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Liming and Plant Density Effect on the Performance of Pepper and Soil Chemical Properties

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Abstract:
This experiment was carried out to evaluate under field condition the effect of lime ($CaCO_3$) at three levels; 80g, 120g and 160g and plant spacing (40cm x 75cm, 50cm x 75cm, 60cm x 75cm) on the performance of pepper and soil chemical properties. The experiment was laid out on a 3 x 3 factorial experiment in a randomized complete block design (RCBD) with two replications. The results obtained from the study showed that both agronomic and soil parameters increased with increase in rates of lime application, the values of agronomic parameters however, was found to decrease as plant density decreases. The values of soil chemical parameters were found to be statistically similar in both plant spacing and rates of $CaCO_3$ except for the results of pH and N. The interaction effect of plant spacing and $CaCO_3$ was found not to be effective in all the parameters measured in this study.

Keywords:
$CaCO_3$, Lime, Pepper, Plant Density, Soil Chemical Properties

1. Introduction

Pepper (*Capsicum species*) is one of the most important solanaceous vegetable crops grown in Nigeria. Its production in the country can rank with tomato or okra. At least according to the record of FAO [1], Nigeria is the largest producer of pepper including chillies in Africa, producing about 50% total African production, while the total area devoted to the pepper production is about 100,000 – 200,000 hectare annually and the Nigerian annual production of the crop was put at 850,000 and 900,000 metric tons 2002 – 2003 respectively. Pepper is equally one of the oldest crops grown by man throughout the world and most widely cultivated and economically the most important species. Pepper is used in the flavouring or garnishing of various kinds of diets, salads and sauces etc. In fact, it is parts and parcel of human diets and contributes to the income of farmers. It can be used fresh or crushed into paste and canned. In this form, it can be stored longer especially when

crushed together with tomatoes into paste. Medicinally, it has been reported to have antioxidant properties. The pharmaceutical industries use it as a counter irritant balm for external application, of which repeated use of the balm counters the production of substance P in the joint hence less pain and in turn reduce long term inflammation which can cause cartilage breakdown [2]. This attributes notwithstanding, the cultivation of pepper in Nigeria and south eastern part of the country in particular have remained mainly in the hands of peasant farmers who grow them in mixture with other crops and rarely as sole crops.

The studies on plant density for different types of pepper by Khasmakhi*et al.* [3]have shown that plant density and plant arrangement influence plant development, growth and marketable yield of peppers. Also, Akintoye*et al.* [4] opined that yield per unit area increase as plant density increases up to a point and then decreases, while Nasto*et al.* [5] in their studies observed that increasing plant density resulted in greater yield of bell pepper in $kgha^{-1}$. Plant spacing is another crop management system that has being found to influence yield of crops especially vegetables crop greatly. The work of Nweke*et al.* [6] showed that closer spacing increased the fruit yield and marketable fruits of cucumber, while Law and Eghorevba [7] in their studies found out that wider spacing led to increases in fruit yield per plant in tomato. Another management practices that tend to increase the performance and yield of crops especially vegetable crops is the use of fertilizer whether organic or inorganic fertilizer of which the objectives is to maintain good yield. The productivity of pepper have been found to be influenced greatly by nitrogen fertilizer application as fruit weight, fruit number, shoot dry weight, chlorophyll content and leaf nitrogen concentration were found to increase following nitrogen fertilizer application. Inorganic fertilizers exert strong influence on plant growth development and yield, improves cell activities, enhanced cell multiplication and enlargement and luxuriant growth [8, 9, 10, 11] and larger dry matter due to better infiltration of solar radiation and more nutrients. Adopting a good fertilizer performance and crop spacing is a major way of improving yield in crops. Thus, the aim of this study was to find the best plant spacing and $CaCO_3$ lime level adequate for Nsukka yellow pepper *Capsicum annum* cultivation under field trial in Igbariam soil.

2. Materials and Methods

2.1. Site Location

The field trial was conducted in the Teaching and Research Farm of Faculty of Agriculture, ChukwuemekaOdumegwuOjukwu University, Igbariam Campus. Igbariam is a town located in Anambra East Local Government Area of Anambra State and is bounded on the North by Anambra River, on the south by Awkuzu, on the West by Nteje and by the East of Achalla town. Igbariam is located on latitude of06˚14'N and longitude of06˚45'Ewith annual rainfall of about 2000mm. The rainfall distribution is bi-modal with a high period of precipitation. The mean temperature is between 28˚C – 37˚C as maximum relative humidity is 78.2% while sunshine stood at 2.8 hours [12]. Soils of the study area have been reported by Nweke and Emeh [13] to be deficient in major plant nutrients and soil acidity attributable to high rainfall leading to loss of basic cations.

