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INFLUENCE OF STAKING AND PLANT POPULATION DENSITIES ON THE YIELD OF CUCUMBER (*Cucumis sativus* L.).

Eniokhien Kevin EIFEDYI • Samson REMISON • Victor OKAKA
Department of Crop Science, Ambrose Alli University, Ekpoma, Nigeria

ABSTRACT

Field experiment was conducted during the wet season of 2008 at the Teaching and Research Farm of the Ambrose Alli University, Ekpoma (Lat. 6° 45' North and Long. 6° 08' East and an altitude of 450 metres above sea level), to determine the effects of staking and planting density on the performance of cucumber. The experiment comprised four plant populations 14815 (75 x 90 cm), 17778 (75 x 75 cm), 22,222 (75 x 60 cm) and 29,530 (75 x 45 cm) plants per hectare and two staking treatments (staking and no staking) using a 2 x 4 factorial scheme replicated three times. Data were collected on vegetative traits, yield and yield components of cucumber and analyzed using analysis of variance. Results revealed that staking increased the growth and yield components of cucumber such as vine length, number of branches, leaf area per plant, number of leaves per plant, fruit length and fruit girth, fruit weight per plant and total yield per hectare. Increase in population density from 14,815 plants/ha, generally resulted in decrease of growth and yield components. The fruits of the staked plants had a uniform deep green coloration compared to unstaked plants which had different colours.

Key words: Cucumber, plant population density, staking and yield, Ekpoma, Nigeria

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INTRODUCTION

Cucumber (*Cucumis sativus* L., 2n = 24) is an economic vegetable crop and one of the most popular members of the cucurbitaceae family (Lower and Edwards, 1986). The four major food crops of the cucurbitaceae are watermelon (*Citrullus lanatus* (Thunb.) Matsum and Nakai), cucumber (*Cucumis sativus* L.), melon (*Cucumis melo* L.) and squash (*Cucurbita* spp.). Other important cucurbit crops include Lofia (*Luffa acutangula* (L.) Roell), bottle gourd (*Lagenaria scariola* (Molina) Standl.), chayote (*Sechium edule* (Jacq.) Swartz), wax gourd (*Bemisia ficulnea* (Thunb.) Cogn.) and bitter melon (*Momordica charantia* L.) (Robinson and Decker-Walters, 1997). The genus *Cucumis* contains 52 species, of which *C. sativus* and *C. melo* are the two most economically important (Ghebretinsae et al., 2007).

It is the oldest vegetable crop cultivated for its fruits (Swiader et al., 1992). Cucumber is the fourth most important vegetable crop after tomato, cabbage and onion in Asia (Tasdoglu, 1993), the second most important vegetable crop after tomato in Western Europe (Phu, 1997). In tropical Africa, the place of the crop has not been ranked because of its limited use.

Many methods have been used to increase cucumber yield. One of them is to increase planting density (Silva et al., 1996) and another is the use of trellises or stakes (Shetty and Viener, 1998). Increase in planting density usually results in the reduction of the size of the plant frame, topping of the vines between rows and low light intensity (Nu, 1999) which then results in shorter fruits (Lower and Edwards, 1986). Several studies have shown the effects of plant densities on the yield of cucumber (Widder and Price, 1969; van Wynn, 1993).

Cucumber on stakes or trellises produce higher yields, improved fruit quality, better control of diseases and pests, less damage to vines during harvesting and easier harvesting of the fruits (Sanders and Davis, 1990). Korber and Shroder (1973) reported that the use of stakes or trellis increased fruit yield and quality, provided better control of foliar and fruit diseases. Hanna et al. (1987) also reported that the use of stakes or trellis increased fruit yield, number of marketable flowers, leaf size and photosynthesis while reducing the incidence of belly rot (*Rhizoctonia solani* Kühn).

This work was carried out to determine the effect of staking and plant population density on the performance of cucumber.

