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Performance of Sweet Pepper (*Capsicum annuum* L.) under Five Levels of Nitrogen Fertilizer in Zaria, Kaduna State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author RY designed the study. Author MDT performed the statistical analysis, wrote the protocol, wrote the first draft of the manuscript, and managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The research on the performance of cubanelle, variety of Sweet Pepper (*Capsicum annuum* L.) in Zaria, Kaduna State of Nigeria was conducted in 2015 and 2016 in on station and on farm trials at Irrigation research station (IRS) farm village. The location is the Sudan savannah ecological zone, 11°39'N, 08°021'E at 500 m above sea level. The treatments evaluated consisted of five nitrogen rates, (A= 40, B = 60, C = 80, D = 100 and E = 120 kgN/ha) and three Stand density (1, 2 and 3 seedlings per stand). The combinations were laid out in a randomized complete block design (RCBD) and replicated three times. The gross plot size was 13.5 m^2 and a net plot size of 9 m^2 inter and intra- row spacing's of 75 cm and 30 cm were adopted respectively. Seedlings were raised in the nursery bed by drilling in rows 10 cm apart at depth of 1 cm and covered lightly with

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top soil and then mulched with dry grass and watered regularly until seedling emerged (5 DAS). Inter- row mulching was carried out using dry grass to conserve moisture. The nursery seedlings were managed until the 5th week when they were transplanted to the field (on the 2nd week of November each year). The land was harrowed to a fine tilt and ridged 75 cm apart. Field was marked out into plots, separated by 1 m path and blocks were separated by a 2 m path. Transplanting was done 35 days after sowing. The recommended agronomic practices were dully observed at the appropriate time to ensure good crop performance. Parameters such as plant height (cm), number of leaves per plant, number of branches per plant fruit diameter (cm), fruit length (cm), total dry matter (TDM), days to 50% flowering and fresh fruit yield (kg/ha) were taken and subjected to statistical analysis of variance (ANOVA) according to Gomez and Gomez (1984). Means were separated using Duncan's multiple range test (DMRT). The results showed that the best yield was obtained at 80 kgN/ha with average yield of 4 - 7 pepper/plant; 579 – 600 kg/ha while the 120 kgN/ha gave 2 or 3 pepper/plant; 418 – 420 kg/h and high values of 27.50 cm and 25.50 cm as evidence of luxurious growth. It is therefore recommended to apply 80 kgN/ha on farm and irrigation at the area under study for maximum output and economic returns to the farmers.

Keywords: Pepper; capsicum.

1. INTRODUCTION

Sweet Pepper (*Capsicum annuum* L.) also known as sweet pepper or SHAMBO, TATTASAN GWARI (Hausa) It is a vegetable used on a daily basis for its sweet taste with little more burning sensation commonly called 'heat' than bell pepper (*Capsicum annum*) Sweet pepper has thin wall, making it a great pick for frying or stuffing, have more flavor and lower water content than bell pepper. The fruits are best pick while they are green but could be left to mature. The fruit is about 8-12 cm long, unripe fruit is yellow-green and turns orange, then red as it ripens. Nigeria is known to be one of the major producers of pepper in the world accounting for about 50% of African production as reported by Idowu-agida et al. [1]. Most farmers in northern Nigeria cultivate sweet pepper as a cash crop. Low nutrient supply had been variously reported as the single most important factor limiting successful crop performance in general and sweet pepper production in particular. The meat-processing industry uses about 35 to 40% of the world production. Dried seeds of pepper contain 2% volatile oil, which is used in sausages and of the most spice used on Nigerian dish.

Soils in Nigerian savannah, the predominant production area of pepper were reported to be poor in Nitrogen, as well as exchangeable bases due to low organic matter content and continuous mining resulting from continuous and intensive cultivation [2,3]. Other reasons advanced for the fast deterioration of soil fertility includes high temperature, leaching and soil erosion as reported by [4,5].

Sweet pepper is known to respond to application of fertilizers [3,6]. [7] reported that much elaborate use of inorganic fertilizer is crucial for the necessary increase in food quality and supply.

Farmers yields are reported to be low, due to agronomic constrains, such as the use of low yielding varieties, poor fertilization as a result of adulteration and poor handling of fertilizers resulting in low nutrient content. The use of these low quality fertilizers fails to improve yields among others. The soils of savannah ecologies have been reported to be poor in native Nitrogen, Phosphorus and organic matter [8], hence the need for adequate fertilization so as to increase the yield of sweet pepper.

