the topsoil. Adventitious roots often develop under favorable conditions, enhancing nutrient uptake.
Economically, cucumbers are marketed fresh (whole or sliced) and as pickles (Western Institute for Food Safety and Security, 2016). They are nutrient-dense, providing vitamins, minerals, fiber, and antioxidants (Okafor and Yaduma, 2021). In Nigeria, cucumbers are consumed fresh, as desserts, juices, or in combination with other foods. Their high-water content gives them diuretic and cleansing properties, while their fiber-rich skin and mineral composition (potassium, magnesium) help regulate blood pressure, support nutrient metabolism, and promote smooth circulation (Haifa Group, 2024). Cucumbers also aid in eliminating uric acid, benefiting individuals with arthritis, and their magnesium content helps relax nerves and muscles.
They also have high economic value and, as such are an important source of income for farmers and youths. It has been reported that cucumber production has the capacity to enhance agricultural production and economic empowerment (Adeoye and Balogun, 2016). The vegetable is ranked among major horticultural crops cultivated in Nigeria due to its economic value (Okafor and Yaduma, 2021).
However, production is constrained by poor soil fertility, weed infestation, and inadequate crop management practices (Umeh and Orjiako, 2018). Mulching and staking are cultural practices that can improve growth, yield, and fruit quality. This study evaluated the effects of black polyethylene mulch, dry grass mulch, and staking methods and their combined effects on cucumber performance under tropical conditions in Nsukka, southeast Nigeria.

2 Materials and Methods

Field study was conducted in the Department of Crop Science Research Farm, University of Nigeria, Nsukka between April and August, 2008. Nsukka is located in a derived savanna area at latitude 060 52'N; longitude 070 24'N and at 442 above sea level. A soil sample from various random locations on the site were collected using soil auger to a depth of 0 to 15 cm and bulked together in a composite sample. A sub-sample of the composite soil was taken for physical and chemical analysis for general characterization of the site. The pH of the soil was determined in water and KCl solution.

2.1 Experimental Design and Treatments

A piece of land 22.5 x 7.5 m was selected for the study. The land was manually prepared and made into beds. Each bed represents a plot of 2 m x 2 m in size. Each pathway measured 0.5 m between blocks. There were nine plots in each block, giving a total of twenty-seven plots.
The experiment was laid out in a randomized complete block design (RCBD) with three replications. Seeds of cucumber variety Ashley were sown at stake at the rate of two seeds per hole and at a spacing of 0.5 m by 0.5 m. The seedlings were later thinned to one plant per stand at 14 days after planting to a plant population of 40,000 stands/ha. The experiment was conducted on a 22.5 × 7.5 m field laid out as a 3 × 3 factorial experiment in a Randomized Complete Block Design (RCBD) with three replications. The two factors were mulching and staking, each at three levels. Mulching treatments consisted of no mulch, black polyethylene mulch, and dry grass mulch (Panicum maximum), while staking treatments comprised no staking, table staking, and trellising. The nine treatment combinations were randomly assigned to plots within each of the three blocks, resulting in 27 experimental plots. Each plot measured 2 × 2 m and served as the experimental unit. Blocking was used to account for possible spatial variability across the experimental field. Seeds of the cucumber variety, Ashley were sown at a spacing of 0.5 × 0.5 m, with two seeds planted per hole and subsequently thinned to one plant per

stand, giving a plant population of approximately 40,000 plants/ha. Swine manure was uniformly applied to all plots at the rate of 12.5 t / ha.
For the mulching treatments, black polyethylene sheets measuring 2.5 × 2.5 m were placed over the plots and secured with pebbles. The sheets were perforated at the planting points to facilitate seedling emergence and water infiltration. Dry grass (Panicum maximum) mulch was applied at 15 kg/plot, while the no-mulch treatment was left uncovered.
For the staking treatments, table staking was achieved using 3 m bamboo sticks crossed at the plot corners to support the cucumber vines. Trellising was established using ropes tied to a central stake to provide vertical support for the vines, whereas plants assigned to the no-staking treatment were allowed to grow without artificial support.
Thus, the experiment consisted of nine treatment combinations: no mulch × no staking, no mulch × table staking, no mulch × trellising, black polyethylene mulch × no staking, black polyethylene mulch × table staking, black polyethylene mulch × trellising, dry grass mulch × no staking, dry grass mulch × table staking, and dry grass mulch × trellising. The treatments were evaluated as a factorial RCBD to determine the main effects of mulching and staking and their interaction on cucumber growth, weed suppression, and yield.

