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The effect of inorganic fertilizer rate on the growth and yield of two cucumber (*Cucumis sativus* L.) varieties in the forest-savanna – transition agro-ecological zone of Nigeria

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Abstract

The increasing population in Nigeria has resulted in a high demand for food including cucumber (Cucumis sativus L.). Some of cucumber production constraints include limited high yielding varieties and appropriate fertilizer regimes. Therefore, two field trials were conducted to determine growth and yield of two cucumber varieties in 2019, at the research farm of Federal University of Agriculture Abeokuta (Latitude 7°15¹N and Longitude 3°25¹E). The experimental design was Randomized Complete Block Design (RCBD) in a split plot arrangement and replicated three times. The factors: varieties (CU 999 and Monalisa), and Fertilizer rates (0, 100, 200 and 300 kg ha^{-1} NPK) were allocated to the main plot and sub plot respectively. Data were collected on plant height, number of leaves per plant, days to 50% flowering, days to fruit set, fruit weight, number of fruits per plant and yield. Data collected were subjected to analysis of variance and means of significant treatments were separated using Least Significant Difference ($p<0.05$). Monalisa produced significantly ($p<0.05$) longer vines than CU 999 in the early season of 2019 while the vine lengths were similar in the late season. Significantly ($p<0.05$) higher yield was obtained in CU 999 with 300 kg ha^{-1} NPK 15-15-15. Fertilizer application significantly ($p<0.05$) reduced days to 50 % flowering and number of days to fruit set in both seasons. Plants fertilized with 300 kg ha^{-1} flowered and produced fruits earlier than plants in other plots. Variety CU 999 fertilized with 300 kg ha^{-1} NPK 15-15-15 yielded higher than other treatment combinations.

Keywords: Cucumber, Variety, Spacing, Growth, Yield.

Introduction

Cucumber (*Cucumis sativus* L.) is one of Nigeria's most important fruit vegetables. It is the world's fourth most produced vegetable and one of the healthiest foods available[1]. It belongs to the Cucurbitaceae family and is one of the most popular members. Cucumber is a good source of vitamin C, beta-carotene, and manganese, which are all antioxidant minerals.

It's a versatile ingredient that may be used in a wide range of cuisines[2,3]. Cucumber fruit is high in vitamins A, C, K, B6, potassium, dietary fiber, pantothenic acid, magnesium, and phosphorus, as well as dietary fiber and pantothenic acid[4]. Cucumber cultivation is growing increasingly popular in a large area of Nigeria, according to Nweke et al.[5], possibly due to its strong nutritional and medicinal benefits, as well as its use as a component ingredient in pharmaceuticals[6].

Cucumbers are grown in fertile soils; poor soils produce bitter, deformed fruits that are frequently rejected by consumers, lowering farmers' income. In the tropics, bush fallowing has proven to be an effective, balanced, and long-term agricultural approach for soil productivity and fertility restoration[7]. Chemical fertilizers have allowed man to increase soil productivity beyond what could be achieved by depending on the natural recycling process. Many studies on various crops have demonstrated that using inorganic fertilizers has considerable benefits[8]. Inorganic or organic sources might be used to provide nutrients[9,10]. Increased agricultural production is widely regarded as a means of achieving the necessary food security. Enhanced productivity refers to a set of actions taken to increase the amount of farm resources available and to make better use of those resources[11]. To get the most out of production techniques, productivity and efficiency of resource utilization in production must be maintained. Therefore this study was conducted to determine the inorganic fertilizer rate needed for the optimal growth and development of cucumber fruits in south western Nigeria.

Materials and methods

The experiment was conducted at the Teaching and Research Farm of the Directorate of University Farms (DUFARMS), Federal University of Agriculture, Abeokuta, in the forest-savanna – transition agro-ecological zone (latitude 7°15¹N and longitude 3°25¹E, altitude 144 m above the sea level).

The rainfall distribution pattern for Abeokuta is bimodal, having the first mode between June and July and the second mode in September. The annual rainfall ranges from 1145 to 1270mm. The experiment was conducted in two trials in 2019.

