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Effect of Spacing and Poultry Manure Rates on Growth, Yield and Quality of Cayenne Pepper (*Capsicum frutescens. L*) in Southern Rain Forest of Nigeria

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Abstract *– Field experiment was conducted at the Teaching and Research Farm of the Department of Agriculture, Ndele Campus, Ignatius Ajuru University of Education, Port Harcourt, Rivers State, to study the effects of poultry manure rates and crop spacing on growth, yield and quality of Cayenne pepper. The 3 x 3 factorial experiment with three replicates was arranged in a Completely Randomized Design. The main plots were three poultry manure rates (0, 10, 20tons/ha-1) and sub plots, three spacing (50cm x 50cm, 100cm x 50cm and 100cm x 100cm). Data collected were plant height, number of leaf per plant, leaf area; number of fruits per plot, fruit weight per plot, fruit yield per hectare, fruit lycopene and vitamin C contents. Results showed plant height increased with reducing planting distance and increasing Poultry manure rate; 50cm by 50cm fertilized at 20tons/ha produced the tallest plants with most number of leaves but least leaf area LA. Number of fruits, fruit weight and yield per plot, per hectare increased with increasing planting density and increasing Poultry manure rates lycopene and vitamin c contents increased with Poultry manure levels within the different spacing. Spacing of 50cm by 50cm fertilized with poultry manure at 20 tons per hectare is recommended.*

Keywords— Cayenne pepper, Poultry Manure, Rainforest, Spacing, Yield.

I. INTRODUCTION

Cayenne pepper, *Capsicum frutescens*, a member of hot pepper Solanaceous family, thought to be native of South America, is commonly used as ingredient in the preparation of soups, sauces, stew probably because it contains essential nutrients and vitamins such as A, E and C. It is called "sombo" and produced in Nigeria where it is consumed by the people fresh, dried or processed [1, 2, 3]. The land area under pepper production in Nigeria as at 1988 and increasing was estimated to be 100 – 200 hectares [4]. Factors accounting for this increasing land under *Capsicum* production on the one hand, is its consumption in Nigeria which accounts for 40 percent of the total vegetable consumed per day and on the other hand the lucrative export business. Nigerian pepper is in high demand abroad because of its pungency and good flavor and it can be readily dried, ground and packaged for export [5].

Although pepper can be grown all over Nigeria, the northern region between latitude 10° N and 12° N is the major area for production where an estimated 77,000 hectares of land under pepper cultivation yields about 695 000 metric tons [6]. The export attraction has encouraged pepper production in western Nigeria where production have been accompanied with a lot of research [1, 2, 7] and in the eastern region that even has special indigenous variety, "Nsukka yellow pepper" [8, 9]. Literature is scarce for *Capsicum* spp. production in the southern rainforest region of Nigeria.

Capsicum yield among peasant farmers are often very low [10]. In general *Capsicum* yield in the developing countries is comparatively lower than those of the developed countries in the region of about 10 – 30% less.

Reduced and inherent soil fertility and management practices, weeds infestation and diseases problems have been largely attributed to the lower yields [3, 5]. Crop intensification, higher planting densities, judicious use of fertilizers and organic matter maintenance have been proffered as panacea for improved production output of tropical crop production [11, 12]. The southern rainforest of

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Nigeria, a typical rainforest is characterized by high rainfall amounts and intensity that has been credited with high leaching that has resulted in impoverishing of the soil making it fragile [13]. Therefore, fertilization studies on pepper production in this region become imperative.

Organic manure application has been reported to be more beneficial over the use of chemical fertilization in tropical crop production, sustainability and soil fertility management. The addition of organic manure enhances crop yield because of improved soil productivity as a result of increased soil organic carbon content and improved soil physical, soil chemical and soil biological properties [6, 14]. Whereas the use of chemical fertilizers supply mainly one or a few macronutrients, in addition to their ruinous effect to the soil, organic fertilization conditions the soil, supplies several macro and micro nutrients, improves and maintain soil fertility status and also improves crop response to inorganic fertilization [15, 16]. The use of organic fertilizer has been reported to improve flavor and quality of vegetable crops as against the use of inorganic fertilizer. Inorganic fertilization dis-flavored the 'Nsukka yellow' pepper while organic manure enhanced flavor and opined the best option in the cultivation of the pepper [17]. Amaranth plants with organic manure treatment had higher nutritional values in the entire plant (leaf, stem, inflorescence and root) than those with inorganic fertilizer treatment [18]. The above informed the researchers on the study of organic fertilization instead of inorganic fertilization. Poultry manure among other sources of organic manure was selected because it is superior and has higher nutrient content than other sources at the farmer's disposal [19, 20, 21].