2.2. Land preparation/ Experimental Design and Treatment Application

A land area measuring 9.5m x 11m was mapped out and manually cleared and beds were made using hoe. The land area was divided into two equal blocks. Each of the blocks made up of plots, given a total of 18 test plots, each plot measured 2m x 2m ($4m^2$) with 0.5m between plots and 1m alley between blocks to ensure free movement during the study. The study was conducted as 3 x 3 factorial laid out in randomized complete block design (RCBD) with two replications. Three plant spacing (40cm x 75cm; 50cm x 75cm; 60cm x 75cm) and three levels of $CaCO_3$ (lime) , 160g (400kg/ha); 120g (300kg/ha); and 80g (200kg/ha) were the treatments used in the study. The $CaCO_3$ level were evenly spread on their respective plots and incorporated into the soil four days before seedling transfer to allow mineralization of nutrient in the fertilizer. Pepper seedlings were transplanted six weeks from the nursery. Each was buried up to soil mark and was watered daily early hours of the day and in the evening for two weeks. This is to ensure proper establishment and high survival rate. The field were relatively kept weed free manually till harvest which started at ripening stage when the pepper turn from white greenish to yellow at almost four months after seedlings transfer. The agronomic parameters studied were plant height, number of fruits and weight of fruits. At the end of the study, soil samples were collected from each plot, air dried and sieved thoroughly with 2mm mesh, after which chemical properties of the soil were determined. Soil pH was determined using digital pH meter at 1:2.5 solid water ratios. Organic carbon was determined by the methods of Nelson and Sommers [14] and Total nitrogen by Bremner and Mulvancy [15]. Available P was determined by Bray II method and cation exchange capacity (CEC) by ammonium acetate technique. Exchangeable acidity was determined by method of Mclean [16].

Data generated from the study were subjected to statistical analysis using the procedure outlined by Steel and Torrie [17] for a factorial experiment in randomized complete block design (RCBD). Significant difference between treatments means were done by the use of least significant difference (LSD) at 5% alpha level.

3. Results

The agronomic parameters assessed in this study are presented on Table 1. The result of the plant height showed that taller plants (75.50cm) are observed in 120g rate of $CaCO_3$ and 60cm x 75cm plant spacing respectively. Though the plant height showed non-significant difference ($P < 0.05$), the height of the pepper plant increased as spacing increased 72.82cm (60 x 75cm) >67.03cm (50 x 75cm) >65.63cm (40 x 75cm) while in the rate of lime, it increased in 120g but decreased in 160g rate. The number of fruit and weight of fruits results showed statistical significant difference among the treatments. The number of fruits and weight of fruit increased with attendant increase in the rates of $CaCO_3$ and decreased with an increase in plant spacing. The highest value recorded for the two parameters were observed in 160g rate of $CaCO_3$and 40cm x 75cm spacing of which the values is 4.75g/plot and 3.75kg/plot respectively. The percentage decrease in weight of fruit in 50 x 75 cm and 60 x 75cm relative to 40 x 75cm were 16.15% and 20% respectively, while increase in weight of fruit in 80gand 120g$CaCO_3$ relative to 160g$CaCO_3$ were 302.44% and 20% respectively. The result of the agronomic parameters of pepper assessed in this study indicated that plant spacing and lime have profound effect on the assessed parameters.

The results of soil chemical properties in Table 2 indicated that OC, P and CEC results were not statistically significant, an indication that the influence of spacing and lime on the parameters are not effective, however, the value recorded for the

parameters indicated increase in value as rates of $CaCO_3$ increased and decreased as planting spacing increased. The percentage increase in value of data generated from 80g and 120g for the parameters relative to 160g$CaCO_3$ were 102.13%, 15.85% (OC), 200.60%, 60.98% (P) and 49.33%, 27.77% (CEC) respectively. While percentage decrease in value as planting spacing increased from 40 x 75cm to 60 x 75cm were 10.98%, 17.07% (OC), 2.51%, 4.25% (P), and 6.47%, 18.88% (CEC) respectively. The result of soil pH and TN showed statistical significant difference among the treatment means of which indicated that spacing and lime had profound influence on the two parameters. Their values decreased with increasing plant spacing, but increased with attendance increase in rates of $CaCO_3$. The interaction effect of plant spacing and lime were found not effective in this study.