2.2 Data Collection

The growth parameters measured were plant height (cm), from the soil surface to the apical bud of the plant, number of leaves per plant, dry weight of plant leaves, dry weight of plant stem, and dry weight of roots. Representative plants were destructively harvested from the middle rows, separated into fractions, and oven-dried to get the constant weight for dry matter determination of the stem, roots, and leaves per plant. The root was recovered by driving a tin of known circumference and depth into the soil, recovering it and then washing off the soil from the roots with running water. The circumference of the tin used in harvesting the roots from the soil was determined with the formula $C = 2\pi r$
Weed biomass was assessed using a 0.5 × 0.5 m quadrat (0.25 m^2). The quadrat was randomly placed at two different locations within each plot, and all weeds within each quadrat were collected. Weed species were not individually identified; therefore, measurements represented the total weed biomass present within the sampled area. The collected weed materials were oven-dried to constant weight and weighed to determine dry matter. The dry weights from the two quadrats were used to obtain the mean weed dry matter for each plot and were expressed on a unit-area basis (g / m^2). The same locations were not deliberately sampled repeatedly.
Harvesting of cucumber fruits was done at five times at four days intervals from the first day of harvest. The following measurements were recorded: weight of fruit per plant, number of fruits per plant, and number of flowers per plant.

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using SAS statistical software (SAS Institute Inc., 2021). The experiment was analyzed as a 3 × 3 factorial experiment in an RCBD, with replication, mulching, staking, and mulching × staking interaction included in the model. The significance of the main effects of mulching and staking and their interaction was assessed using the F-test at the 5% probability level. Treatment means were separated using Fisher's Least Significant Difference (LSD) test at $P \leq 0.05$.

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3 Results

Table 1. Effects of staking and mulching on vine length (cm) and leaf number of cucumber/plots

		Length of vine (cm)/plot					**Leaf number/plot**		
Mulching	**No staking**	**Table staking**	**Trellis**	**Means**		**No staking**	**Table staking**	**Trellis**	**Means**
At 15 DAP									
No mulch	11.4	13.2	12.3	12.4		11.4	12	11.3	11.6
Black polyethylene mulch	14.9	14.9	16	15.3		14.0	14.3	13.9	14.1
Dry grass mulch	10.3	12.1	10.3	10.9		10.3	13	11.7	11.7
Means	12.2	13.4	12.9	12.8		11.9	13.1	12.3	12.4
At 45 DAP									
No mulch	79.9	80.8	75.2	78.6		27.7	30.2	31	29.7
Black polyethylene mulch	89.4	97.7	103	96.7		36.8	40.1	39.5	38.8
Dry grass mulch	65.3	76.2	77.3	72.9		27.9	31	31.6	30.2
Means	76.5	84.9	85.1	82.2		30.8	33.8	34	32.9

Vine length
LSD 0.05 for 3 mulching means 15 DAP 45 DAP
LSD 0.05 for 3 mulching means 2.37 8.18
LSD 0.05 for 3 staking means ns ns
LSD 0.05 for 3 mulching by staking means 4.10 14.7

Leaf number
LSD 0.05 for 3 mulching means 15 DAP 45 DAP
LSD 0.05 for 3 mulching means 1.01 3.70
LSD 0.05 for 3 staking means 1.01 ns
LSD 0.05 for 3 mulching by staking means 1.76 6.4

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Table 2. Effects of staking and mulching on leaf, stem and root dry matters (g / plant) of cucumber

	Leaf dry matter (g/plant)				Stem dry matter (g/plant)				Root dry matter (g/plant)			
Mulching	No staking	Table staking	Trellis	Means	No staking	Table staking	Trellis	Means	No staking	Table staking	Trellis	Means
No mulch	4.23	6.45	5.5	5.39	1	1.61	0.83	1.15	0.4	0.45	0.37	0.41
Black polyethylene mulch	7.27	5.62	8.68	7.19	2.56	1.92	2.93	2.47	0.53	0.55	0.62	0.57
Dry grass mulch	3.28	2.88	5.17	3.78	0.8	1.16	1.6	1.19	0.27	0.32	0.5	0.36
Means	4.93	4.99	6.45	5.46	1.45	1.56	1.79	1.6	0.4	0.44	0.5	0.45