Increasing the number of crops per unit farmland is one of recommendations for increased yield or crop produce output. Yield increase as a result of closely spaced crops (i.e. higher density) in a crop like pepper is because more plants will produce more fruits, hence increase in number of fruits or yield [22]. Increasing the planting density of bell pepper resulted in higher yield (kg·ha-1) [23]. Southern Nigeria tropical rainforest is characterized by high rainfall amounts with wide monthly variation, intensification in terms of high planting density might favor high yield in cayenne pepper production.

The study was therefore undertaken to assess the effect of spacing and poultry manure rates on the growth, yield and fruit quality of *Capsicum frutescens* in the southern Rainforest of Nigeria.

II. MATERIALS AND METHODS

Study Site

The experiment was conducted at the Teaching and Research Farm of the department of Agriculture, Ignatius Ajuru University of Education, Ndele Campus, Port Harcourt, River state, between July and November, 2017. Ndele is located in the southern rainforest region with about 9.5 months of adequate rainfall, 2.5 dry season months, and cumulative insolation of 120 – 160 Kcal /cum per annum [24].

Nursery practice

Seeds of cayenne pepper variety of *Capsicum frutescens* were on enclosed 1 m x 1 m nursery beds made of dark top soil. The beds were watered before the seeds were broadcasted evenly and watered. After emergence, thinning was done, removing some seedlings so that strong healthy pepper seedling can be obtained for transplanting. Seedlings were watered daily and ready for transplant after 40 days.

Land Preparation

The total experimental area was manually cleared, grass stumps dug out. The soil was tilled with spade and 3 m by 3 m beds were constructed. The individual beds were then mapped out according to the respective spacing ready for seedling transplant.

Experimental Design/Treatment

The study adopted a 3 x 3 factorial experiment arranged in a randomized complete block design (RCBD) and replicated three times. The treatments were (i) Poultry manure rates (0, 10 and 20 tons per hectare) and (ii) Spacing (50 cm x 50 cm; 100 cm x 50 cm and 100cm x 100cm). Poultry manure rates were the main plots while spacing the sub plots, replicated 3 times to give a total of 9 main plots and 27 sub plots. Treatment combinations were randomly allotted to plots. Application of poultry manure was done 2 weeks after transplanting. Soil sample of the experimental sight were obtained using soil auger ad sent to the Laboratory for analysis.

Data collection and analysis

Vegetative and growth parameters measured at 2, 4 6, 8 and 10 weeks after transplanting were plant height (growth rate), number of leaves and leaf area.

Yield parameters determined at harvest were number of fruits per plot, fruit weight per plot and estimated fruit yield per hectare.

Fruit quality were accessed by determining fruit moisture and Vitamin C contents [25] and lycopene content [26].

Data collected were subjected to analysis of variance and means separated by Duncan Multiple Rang Test (DMRT) using PASW 18th Edition statistical software.

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III. RESULTS

Visual Observation

It was observed that application of poultry manure irrespective of the spacing resulted in darker green leaves of the pepper. Application of the manure also enhanced the establishment of the transplanted seedling.

Growth Response

Growth response (plant height) of cayenne pepper to varying rate of poultry manure and spacing is displayed in Table 1. Irrespective of treatments, plant height i.e. growth rate increased with age of the plants. Also, plant height increased with density i.e. spacing. The growth rate response to spacing was significant ($P \leq 0.05$), indicating that the variation in plant height was due to the different spacing. The trend was that plant height increased as the distance (spacing) between plants reduced. At 10 weeks after transplanting (WAT) cayenne plants spaced at 50 cm x 50 cm were 1.5 times taller than the most widely spaced plant at 100 cm x100 cm.

Application of poultry manure rates was also responsible for the variation in plant height (Significant Fcal $P < 0.05$). Increasing rates of poultry manure resulted in positive correlating increase in plant height of cayenne plants. While the difference in height between the control plants and those that received poultry manure was not significant at 2 WAT, it became significant by 10 WAT, the difference in height was 40% over the control plants.