2. MATERIALS AND METHODS

Two field experiments were conducted on station and on farm at Irrigation research station (IRS) farm Kadawa and Kadawa village in the Sudan savannah ecological zone at. 11°39^{1}N, 08°02^{1}E and 500 m above sea level The treatments evaluated consisted of five Nitrogen rates, (A=40, B=60, C=80, D=100 and E=120 kgN/ha) and three Stand density (1,2 and 3 seedlings per stand). The treatments combinations were laid out in a randomized complete block design (RCBD) and replicated three times. The gross plot size of 13.5 m^2 and a net plot size of 9 m^2 inter and intra- row spacing's of 75 cm and 30 cm were adopted respectively. Seedlings were raised in the nursery bed by drilling in rows 10 cm apart at depth of 1 cm and covered lightly with top soil and then mulched with dry grass and watered regularly until seedling emerged (5

DAS). The dry grass was then removed and spread between the rows of emerged seedlings to further conserve moisture. The seedlings were managed until the 5th week i.e., 35 days after sowing, week when they were transplanted to the field (on the 2nd week of November each year). The land was harrowed to a fine tilt and ridged 75 cm apart. Field was marked out into plots, separated by 1 m path and blocks were separated by a 2 m path. All the necessary improved agronomic practices were dully observed at the appropriate time to ensure good crop performance as recommended by [9].

Parameters used and procedures: The following data were measured:

Plant height (cm): The height of ten selected plants from each net plot taken at 9 and 12 weeks after transplanting (WAT) and measured from the ground level to the apex using a meter rule. The average was computed and recorded as mean height.

Number of leaves per plant: Ten plants were randomly selected from each net plot at 9 and 12 WAT; their leaves were counted and the mean leaves per plant were then determined.

Number of branches per plant: Ten plants were also randomly selected from each net plot and number of branches per plant counted at 9 and 12 weeks after transplanting and the mean was recorded.

Fruit diameter (cm): Fresh fruits diameter was determined using vernier caliper from 5 randomly selected plants from each net plot and the means was recorded.

Fruit Length (cm): The fruit length was also measured using 30 cm ruler from 5 randomly selected plants from each net plot and the means was recorded.

Number of fruits per plant: The number of fruits per plant from randomly selected 15 plants at 12 WAT was taken from each plot and the means was recorded.

Days to 50% flowering: This was determined by counting the number of days from transplanting to the time when 50% of the plants in the plots have flowered.

Fresh fruit yield (kg/ha): Twenty fresh fruits selected randomly from each plot were taken and the mean computed as mean fresh fruit.

Statistical analysis: Data collected were subjected to analysis of variance (ANOVA) according to [10]. The treatment means were separated using Duncan's Multiple Range Test (DMRT).

3. RESULTS AND DISCUSSION

The effects of Nitrogen rates on sweet pepper plant height are presented in Table 2. There was significant difference in plant height at ($P<0.05$). The tallest was observed on combined mean treatment E = 120 kg/ha of Nitrogen (N) with 27.50 cm on the on station and followed by the on farm treatments with 25.50 cm. These may be due to the high level on N on the treatments. Treatments A (40 kg/ha) recorded the lowest plant height with 17.00 and 18.50 at both the on station and the on farm treatments respectively. The result is in agreement with the experiments of [3,9,6] which stated that, sweet pepper is known to respond to application of fertilizers.

Table 1. Physical and chemical properties of the experimental soil during 2012 and 2013 dry season at Kadawa

Physical properties	2012	2013
% clay	28	32
% silt	22	18
% sand	50	60
Textural class	Clay loam	Sandy loam
Chemical properties		
pH(H_2O) 1:2:50	7.20	7.80
pH(0.1M$CaCl_2$	6.30	6.20
%Total Nitrogen	0.03	0,05
Available P(ppm)	7.24	7.62
% Organic carbon	0.18	0.31
Calcium Cmol/kg	4.20	5.10
Magnesium Cmol/kg	0.63	0.56
Potassium Cmol/kg	0.43	0.44
Sodium Cmol/kg	1.30	1.52
CEC	6.90	7.60
H+Al	0.10	0.10

The effect of inorganic fertilizer Nitrogen on the number of leaves is presented in Table 3. The highest number of leaves was recorded at treatment E (120 kg/ha) of N on both sites while the lowest was recorded on treatments A, respectively. There was significant difference between the highest and the lowest treatments at $P < 0.05$ as presented on the Table.

Table 2. Plant height (cm)

Treatments	9 WAT – 12 WAT (45- 60 days)					
	On station			On farm		
N Fertilizer kg/ha	2016	2017	Combined	2016	2017	Combined
A = 40	18c	16d	17.00d	20bc	17c	18.50c
B = 60	20bc	19c	19.50c	18c	20ab	19.0c
C = 80	22b	23b	22.50c	23b	24a	23.50ab
D = 100	25b	24b	24.50b	24b	23ab	23.50a
E = 120	28a	27a	27.50a	26a	25a	25.50a
SE±	2.18	2.09	2.23	1.67	1.68	2.14

Source: Field work, 2016 and 2017

Means followed by the same letter(s) in each treatment are not significantly different at P = 0.05 (DMRT).