Soil samples collected from experimental sites were subjected to routine laboratory analysis before planting. The treatments were arranged as a split plot fitted into a Randomized Complete Block Design with three replications using sub plot size of 2m × 2m. The treatment consisted of two cucumber varieties (CU 999 and Monalisa) and fertilizer rates (0, 100, 200 and 300kg ha^{-1} NPK).

Primary vine length was measured with a meter rule from the soil surface to the tip of the stem of the five tagged plants in the middle row at 3, 4 and 5 WAS. Number of leaves on the sample plants were counted at 3, 4 and 5 WAS. The number of flowers was observed on 50% of cucumber stands in each plot and was recorded as days to 50% flowering. This same procedure was used for days to fruiting. Weight of fruit was done using a top scale to weigh the fruits harvested from each net plot. Number of fruits harvested from the sample plants was counted at each harvest.

Statistical Analysis: Data collected were subjected to Analysis of Variance (ANOVA). Means of significant treatment was separated using Least Significant Difference (LSD) at a 5% level of probability.

Results and Discussion

The experimental site's soil texture was sandy loam. The soil had a slightly acidic pH. In both of the 2019 trials, the pH was 6.8. The soil had a medium nitrogen concentration (between 0.16 percent and 0.19 percent). Low nitrogen content is less than 0.15 percent, medium nitrogen content is between 0.15 and 0.20 percent, and high nitrogen content is greater than 0.20 percent. The soil had a low organic matter concentration (Table-1).

Effect of variety and fertilizer on vine length and number of leaves: In the early season of 2019, there was a significant ($P \leq 0.05$) varietal variation in primary vine length of cucumber at 3, 4, and 5 WAS, whereas there was no difference in the late season (Table-2). Compared to CU 999, the Monalisa variety had longer vines in the early season. At 4 WAS only in the early season, and at 5 WAS in both seasons, fertilizer rates had a substantial impact on vine length (Table-2). Longer vines were found in plots with the highest fertilizer rate (300 kg/ha).

Significant difference was observed on number of leaves of the varieties at 3, 4 and 5 WAS in the early season of 2019 (Table-3). Monalisa variety produced plants with higher number of leaves compared to CU 999. Fertilizer rates significantly influenced number of leaves only in the early season at the 3rd and 5th week (Table-2). Plants in plots with the highest fertilizer rate (300kg/ha) had higher number of leaves.

In this study, there were substantial differences in cucumber vine length and number of leaves per plant. According to 12, discrepancies in growth rate indices are usually due to plant genetic make-up. This was in line with the findings of 13, who found that genetic variables improved plant height, leaf area, and pod output. For the two cucumber varieties in 2019, this experiment demonstrated a significant increase in some vegetative features such as vine length and number of leaves with an increase in fertilizer treatment rates. Cucumber plants grown on unfertilized plots had the shortest primary vine lengths and the smallest number of leaves, since they had to rely on the cultivated soil's native fertility.

Cucumber growth and yield components increased in response to fertilizer application, according to 14 and 15. N.P.K fertilizer was found to be particularly beneficial in boosting primary vine length in the CU 999 and Monalisa varieties. This is consistent with 16 and 17 findings. The experiment revealed that the higher the amount of nutrients applied, the longer the vines grew and more leaves per plant were generated. The strong growth of cucumber crops observed in both 2019 trials, as shown by vine length and number of leaves produced per plant, indicates that nutrients from mineral fertilizers aided crop establishment. This was in line with the findings of 18, who found that when fertilizer rates increased, plant vegetative growth increased.

The rate of photosynthesis, which was governed by nutrient availability, was the primary determinant of plant growth and development. The higher the NPK level, the more vegetative growth occurred, resulting in lengthy vines. Increased intracellular meristemic activity, which leads to increased internode elongation, may have produced the rise in cucumber growth generated by nitrogen fertilizer.

The beneficial effect of phosphorus on plant growth is mostly owing to its ability to improve energy creation, which leads to higher photosynthesis. These findings are similar to those of 19 and 20. The findings were also consistent with those of 21 and 22, who found that increasing nitrogen fertilizer treatment increased cucumber vine length.