METHODS

This experiment was conducted at the Teaching and Research farm of the Ambrose Alli University, Ekpoma on Lat. 6° 45' N and Long. 6° 08' E in a forest, savanna transition zone of Nigeria. The area is characterised by a bimodal rainfall pattern with a long rainy season which starts in late March and ends in late July while the short rainy period extends from September to late October after a dry spell in August. The soil order is a ultisol and the site is classified locally as kulo series (Moss, 1957). The site was left fallow for three years after it was cropped to maize, yam and cassava for two years prior to the establishment of the experiment. A composite soil sample was collected from 0-30 cm depth prior to planting to determine the pH and the nutrient status of the soil. Soil pH was analyzed in 1:2 soil: water ratio, total N content was determined by Kjeldahl method (Bremner, 1965), available phosphorus and organic C

in the soil was determined by the modified method of Wakley and Black as described by Nelson and Sommers (1982).

Four plant population densities and two staking treatments were used and the experiment was laid out in a 2 x 4 factorial scheme replicated three times. There were eight treatments (24 plots) and each plot measured 3.0 x 4.5 m. The plots were separated from each other by 1 m alleys. The four populations were as follows: 14 815 (75 x 90 cm), 17 778 (75 x 75 cm), 22 222 (75 x 60 cm) and 29 530 (75 x 45 cm) plants per hectare. The experimental site was cleared of existing vegetation and packing of the debris was carried out before raised seed beds were prepared using hoes and marked into plots. Planting was done on 30 April 2008. Two seeds of cucumber variety Asprey were sown per hole which were later thinned down to one plant per stand three weeks after planting. 14 P:K 20:10:10 fertilizer was applied at the rate of 200 kg/ha at three weeks after planting basally by using the side band placement method. The plots receiving the staking treatments were staked at 3 weeks after planting just when their tendrils were being formed and the vines were tied to the stakes with twines.

The experimental site was weeded three times manually by using a hoe at 3, 5 and 7 weeks after planting. The cucumber crop was sprayed three times with lamdacyhalothrin as Karate (insecticide) and Benomyl (Dentane) fungicide at the rates of 2 litres and 1.5 kg/ha respectively at 4, 6 and 8 weeks after planting to protect them against insect pests and fungal diseases. Harvesting of the fruits commenced at six weeks after planting when the fruits had turned deep green in colour. Harvesting was done by hand picking the matured fruits twice weekly.

The parameters recorded were vine length (determined by measuring the mean vines from the base of the crop to the terminal points using a flexible tape), number of leaves (assessed by visual count of the green leaves), leaf area determined by the dry weight disc method as described by Rhoads and Bloodworth (1964). Five fruits from different plants within the net plots over several harvests were randomly taken and the distance between their bases to the distal end of the fruits measured. A pair of vernier caliper was used to measure the fruits at the middle where it was thickest. Total yield per hectare was obtained by extrapolating plot yields and expressed in kilogrammes per hectare (kg/ha). Data collected were analyzed using the analysis of variance (ANOVA) and means were compared by using the Least Significant Difference (LSD).

RESULTS AND DISCUSSION

The analysis of the soil used is presented in Table 1.

Table 1. Chemical properties of the soil at the experimental site

Properties	Value
pH (1:2.5 in H ₂ O)	6.18
Organic matter content	20.90 g/kg
Organic carbon	12.16 g/kg
Nitrogen	0.61 g/kg
Exchangeable Ca	8.80 mg/kg
Exchangeable Mg	0.06 mg/kg
Available P	15.55 cmol/kg
Exchangeable K	1.14 cmol/kg

The effects of staking and different plant population densities on the vine length at 4, 6 and 8 WAP are shown in Table 2. Staking and plant population density did not have significant effect on the mean vine length of cucumber at 4 and 6 WAP. At 8 WAP, staking significantly ($P < 0.05$) increased vine length and increase in plant population decreased the length but there was no significant staking and plant population interaction.

The effects of staking and different plant population densities on the mean number of branches at 4, 6 and 8 WAP are shown in Table 2. Staking and plant population density did not have significant effect on the mean number of branches of cucumber at 4 and 6 WAP. At 8 WAP there was significant effect of plant population density ($P < 0.05$). As the population increased, there was a significant decrease in the mean number of branches. The staked cucumber had higher number of bunches than the unstaked cucumber.