**= Significantly different at 5% level of probability*

Table 3. Number of leaves

Treatments	9 WAT – 12 WAT (45 - 60 days)					
	On station			On farm		
N Fertilizer k/ha	2016	2017	Combined	2016	2017	Combined
A = 40	38d	43d	40.50d	39d	42d	40.50d
B = 60	48c	49c	48.50c	47c	48b	47.50c
C = 80	51b	56b	53.50b	57b	55b	56.00b
D = 100	60a	58b	59.00a	59a	60a	59.50a
E = 120	63a	61a	62.00a	60a	62a	61.00a
SE±	2.52	2.56	2.65	2.52	2.55	2.59

Source: Field work, 2016 and 2017

Means followed by the same letter(s) in each treatment are not significantly different at P = 0.05 (DMRT).

**= Significantly different at 5% level of probability*

The number of branches as influenced by N fertilizer is presented in Table 4. The highest combined mean number was observed at treatment C being (8.80) and 8.55 in both the on station and the on farm treatments, while the lowest was recorded in treatments A at 5.65 and 5.95 in both the sites respectively. There was also significant difference between the highest number of branches and the rest at P <0.05 (Table 4). [11] opined that, the amount of inorganic fertilizer added to cropping systems affects both the yield and the residues.

The results on fruits diameter as presented on Table 5, indicates that, treatments C (80 kgN/ha) has the highest mean combined fruit diameter of 7.35 cm and 7.20 cm respectively at both the on station and the on farm treatments during the two seasons under study. The lowest fruit diameter was recorded in treatment E, with combined means of 4.70 cm and 4.55 cm both the on station and the on farm treatments. However, there was a significant difference between the largest fruit diameter and the lowest at P < 0.05. The results are in agreement with [12] and [13]

Table 4. Number of branches

Treatments	9 WAT – 12 WAT (45 - 60 days)					
	On station			On farm		
N Fertilizer kg/ha	2016	2017	Combined	2016	2017	Combined
A = 40	5.2c	6.1b	5.65c	6.2b	5.7c	5.95c
B = 60	6.1b	6.4b	6.25b	7.0a	6.8bc	6.90bc
C = 80	8.9a	8.7a	8.80a	8.6a	8.5a	8.55a
D = 100	8.0a	8.2a	8.10a	7.9a	7.7a	7.80b
E = 120	7.8ab	7.7ab	7.75ab	7.6a	7.5b	7.55b
SE±	0.40	0.42	0.43	0.39	0.41	0.42

Source: Field work, 2016 and 2017

Means followed by the same letter(s) in each treatment are not significantly different at P = 0.05 (DMRT).

**= Significantly different at 5% level of probability*

Table 5. Fruits diameter (cm)

Treatments	9 WAT – 12 WAT (45 - 60 days)					
	On station			On farm		
N Fertilizer kg/ha	2016	2017	Combined	2016	2017	Combined
A = 40	5.2b	5.6b	5.40b	5.1bc	5.3b	5.20c
B = 60	6.1a	6.2a	6.15a	6.0b	6.1a	6.05b
C = 80	7.2a	7.5a	7.35a	7.3a	7.1a	7.20a
D = 100	5.7b	5.6b	5.65b	5.8b	5.5b	5.65c
E = 120	4.2bc	5.2b	4.70bc	4.5c	4.6bc	4.55bc
SE±	0.39	0.42	0.58	0.40	0.41	0.57

Source: Field work, 2016 and 2017

Means followed by the same letter(s) in each treatment are not significantly different at P = 0.05 (DMRT).

**= Significantly different at 5% level of probability*

that, selection of cropping system and fertilizer application will give high yield and the effects of different levels of inorganic fertilizer on pepper increased fruit diameter and subsequently yield of the crop respectively.

The longest fruit combined mean length was obtained where E = 120 kg/ha^{-1} of Nitrogen (N) fertilizer as applied on both the on station and on the farm experimental sites with 10.90 cm and 10.8 cm lengths respectively (Table 6). This was not unconnected with luxurious growth associated with the high level of N applied on the treatment. The least fruit length was observed at treatment A = 40 kg/ha of N on the on farm site with combined mean value of 7.65 cm and followed by the on station site with 7.70 cm.