Effect of variety and fertilizer on days to 50% flowering and days to fruit set: Variety had significant ($P \leq 0.05$) effect on days to 50% flowering and days to fruit set of cucumber during both trials of 2019 (Table-4). Variety CU 999 flowered and produced fruits earlier than Monalisa in both trials of 2019. Fertilizer significantly ($P \leq 0.05$) influenced days to 50% flowering and days to fruit set in both trials. Plants with NPK fertilizer applied at the rate of 300 kg/ha flowered and produced fruits earlier than plants in other plots (Table-4). Interaction between variety and fertilizer on days to 50 % flowering and days to fruit set was significant ($P \leq 0.05$) during both trials of 2019 (Table-4). Variety CU 999 with NPK fertilizer rate of 300 kg/ha flowered and produced fruits earlier.

From the experiment, decreased NPK levels slowed plant growth, resulting in a longer time for flowering. NPK levels were increased, which shortened the time it took for the crops to blossom. 23 came up with similar conclusions. The early flowering seen in days to 50% flowering could be related to improved nutrient translocation to the aerial regions of the plant and subsequent increase in the reproductive phase as a result of the application of a sufficient amount of NPK fertilizer. Similarly, phosphorus (P) is required for the development of reproductive organs and the commencement of flowering.

The days to fruit set were inversely linked to the increase in NPK level. Increased NPK levels shortened the time it took for fruit to set. In the control group, it took longer for the fruit to set. Plant growth was slowed due to a lack of important nutrients, which resulted in a longer time to fruit set. With a 300 kg/ha fertilizer treatment, fruit set was faster in crops. Phosphorus is a crucial element that is required for flowering to begin, resulting in early yield. This conclusion corroborated the findings of 24, who found that the number of days to fruit set was related to NPK levels in chilli.

Effect of variety and fertilizer on fruit girth (mm), fruit length (cm), unit fruit weight (kg), number of fruits and yield (t/ha) of cucumber: Variety significantly ($P \leq 0.05$) influenced fruit girth in both trials of 2019. CU 999 produced fruits with larger girth compared to Monalisa variety. There was no significant ($P \leq 0.05$) effect of fertilizer on fruit girth in the early season of 2019 (Table-5), while significant difference was observed in the late season. Plants in plots with fertilizer rate of 300 kg/ha produced fruits with the largest girth.

Varietal influence was observed on fruit length in both seasons of 2019 (Table-5). Variety CU 999 produced significantly ($P \leq 0.05$) longer fruits than Monalisa. Fertilizer significantly ($P \leq 0.05$) influenced fruit length in both trials of 2019. Fruits from plots with fertilizer rate of 300 kg/ha were longer than fruits from other plots.

Variety significantly ($P \leq 0.05$) influenced unit fruit weight in both trials in 2019 with CU 999 producing heavier cucumber fruits than Monalisa (Table-5). Fertilizer rate significantly ($P \leq 0.05$) influenced fruit weight in both seasons. Fertilizer rate of 300 kg/ha produced fruits with higher fruit weight. There was significant ($P \leq 0.05$) interaction between variety and fertilizer on fruit weight in both seasons. Variety CU 999 with fertilizer rate of 300 kg/ha had higher fruit weight.

Variety significantly ($P \leq 0.05$) influenced number of fruits per plant in both seasons. Variety CU 999 produced plants with higher number of fruits (Table-5). Fertilizer rate significantly ($P \leq 0.05$) influenced number of fruits per plant in both seasons of 2019 (Table-5). Plants in plots with fertilizer rate of 300 kg/ha producing highest number of fruits. Varietal influence was observed on fruit yield (t/ha) in both seasons of 2019. Yield of CU 999 was higher compared to Monalisa.

Fertilizer also influenced yield significantly ($P \leq 0.05$) in both seasons of 2019. In both seasons, plants in plots with fertilizer rate of 300 kg/ha had higher yield than plants in other plots. The lowest yield was found from the control plants (Table-5). Significant ($P \leq 0.05$) interaction was observed between variety and fertilizer on yield in both trials of 2019. Variety CU 999 with fertilizer rate of 300kg/ha had higher yield (Table-5).