LSD 0.05 for 3 mulching means	Leaf dry matter	Stem dry matter	Root dry matter
LSD 0.05 for 3 mulching means	2.33	0.70	0.12
LSD 0.05 for 3 staking means	ns	ns	ns
LSD 0.05 for 3 mulching by staking means	3.87	1.22	0.21

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Table 3. Effects of staking and mulching on number of flowers/plants

Mulching	No staking	Table staking	Trellis	Means
No mulch	16.7	37.7	29.7	28.0
Black polyethylene mulch	36.7	38.7	48.3	41.2
Dry grass mulch	20.7	22.3	27.0	23.3
Means	24.7	32.9	35.0	30.7

LSD 0.05 for 3 mulching means	Flower	First harvest	Second harvest
LSD 0.05 for 3 mulching means	9.4	0.40	0.9
LSD 0.05 for 3 staking means	9.4	0.4	ns
LSD 0.05 for 3 mulching by staking means	1.3	0. 6	ns

Black polyethylene mulch consistently enhanced vine length and leaf number compared with dry grass mulch and no mulch (Table 1). At 15 days after planting (DAP), vines under polyethylene mulch reached 15.3 cm with 14.1 leaves, significantly higher than dry grass mulch (10.9 cm, 11.7 leaves). At 45 DAP, polyethylene mulch-maintained superiority (96.7 cm, 38.8 leaves). Staking showed minor improvements, with table staking slightly increasing leaf number. The combination of polyethylene mulch and trellising produced the longest vines, while polyethylene mulch with no staking gave the highest leaf number.

Polyethylene mulch significantly increased leaf, stem, and root dry matter compared with dry grass mulch and no mulch (Table 2). Interaction effects showed that polyethylene mulch combined with trellising enhanced stem dry matter, while polyethylene mulch with no staking maximized leaf and root dry matter. Flower production was also highest under polyethylene mulch, particularly when combined with trellising (Table 3).

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Table 4. Effects of staking and mulching on number of fruits of cucumber / plant

Mulching	First harvest				Second harvest				Third harvest			
	No staking	Table staking	Trellis	Means	No staking	Table staking	Trellis	Means	No staking	Table staking	Trellis	Means
No mulch	1.68	2.15	1.49	1.7	1.86	1,72	1.29	1.62	1.91	1.25	2.24	1.8
Black polyethylene mulch	1.84	2.6	2	2	2.41	2.28	2.72	2.47	1.77	2.45	2.57	2.26
Dry grass mulch	1.58	1.46	1.43	1.63	2.17	1	1.39	1.19	1.27	0.88	1.62	1.25
Means	1.7	1.98	1.63	1.77	1.81	1.67	1.8	1.76	0.53	1.53	2.14	1.77

	First harvest	Second harvest	Third harvest
LSD 0.05 for 3 mulching means	0.40	0.9	0.97
LSD 0.05 for 3 staking means	0.40	ns	0.95
LSD 0.05 for 3 mulching by staking means	0. 68	ns	ns

Table 5. Effects of staking and mulching on the number of fruits of cucumber/plant

	Fourth harvest				Fifth harvest			
Mulching	No staking	Table staking	Trellis	Means	No Staking	Table Staking	Trellis	Means
No mulch	2.55	2.57	1.79	2.3	0.71	0.71	0.88	0.76
Black polyethylene mulch	3.58	3.28	2.87	3.24	1.32	1.29	1.25	1.29
Dry grass mulch	1.94	1.17	1.72	1.61	1.17	0.88	1.05	1.03
Means	1.6	2.34	2.13	2.38	0.35	0.96	1.06	1.03

	Fourth harvest	Fifth harvest
LSD 0.05 for 3 mulching means	0.59	ns
LSD 0.05 for 3 staking means	0.59	ns
LSD 0.05 for 3 mulching by staking means	1.01	ns

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Table 6. Effects of staking and mulching on early-yield (t / ha) (first and second harvests) and mid-yield (t /ha) (third harvests) of cucumber