The number of pepper per plant is presented in Table 7. The highest number of pepper per plant was recorded at treatments C = (80 kgN/ha) with combined mean of 6.50 pepper per plant on the on station treatments while the on farm treatment recorded 6.00 pepper per plant. The least number of pepper per plant was observed at treatments E = (120 kgN/ha) which recorded

Table 6. Fruits length (cm)

Treatments	9 WAT – 12 WAT (45 - 60 days)					
	On Station			On Farm		
N Fertilizer kg/ha	2016	2017	Combined	2016	2017	Combined
A = 40	7.6bc	7.8bc	7.70bc	7.7bc	7.6c	7.65c
B = 60	8.4b	8.6b	8.50b	8.1b	8.2bc	8.15bc
C = 80	10.5a	10.6a	10.55a	9.7ab	9.6b	9.65b
D = 100	10.7a	10.8a	10.75a	10.1a	10.5a	10.30a
E = 120	10.9a	10.9a	10.90a	10.8a	10.7a	10.75a
SE±	0.33	0.40	0.42	0.32	0.39	0.40

Source: Field work, 2016 and 2017

Means followed by the same letter(s) in each treatment are not significantly different at P = 0.05 (DMRT).

**= Significantly different at 5% level of probability*

Table 7. Number of pepper per plant

Treatments	8 WAT (40 days)					
	On station			On farm		
N Fertilizer kg/ha	2016	2017	Combined	2016	2017	Combined
A = 40	5b	2bc	3.50b	4b	3bc	3.50bc
B = 60	4b	3b	3.50b	5ab	4b	4.50bc
C = 80	7a	6a	6.50a	6a	6a	6.00a
D = 100	4b	5a	4.50b	6a	4b	5.00ab
E = 120	2c	3b	2.50bc	2c	2bc	2.00c
SE±	0.027	0.026	0.022	0.026	0.026	0.023

Source: Field work, 2016 and 2017

Means followed by the same letter(s) in each treatment are not significantly different at P = 0.05 (DMRT).

**= Significantly different at 5% level of probability*

Table 8. Fresh fruit yield (kg/ha)

Treatments	8 WAT - 12 WAT (40 - 60 days)					
	On Station			On Farm		
N Fertilizer kg/ha	2016	2017	Combined	2016	2017	Combined
A = 40	280.5c	281.4c	280.95c	278.8d	283.1d	280.95d
B = 60	422.4b	421.7b	422.05b	420.8b	421.6b	421.20b
C = 80	601.2a	600.4a	600.80a	559.7a	600.1a	579.90a
D = 100	427.5b	425.6b	426.55b	426.7b	425.3b	426.00b
E = 120	420.2b	421.3b	420.75b	419.3c	418.5c	418.90c
SE±	74.76	73.87	75.76	73.66	72.85	74.88

Source: Field work, 2016 and 2017

Means followed by the same letter(s) in each treatment are not significantly different at P = 0.05 (DMRT).

**= Significantly different at 5% level of probability*

2.50 and 2.00 number of pepper per plant on both the two seasons under study for both on station and on farm treatments respectively. There was significance difference between the highest combined mean numbers of pepper per plant and the lowest pepper number per plant at P <0.05.

The highest combined mean yield of 600.80 kg/ha was obtained at treatment C, the on station experimental site where C= 80 kg of Nitrogen(N) fertilizer was applied, which is followed by the on farm site which gave 579.90 kg/ha at the same rate. These were closely followed by the on station and on farm sites where D = 100 kg/ha were applied which gave 426.55 and 426.00 kg/ha respectively. The least yields were obtained at treatment A= 40 kg/ha at the on station trials with 280.95 kg/ha while at the on farm trials the least yield were obtained at treatment B= 60 kg/ha of N which gave 421.20 kg/ha. These were closely followed by the application of E = 120 kg/ha of N which gave 420.75 and 418.90 kg/ha yields on both the on station and on farm experiments respectively as can be seen on Table 8.

4. CONCLUSION AND RECOMMENDATIONS

The results of the experiments indicated that, Sweet Pepper (*Capsicum annum*.) variety cubanelle responds to different levels of Nitrogen fertilizer at both the sites under study. The highest combined mean number of pepper per plant was obtained at treatments C = (80 kg/ha N) with combined means of 6.50 and 6.00 on both the on station and the on farm trials respectively. The highest yield kg/h of sweet pepper was also obtained at the same treatment of C = (80 kg/ha) of N with 600.80 kg/ha and 579.90 kg/ha of sweet pepper per hectare on respective treatments. Based on the study, 80 kg/ha of Nitrogen fertilizer is recommended to be adopted in the study area for economic yield. Government should also provide adequate fertilizer on time and at an affordable rate to enable the farmers to buy and apply them on their farms for high yield. Non-Governmental Organizations and the Governments at various levels should also sensitize and encourage farmers to use Nitrogenous fertilizers on their crops. Further studies are also recommended on the best performance and production of Sweet Pepper (*Capsicum annum*) in Kaduna State and all pepper producing States of Nigeria.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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