The yield characteristics of the CU 999 and Monalisa varieties were varied. CU 999 had a much higher number of fruits per plant, a heavier fruit plant, and a higher total yield per hectare. The CU 999 type may have adapted to the surroundings more quickly than Monalisa. The CU 999 variety's vegetative features may have been more active, resulting in a robust source-to-sink interaction that led in the variety's high yields 25. This was in line with 26 findings, which claimed that genetic and environmental factors influence cucumber yield, which varies based on the growing season and region.

The highest fruit output came from NPK fertilizer applied at 300 kg/ha. The rate of photosynthesis, which was affected by the availability of nutrients in sufficient quantities determined plant growth, development, and production. Due to a lack of nutrients, the photosynthesis process became slow and ineffective, resulting in a reduction in the amount of photosynthetic transferred to the fruit, lowering the fruit weight, yield, and quality. This is consistent with the findings of 27, who linked curcurbit development and fruit output to a higher availability of nutrient components.

Fertilizer use boosted cucumber crop growth, resulting in a rise in the amount of fruits per plant. This was in agreement with 23 findings. The two cucumber types employed in the experiment have significant varietal differences in fruit output. The fruit production of CU 999 was higher than that of Monalisa. The amount of fertilizer applied has a big impact on the fruit output. Because the nutrients taken up by the plant were well used in cell multiplication and energy formation, the significant response of the parameters tested (vine length, number of leaves, number of fruits, weight of fruits, and yield) to applied NPK fertilizer could be because the nutrients taken up by the plant were well used in cell multiplication and energy formation, resulting in increases in photosynthesis. The photosynthetic products were subsequently transported to the sinks 18. The number of flowers was significantly larger in all fertilizer treatments than in the control. This was in line with 14 findings, which showed a substantial response of cucumber fruit weight per plant and crop output to the inorganic fertilizer applied.

The results of the experiment demonstrated that as the NPK level was increased, the fruit weight gradually increased as well. The findings are consistent with those of 22, who found that as the nitrogen fertilizer rate was increased, cucumber fruit weight increased. 28 found that increasing NPK fertilizer resulted in the cucumber plants producing the most fruit weight (g).

The results of this study corroborated 29 findings that inorganic fertilizer enhanced crop output, as well as 30 conclusions that inorganic fertilizer was the best technique to boost maize yield. NPK administration had a considerable impact on yield ha-1, as fertilizer treatment resulted in higher yield due to increased fruit length and weight. Different dosages of NPK reacted significantly differently for total yield, according to 24. Similarly, 31 found that applying nitrogen improved yield considerably.

The application of fertilizer to boost the delivery of plant nutrients to cucumber would result in higher carbon utilization and subsequent assimilate synthesis 14. In northern Nigeria, 32 found good cucumber vegetative growth due to fertilizer treatment. 33 also found that NPK fertilizer increased the vegetative growth of watermelon. The plant's output grew as the rate of NPK fertilizer was raised. The yield of the cucumber crop grew in lockstep with the rate of fertilizer application. In Samaru Zaria, 34 found that raising fertilizer levels resulted in a considerable increase in cucumber growth and yield. The cucumber crop's vegetative features, such as vine length and number of leaves responded favorably to inorganic fertilizer applications up to 300kg/ha. As a result, the crop and its photosynthetic apparatus developed more fully, increasing assimilates production and accumulation. The assimilates created during photosynthesis were subsequently transported to various sinks, resulting in an increase in the quantity of fruits per plant as well as yield. This study's findings were also in line with those of 18, who observed an increase in cucumber yield as a result of fertilizer application.

Table-1: Physical and chemical properties of soil of the experimental sites.

Properties	Early	Late
	Pre planting	Pre planting
pH	6.8	6.8
N (%)	0.18	0.19
Available P (mg/kg)	19.55	20.12
Org. C (%)	0.48	0.57
Org. M (%)	0.89	0.99
Ex. A (mEq/100g)	0.20	0.20
Na (cmol/kg)	0.28	0.32
k (cmol/kg)	0.40	0.43
Ca (cmol/kg)	0.30	0.32
Mg (cmol/kg)	0.38	0.39
Sand (%)	74.20	74.50
Clay (%)	7.20	6.10
Silt (%)	19.20	19.40
Textural Class	Sandy loam	Sandy loam

Table-2: Effect of variety and fertilizer on primary vine length of cucumber at 3 - 5 WAS in both trials of 2019.