Vegetative Growth

The influence of spacing and poultry manure on vegetative characteristics of cayenne pepper is highlighted in Table 2. Cayenne pepper spaced at 100 cm by 100 cm had plants with the least number of leaves, and significantly different from those spaced at 50 cm by 50 cm and 100 cm x 50 cm ($P < 0.05$). Though, pepper plant spaced at 50 cm by 50 cm had higher number of leaves than those spaced at 100 cm x 50 cm, the difference was not statistically or markedly different.

Poultry fertilizer rate had marked statistically significant effect on number of leaves of cayenne pepper. Number of leaves increased significantly with increase rates of poultry manure application. Plants that were fertilized with 20ton/ha PM rate recorded the highest number of leaves (14) compared to with the control plants.

There were marked variation in cayenne pepper leaf area due to the various spacing (Table 2). Pepper crops spaced 50 cm by 50 cm had the smallest size of leaves (less leaf area), while those spaced and 100 cm x 50 cm and 100 cm by 100 cm were not significantly different but produced leaves with higher leaf area than those spaced at 50 cm x 50 cm.

Poultry manure doses had marked leaf area variation in *Capsicum frutescens*. The Pepper crops that did not receive poultry manure had the smallest sized leaves (leaf area). Increasing levels of poultry manure resulted in increasing sizes of leaves. Cayenne pepper plant that received 20 ton/ha poultry manure application produced the highest leaf area of 56.8cm^2. This is followed by plants that received 10 ton/ha which produced leaf area of 53.9 cm ^{2}.

Fruit Yield

The effect of spacing and poultry manure rate on cayenne pepper fruit yield is shown on Table 3. Number of harvested fruit and fruit weight (yield) were markedly affected by spacing. Fruit yield and numbers increased with the closer high density spacing. Thus plants spaced 50 cm x 50 cm had doubled the yield of those spaced at 100 cm by 100 cm and was the yield per plot was 3 times over those spaced at 100 cm x 100 cm.

The response of *Capsicum frutescens* to poultry manure inclusion was such that fruit yield per plot and per hectare increased with increasing levels of the manure. The yield of the crop at application rates of 10 and 20 ton/ha was not significantly different. However there was marked difference in yield between poultry manure fertilized pepper crop and the control. The increase in yield of 10 and 20 ton/ha fertilized pepper plants over the control plants was 65% and 83% respectively.

Table.1: Effect of Spacing and Poultry Manure rates on Capsicum frutescens growth rate (Plant height cm)

Spacing	**Weeks after Transplanting**				
	2	4	6	8	10
50 cm x 50 cm	17.0^c	19.3^c	27.3^c	34.1^c	39.5^c
100 cm x 50 cm	16.3^b	17.7^b	24.3^b	28.4^b	32.1^b
100 cm x 100 cm	12.4^a	14.4^a	18.4^a	24.3^a	26.1^a
SE	.186	.173	.366	.529	1.020
Poultry Manure (PM) Rate					
0	14.5^a	16.5^a	21.4^a	25.5^a	26.2^a
10 ton/ha	15.2^a	16.9^a	23.8^b	29.9^b	34.4^b
20 ton/ha	16.0^a	18.0^b	24.9^c	31.4^c	36.9^b

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SE ±	.186	.173	.366	.529	1.020
Spacing X PM Rate	NS	*	*	*	*

*Means followed by same letter in each column are not significantly different at P < 05 by Duncan multiple rage test. * = Significant. NS = Not significant.*

Table.2: Influence of spacing and poultry manure rate on vegetative characteristics of Capsicum frutescens (10 WAT)

Spacing	**No. of Leaves**	**LA (cm^3)**
50 cm x 50 cm	13.8[b]	42.3[a]
100 cm x 50 cm	13.3[b]	47.4[b]
100 cm x 100 cm	12.0[a]	47.4[b]
SE	.203	.272
Poultry Manure (PM) Rate		
0 ton/ha	11.2[a]	24.5[a]
10 ton/ha	13.4[b]	53.9[b]
20 ton/ha	14.4[c]	56.8[c]
SE	.203	.272
Spacing & PM Rate	NS	NS

** Means followed by same letter in each column are not significantly different at P < 05 by Duncan multiple rage test *.*

Table.3: Effect of Spacing and Poultry manure levels on yield in Capsicum frutescens