	First harvest				Second harvest				Third harvest			
Mulching	No staking	Table staking	Trellis	Means	No staking	Table staking	Trellis	Means	No staking	Table staking	Trellis	Means
No mulch	0.0598	0.0558	0.0279	0.0478	0.0527	0.0197	0.0735	0.0486	0.0893	0.0915	0.0730	0.0846
Black polyethylene mulch	0.0833	0.0711	0.0803	0.0782	0.0707	0.0887	0.0677	0.0757	0.1230	0.0787	0.1110	0.1042
Dry grass mulch	0.0427	0.0288	0.0518	0.0411	0.0737	0.0817	0.0727	0.0760	0.0712	0.0728	0.0847	0.0762
Means	0.0619	0.0519	0.0533	0.0557	0.0657	0.0633	0.0713	0.0668	0.0945	0.0810		

	First harvest	Second harvest	Third harvest
LSD 0.05 for 3 mulching means:	ns	ns	0.0329
LSD 0.05 for 3 staking means:	ns	ns	ns
LSD 0.05 for 3 mulching × staking means:	ns	ns	0.0570

Table 7. Effects of staking and mulching on late yield (t /ha) (fourth and fifth harvests) and total yield (t /ha) (first to fifth harvests) of cucumber

	Fourth harvest				Fifth harvest				Total harvest			
Mulching	No staking	Table staking	Trellis	Means	No staking	Table staking	Trellis	Means	No staking	Table staking	Trellis	Means
No mulch	0.0714	0.0633	0.0492	0.0629	0.0007	0.0185	0.0483	0.0225	0.2739	0.2488	0.2719	0.2649
Black polyethylene mulch	0.0883	0.0887	0.0747	0.0839	0.0311	0.0023	0.0096	0.0128	0.3964	0.3295	0.3433	0.3564
Dry grass mulch	0.0883	0.0479	0.0635	0.0666	0.0338	0.0187	0.0253	0.0259	0.3097	0.2499	0.298	0.2859
Means	0.0826 (	0.0683	0.0625	0.0711	0.0219	0.0132	0.0277	0.0209	0.3267	0.2761	0.3044	0.3024

	Fourth harvest	Fifth harvest	Total yield
LSD 0.05 for 3 mulching means	ns	ns	0.074
LSD 0.05 for 3 staking means	ns	ns	ns
LSD 0.05 for 3 mulching by staking means	ns	ns	ns

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Table 8. Effects of staking and mulching on weed dry matter (g / 0.25 m2 quadrat)

Mulching	No staking	Table staking	Trellis	Means
15 DAP				
No mulch	1.15	1.17	1.29	1.2
Black polyethylene mulch	0.71	0.71	0.71	0.71
Dry grass mulch	0.98	0.76	0.81	0.85
Means	0.94	0.88	0.94	0.92
30 DAP				
No mulch	1.14	1.3	1.33	1.25
Black polyethylene mulch	0.73	0.71	0.71	0.72
Dry grass mulch	1.02	0.81	0.93	0.92
Means	0.96	0.94	0.99	0.96
45 DAP				
No mulch	2.85	2.15	3.05	2.68
Black polyethylene mulch	0.71	0.73	0.71	0.72
Dry grass mulch	1.85	1.16	1.6	1.54
Means	1.8	1.36	1.79	1.64

	15 DAP	30 DAP	45 DAP
LSD 0.05 for 3 mulching means	0.24	0.26	0.53
LSD 0.05 for 3 staking means	ns	ns	ns
LSD 0.05 for 3 mulching by staking means	0.42	0.45	0.92

Polyethylene mulch produced significantly higher fruit numbers at most harvests compared with dry grass mulch and no mulch (Table 4). At the first harvest, table staking improved fruit number, and its combination with polyethylene mulch gave the highest yield. At later harvests, polyethylene mulch-maintained superiority, though staking effects were less pronounced. Yield advantages were most evident at the third harvest (mid-yield stage), where polyethylene mulch significantly outperformed other treatments (Table 6 and 7). Total yield across all harvests was highest under polyethylene mulch, confirming its role in sustaining productivity. Unmulched plots had significantly higher weed dry matter than mulched plots (Table 8.), while black polyethylene mulch showed the lowest weed dry matter. Dry grass mulch performed poorly, partly due to gradual decomposition that allowed weed growth during flowering. Staking alone did not influence weed suppression. The combination of polyethylene mulch with staking enhanced cucumber performance more than dry grass mulch with staking. Polyethylene mulch conserved soil moisture, suppressed weeds, and improved nutrient uptake, while staking provided physical support to the cucumber vines. Together, these practices promoted better vegetative growth and higher yields.