Variety	3		4		5	
	Early	Late	Early	Late	Early	Late
CU 999	27.22	21.55	169.58	70.13	342.19	131.69
Monalisa	31.69	23.07	216.44	66.12	430.01	112.94
LSD (P≤0.05)	0.432	NS	1.527	NS	5.984	NS
Fertilizer rate (kg/ha)						
0	29.39	24.57	186.72	53.08	378.06	84.89
100	29.19	20.62	192.28	96.95	379.45	152.47
200	29.17	21.45	194.04	61.10	389.28	127.49
300	30.05	22.62	199.00	61.36	397.60	124.40
LSD (P≤0.05)	NS	NS	2.832	NS	7.459	NS
V × F (P≤0.05)	NS	NS	NS	NS	NS	NS

Table-3: Effect of variety and fertilizer on number of leaves of cucumber at 3, 4 and 5 WAS in both trials of 2019.

Variety	3		4		5	
	Early	Late	Early	Late	Early	Late
CU 999	11.38	7.33	21.04	12.68	38.09	18.12
Monalisa	13.24	9.06	24.48	12.34	46.71	16.04
LSD (P≤0.05)	0.043	NS	0.051	NS	0.213	NS
Fertilizer rate (kg/ha)						
0	12.18	8.42	22.15	12.46	41.70	15.25
100	12.19	7.29	23.06	13.94	41.41	18.28
200	12.32	8.79	22.63	12.31	43.00	19.22
300	12.55	8.29	23.19	11.33	43.50	15.58
LSD (P≤0.05)	0.22	NS	NS	NS	1.382	NS
V × F (P≤0.05)	NS	NS	NS	NS	NS	NS

Table- 4: Effect of variety and fertilizer on days to 50% flowering of cucumber in both trials of 2019.

Variety	Days to 50 % flowering		Days to Fruit set	
	Early	Late	Early	Late
CU 999	20.83	22.83	32.08	34.08
Monalisa	26.67	28.67	37.58	39.58
LSD (P≤0.05)	0.949	0.949	0.621	0.621
Fertilizer rate (kg/ha)				
0	25.67	27.67	37.50	39.50
100	24.50	26.50	35.83	37.83
200	23.17	25.17	34.00	36.00
300	21.67	23.67	32.00	34.00
LSD (P≤0.05)	0.825	0.825	0.877	0.877
V × F (P≤0.05)	1.103	1.103	1.105	1.105

Table-5: Effect of variety and fertilizer on fruit girth (mm), fruit length (cm), unit fruit weight (kg), number of fruits and yield (t/ha) of cucumber in both trials of 2019.

Variety	Fruit Girth (mm)		Fruit Length (cm)		Fruit Weight (kg)		No of Fruits		Yield (t/ha)	
	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late
CU 999	55.99	60.26	24.52	25.90	4.09	3.80	10.38	11.65	10.22	9.49
Monalisa	46.81	53.98	17.74	21.46	1.09	1.45	4.75	5.53	2.74	3.62
LSD (P≤0.05)	3.909	3.865	0.720	0.934	0.564	1.310	1.553	1.362	1.398	3.255
Fertilizer rate (kg/ha)										
0	49.43	48.56	19.70	20.07	1.89	1.81	5.58	5.47	4.73	4.54
100	51.10	56.67	20.51	22.87	2.31	2.11	6.83	7.47	5.78	5.29
200	51.67	59.88	21.57	24.29	2.62	2.49	7.83	9.15	6.55	6.22
300	53.41	63.35	22.75	27.48	3.54	4.07	10.00	12.26	8.84	10.17
LSD (P≤0.05)	NS	4.227	0.863	2.653	0.611	0.470	1.422	1.314	1.530	1.177
V × F (P≤0.05)	NS	NS	NS	NS	0.789	0.608	NS	NS	1.973	1.519

Conclusion

From the study, it was established that: Variety CU 999 is higher yielding than Monalisa and fertilizer rate is a major determinant of fruit yield in cucumber.

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