The effects of staking and plant population density on the number of leaves and leaf area are presented in Table 3. At 4 WAP, the mean number of leaves of cucumber ranged from 7.41 – 10.70. There were no significant effects of staking and plant population density on the crop. At 6 WAP, the number of leaves were significantly enhanced by staking ($P < 0.05$) and plant population density ($P < 0.05$), but staking x plant population density interaction was not significant. The staked cucumber had significantly higher number of leaves than the unstaked cucumber and as the plant population density increased, there was a significant reduction in the number of leaves. At 8 WAP, there were significant staking ($P < 0.01$) and plant population density ($P < 0.05$) effects on the number of leaves, but there was no staking x plant population density interaction. The staked cucumber had higher number of leaves than the unstaked cucumber. The response to population was not consistent.

Efediyi • Influence of plant population densities on the yield of cucumber.

The mean leaf area of cucumber at 4 WAP ranged from 921.64 to 1217.65 cm². As the plant population increased, there was a significant reduction in the mean leaf area per plant and the staked plants had higher leaf area. At 8 WAP the effects of plant population density on the leaf area was significant ($P < 0.05$) but the effects of staking and staking $\times$ plant population interaction were not significant. Generally as the plant population increased there was decrease in the leaf area. At 8 WAP the mean leaf area was significantly promoted by staking ($P < 0.05$) and plant population density ($P < 0.05$). The staked cucumber had higher leaf area per plant than the unstaked cucumber. There was a significant reduction in the mean leaf area per plant as the plant population increased. Staking $\times$ plant population density interaction was not significant.

The yield and yield component of cucumber are presented in Table 4. The mean fruit weight of cucumber recorded at each harvest ranged from 16.28 to 17.60 cm. The effects of plant population density on the fruit weight was significant ($P < 0.05$) but the effects of staking, staking $\times$ plant population interaction were not significant. There was a significant reduction in the fruit length as the plant population increased. The mean fruit girth of cucumber ranged from 4.51 to 5.04 cm. Staking ($P < 0.05$) and plant population density ($P < 0.05$) significantly affected the mean fruit girth but there was no staking and staking $\times$ plant population density interaction. As the plant population increased there was a significant decrease in the fruit girth. The effects of plant population density on the fruit number per plant was significant ($P < 0.05$) but staking had no significant effect. The number decreased with increase in density above 1775 plants/ha. Plant density and staking had significant effect ($P < 0.05$) on fruit weight. The staked cucumber plants had higher fruit weight and as the plant density increased there was decrease in the weight of fruits per plant. The fruit yield per hectare ranged from 31 719.75 to 41 160.61 kg/ha. Plant density and staking had significant effect on fruit yield. Generally, there was decrease in yield with increase in plant population density above 1775 plants/ha, the staked plants had higher yield.

The result of experiments on staking and plant population densities of 14815, 17 775, 22 222 and 26 667 plants/ha per hectare showed significant differences among their means. The staked cucumber at different plant population densities had a longer harvest window (12 times) compared to the unstaked or ground culture (10 times). The high yield of the staked cucumber could be due to an increase in the photosynthetic activity of the crop because of larger leaf sizes and the resultant leaf area which were exposed to sunlight and reduced incidence of mutual leaf shading as opposed to the unstaked treatments. Hanna and Adams (1967) reported an increase in the photosynthetic rate in cucumber that was vertically trained. The increase in yield could also be attributed to easier harvesting of the fruits, non tampling of the vines during harvesting which resulted in longer harvest window than the unstaked plants. Improved fruit quality experienced in the staked cucumber was associated with reduced contact with the soil and the fruits had a uniform green colour compared to those treatments on ground culture and this observation was in consonance with the findings of Russo et al. (1991).