Spacing	**Number of Fruit**	**Fruit weight/plant (g)**	**Fruit yield kg/ha**
50 cm x 50 cm	192.4[a]	456.7a	507.4
100 cm x 50 cm	111.2[b]	265.2b	294.6
100 cm x 50 cm	61.7[c]	148.9c	165.4
S.E.	1.478	4.147	
Poultry Manure (PM) Rate			
0 ton/ha	83.8[a]	194.2[a]	215.7
10 ton/ha	133.5[b]	321.5[b]	357.2
20 ton/ha	148.0[c]	355.0[b]	394.4
S.E.	1.478	4.147	

** Means followed by same letter in each column are not significantly different at P < 0.05 by Duncan multiple rage test *.*

Table 4 shows the quality effects to spacing and poultry manure levels by cayenne pepper. Per cent moisture content was not influence by spacing and poultry manure rates as no clear trend was observed. However the widely spaced crops at 100 cm by 100 cm had more moisture in the fruit. Within each spacing treatment vitamin contents in the fruits increased with manure rates, with plants spaced at 50 cm x 50 cm producing pepper plants with highest vitamin c as manure level increase.

Lycopene content in cayenne fruit were positively affected by poultry manure in all spacing treatment. Plants that did not receive manure had lowest levels of lycopene; however among the plants that were spread at 100 cm by 50 cm lycopene content of the control plants had higher lycopene levels than those fertilized with poultry manure.

In plant spaced at 100 cm by 100 cm, increasing poultry manure rate beyond 10 ton/ha resulted in reduction of lycopene content in the fruit. In plants spaced at 50 cm by 50 cm increasing poultry manure content resulted in increasing levels of lycopene in fruit.

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Table.4: Influence of spacing and poultry manure rates on fruits quality cayenne pepper

Spacing	Poultry manure rate Ton/ha	% Moisture Content	Vitamin C	Lycopene (mg/kg)
50 cm x 50 cm	0	77.77	0.26	28.50
	10	74.43	0.61	31.12
	20	75.74	0.77	34.45
100 cm x 50 cm	0	79.43	0.26	28.50
	10	69.1	0.3562	17.95
	20	73.27	0.4272	24.89
100 cm x 100 cm	0	79.87	0.26	28.51
	10	70.2	0.2637	60.19
	20	75.4	0.5148	49.65

IV. DISCUSSION

Effect of Spacing and Poultry Manure Rates on Growth and Yield of Cayenne Pepper

This study observed that plant height, that is, growth rate increased with spacing. This is in line with studies by other researchers who reported increase in plant height in closely spaced green pepper in Kenya [27]. It was also observed that increasing the rate of poultry manure led to increasing plant height of cayenne pepper. This observation corroborates other research findings on aromatic pepper, *Capsicum annum* L var (Nsukka yellow) in Nsukka, Enugu State, Nigeria [28]; that plant height increased with increasing poultry manure rates.

Reducing planting distance and increasing poultry manure rate resulted in increasing number of leaves. This is similar to the reports increasing vegetative growth with poultry manure application in Nsukka yellow anomatic pepper at Nsukka [29].

The fruit yield of cayenne pepper increased with spacing per plot and per hectare. This could be as a result of higher population of plants, with each individual plants producing high number of fruits. Similarly in a different study on green pepper, closely spaced pepper recorded higher yields than widely spaced pepper [27]; while higher yield was observe in tomatoes with increasing levels of poultry manure [30].

Effect of Spacing and Poultry Manure on fruit quality of Cayenne pepper

Increasing levels of poultry manure resulted on the increasing contents of lycopenes and Vitamin C in this study. This finding is similar to the findings of other research done on tomato; which indicated that lycopene content increased with poultry manure levels [30]. However their findings [30] that control tomatoes plant had higher vitamin content than those receiving poultry manure is contrary the observation in this study. It was observed that the control plants had lower levels of Vitamin C compared with cayenne pepper that received poultry manure.

V. CONCLUSION

Spacing cayenne pepper at 50 cm by 50 cm will result in higher growth rate and yield. Application of 20 ton/ha of poultry manure will result in higher growth rate and yield. Spacing has no significant difference on lycopene and vitamin content in cayenne pepper. Increasing rate of poultry manure results in higher Vitamin C content in cayenne pepper. Application of 20 ton/ha poultry manure and a spacing of 50 cm by 50 cm is recommended for cayenne pepper production in the southern rainforest zone of Nigeria.

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