4 Discussion

The results showed that black polyethylene mulch consistently improved cucumber growth, yield, and weed suppression compared with dry grass mulch and no mulch. Polyethylene mulch produced greater vine length, leaf number, dry matter, flower number, fruit number, and fruit yield. It also produced higher fruit yield during the early and mid-harvest periods, although the difference became less pronounced at the late harvest stage as yield declined. Its better performance may be partly related to lower weed competition, as shown by the lower weed dry matter recorded under polyethylene mulch. Similar benefits of mulching on vegetable growth and yield have been reported (Aniekwe, 2015; Mahadeen, 2014). The weed suppression by black polyethylene mulch may be due mainly to reduced light reaching the soil surface, which limits weed emergence and growth. Kasirajan and Ngouajio (2012) also reported that plastic mulches can improve crop performance through weed suppression and modification of the soil environment. Dry grass mulch generally performed less effectively than black polyethylene mulch and was sometimes comparable to or lower than no mulch in cucumber growth and yield. Its relatively poor performance may be associated with gradual decomposition, which could have reduced its effectiveness as a physical barrier against weeds. As the mulch decomposed, more of the soil surface may have become exposed, allowing greater weed emergence later in the season. In contrast, polyethylene mulch provided a more persistent soil cover, which may explain its better weed suppression and associated advantage in crop growth and yield.

Staking produced some improvements in growth, particularly leaf number, but its effects on yield and weed suppression were not significant. Thus, the present results do not provide sufficient evidence that staking alone increased cucumber yield or suppressed weeds. Previous studies have reported positive effects of staking on vegetable yield (Pradhan et al., 2021). Differences from the present findings may be due to differences in crop species, staking methods, environmental conditions, and crop-management practices.

The interaction between mulching and staking showed that combinations involving black polyethylene mulch generally performed better than those involving dry grass mulch, particularly for growth and yield. This suggests that the benefits of effective weed suppression by polyethylene mulch were maintained when staking was used. Although staking may have influenced canopy arrangement and plant support.

5 Conclusion

Black polyethylene mulch was the most effective treatment for improving cucumber growth, yield, and weed suppression under the conditions of this study. It consistently outperformed dry grass mulch and no mulch, particularly during the early and mid-harvest periods. Staking had comparatively limited effects on yield and weed suppression, although its combination with polyethylene mulch generally produced better crop performance than combinations involving dry grass mulch. Therefore, black polyethylene mulch, alone or combined with staking, can be recommended for improved cucumber production and weed management under tropical conditions.

Table 9. Mechanical and chemical properties of soil at study site

Mechanical composition of the soil	%
Clay	22
Silt	19
Fine sand	18
Textural class	Sandy clay
Chemical Properties of the soil	
pH (H_2O)	5.3
pH (KCl)	3.9
Organic C (%)	0.86
Organic matter (%)	1.49
Total N (%)	0.07
Exchangeable bases (cmol(+) kg^{-1})	
Na	0.2
K (cmol(+) kg^{-1})	0.07
Ca	1.4
Mg	0.6
CEC (cmol(+) kg^{-1})	8.4
Available P	17.91 mg kg^{-1}

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Table 10. Meteorological data for Nsukka, April – August 2008

Month	Rainfall (mm)	Rain days	Max Temp	Min Temp	RH at 0900%	RH at 1500 (%)
April	143.3	11	31.73	22.00	74.83	66.20
May	254.01	12	31.16	20.81	75.00	70.30
June	186.43	15	29.83	21.40	76.93	72.70
July	246.0	14	28.94	20.84	78.16	74.60
August	203.0	19	27.81	20.68	79.55	75.00

Source: Meteorological records, University of Nigeria, Nsukka (2008).

Table 11. Analysis of variance table for the 3 × 3 factorial RCBD
With three replications, the degrees of freedom

Source of variation	Df
Replication/Block	2
Mulching (M)	2
Staking (S)	2
M × S	4
Error	16
Total	26

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