The yields of cucumber in this study were lower than those of Hanna and Adams (1967) in Florida who reported an average marketable yield of 61 800 kg/ha for staked cucumbers and 49 500 kg/ha for those on ground culture. The results were slightly lower than what was reported by Hussain et al. (1987) in Oklahoma, United States of America, using ground culture and staking methods. They reported average yields of 39 520 kg/ha and 48 900 kg/ha for the staked and the unstaked cucumbers, respectively. The staked cucumber consistently had higher values in both the growth and yield components which resulted in higher yields observed in the staked cucumber. The mean leaf area was in consonance with Ramirez et al. (1988) who reported leaf area of 3734 to 5744 cm². Large leaf area has been associated with high solid contents in tomato fruits (Howett and Stevens, 1986). This high solid content led to high weight of the fruit which was experienced in this study.

The growth and yield components in the staked cucumber were superior to the unstaked cucumber and the higher the plant density the lower the values of the treatments and this was in conformity with the work of Hussain et al. (1987) who reported that vertically trained vines produced significantly higher growth and yield than those on ground culture.

The results of the study on plant population indicate that as the spacing increased, there was reduction in the vegetative growth in terms of vine length, number of leaves, leaf area and number of branches. This result agrees with the report of Balci and Husku (1991). Owerka and Kosteewicz (1989) who reported that cucumber plants at lower plant densities produced higher vines than at high plant density and that closer spacing increases competition for nutrients and other factors that influence fruit

Table 4. The effects of staking and plant population density on the yield and yield components of cucumber

Fruit length (cm)	Plant population density/ha				Mean
	14,815	17,778	22,222	29,530	
Staking	18.15	16.88	15.96	15.21	16.55
No Staking	17.05	66.66	15.90	15.34	18.24
Mean	17.60	16.77	15.93	15.28	
LSD (P<0.05)					
Staking means			0.461NS		
Plant population density means			0.661		
Staking x plant population density interaction			0.930NS		
Fruit girth (cm)					
Staking	5.04	4.95	4.77	4.65	4.85
No Staking	5.04	4.87	4.47	4.37	4.69
Mean	5.04	4.91	4.62	4.51	
LSD					
Staking means			0.121*		
Plant population density means			0.162**		
Staking x plant population density interaction			0.232NS		
Fruit no./plant					
Staking	10.38	9.23	8.49	5.02	7.78
No Staking	6.70	8.97	5.82	3.84	6.33
Mean	8.54	9.10	6.15	4.43	
LSD					
Staking means			1.543NS		
Plant population density means			2.181**		
Staking x plant population density interaction			3.082NS		
Fruit weight (kg)/plant					
Staking	2.85	2.72	1.66	0.99	2.06
No Staking	2.61	1.90	1.48	0.79	1.70
Mean	2.73	2.31	1.57	0.69	
LSD (P<0.05)					
Staking means			0.012*		
Plant population density means			0.132*		
Staking x plant population density interaction			0.191*		
Fruit yield/ha					
Staking	42222.22	48518.52	39456.79	35402.47	41400.00
No Staking	38753.09	33802.70	32901.23	28037.04	33373.51
Mean	40487.65	41160.61	36179.01	31719.75	
LSD (P<0.05)					
Staking means			2096.421*		
Plant population density means			2967.610*		
Staking x plant population density interaction			4196.842**		

*Significant at 5%

**Significant at 1%

N.S. Not Significant

maturation. At low plant density, plants had greater access to available soil nutrients and water than under higher plant densities. The best growth (higher values were recorded for vine length, number of leaves, leaf area etc) was at the lowest plant population density of 14,815 plants per hectare. This is in conformity with Liebig (1981) who reported that optimum plant density was 2 plants per metre square. Phu (1997) in his trial observed that spacing had significant effect on the yield of cucumber and found that the highest yield of 57 t/ha was obtained from a spacing of 80 x 45 cm. This yield was higher than the mean yield from this experiment.

From the study, it was observed that the number of fruits per plant and total biomass accumulation decreased with increasing plant population density resulting in reduced fruit production on a per plant basis. This is in agreement with the findings of Widders and Price (1989) who reported that an increase in plant density resulted in less biomass accumulation and reduced fruit production per plant. There is the need for wider spacing for the crop because it is a crop that needs space to trail as narrower spacing tends to increase high relative humidity in plant canopy, a situation that promotes fruit rot.

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