Table 1. *Effect of plant spacing and lime ($CaCO_3$) on yield and yield components of pepper.*

Parameter	Spacing (cm)	80g	120g	160g	Mean
Number of Fruit/Plot	40cm75cm	2.50	4.00	4.75	3.75
	50 cm x 75cm	2.20	3.96	4.35	3.50
	60cm x 75cm	1.50	3.45	4.20	3.05
	Mean	2.07	3.80	4.43	
Plant Height (cm)	40cm75cm	64.17	67.11	65.61	65.63
	50 cm x 75cm	65.83	68.72	66.55	67.03
	60cm x 75cm	70.85	75.50	72.39	72.82
	Mean	66.85	70.44	68.18	
Weight of Fruits (kg/Plot)	40cm75cm	1.05	3.00	3.75	2.60
	50 cm x 75cm	0.80	2.60	3.15	2.18
	60cm x 75cm	0.60	2.65	3.30	2.08
	Mean	0.82	2.75	3.30	

Number of fruits/plot
$LSD_{0.05}$= 0.54 (comparing spacing and $CaCO_3$)
$LSD_{0.05}$= 0.32 (comparing spacing or $CaCO_3$)
Spacing x lime = NS
Plant height = NS

Weight of fruits kg/plot
$LSD_{0.05}$= 0.66 (comparing spacing and $CaCO_3$)
$LSD_{0.05}$= 0.39 (comparing spacing or $CaCO_3$)
Spacing x lime = NS
NS = Not-significant

Table 2. *Effect of plant spacing and lime (CaCO3) on soil chemical properties.*

Parameter	Spacing (cm)	80g	120g	160g	Mean
pH(H_2O)	40 x 75	6.70	8.60	8.70	8.0
	50 x 75	6.40	7.50	7.3	7.07
	60 x 75	4.60	5.90	6.10	5.53
	Mean	5.90	7.33	7.37	
OC %	40 x 75	0.56	0.88	1.03	0.82

	50 x 75	0.42	0.84	0.94	0.73
	60 x 75	0.43	0.74	0.88	0.68
	Mean	0.47	0.82	0.95	
N %	40 x 75	0.26	0.39	0.48	0.38
	50 x 75	0.24	0.33	0.37	0.31
	60 x 75	0.22	0.32	0.36	0.30
	Mean	0.24	0.35	0.40	
P $mgkg^{-1}$	40 x 75	7.95	19.51	31.10	19.52
	50 x 75	8.05	18.84	30.21	19.03
	60 x 75	7.85	18.31	29.92	18.69
	Mean	7.99	18.89	30.41	
CEC	40 x 75	40.00	40.00	52.20	44.07
	50 x 75	33.00	40.15	50.50	41.22
	60 x 75	26.00	36.09	45.15	35.75
	Mean	33.00	38.75	49.28	

pH (H2O)
LSD $_{0.05}$ = 1.72 (comparing $CaCO_3$ and plant spacing)
LSD $_{0.05}$ = 0.99 (comparing $CaCO_3$ or plant spacing)
Plant spacing x $CaCO_3$ = NS

T N
LSD $_{0.05}$ = 0.06 (comparing $CaCO_3$ and spacing)
LSD $_{0.05}$ = 0.03 (comparing $CaCO_3$ means)
$CaCO_3$ x spacing = NS
% C = NS; P and CEC = NS

4. Discussion

Apart from plant height result, every other agronomic parameter in this study was found to be significantly influenced by plant density and lime ($CaCO_3$). The assessed parameters were found to be increased as the rate of lime application increased and decreased with attendance increase in low plant density. The result is in tandem with the findings of Dean *et al.* [18]; Ara*et al.* [19]; Nasto*et al.* [5] and Nweke*et al,* [20]. The highest plant height of pepper (75.50cm) was observed in low plant density (60cm x 75cm), this might be due to less competition in environmental factors in low plant density. Plant height, leaf area index, leaf area expansion rate and shoot leaf area distribution are some of the main characteristics of plants involved in competition for light, these of course can be improved through changes in crop management practices such as plant spacing or plant population [21]. The findings from the chemical analysis of the studied soil was of evidence that lime application greatly increased the pH of the soil leading to the liberation of plant nutrients of which increased proportionally with the rates of lime applied as recorded in Table 2. The work of Okeke and Onyeanuforo [22], Adeleye et al [23] and Mbah et al [24, 25] showed that lime increase soil pH, chemical components of soil and reduced soil acidity to levels required by the maize production. Also most of the result obtained was found not to have been dependent on the levels of plant density. This probable being the nature of root spread in soil pepper being a shallow rooted crop its root spread to a large extent

will determine the uptake of water and all that dissolved there in, nutrients and their utilization. The work of the following authorsOzier-lafontaine et al., [26]; Adiku et al., [27]; Li et al., [28] indicated that roots tend to grow profusely into all sections of soil, when water is not a limiting factor, but under water stress they clump within their own zone and under severe water stress the roots do not intermingle at all. This scenario invariable will affect the efficiency of nutrient absorption and general morphological characteristics of the plant that led to differences in yield and chemical parameters obtained from the study.The agronomic and soil parameters results are found to be better in 160g and higher plant density compared with 80g and 120g rates and low plant density. The result may be associated with soil acidity level of studied area [13], rates of lime applied and plant density observed all this acting together might have influenced the liberation and mineralization of nutrients by the activities of soil organism.

5. Conclusions

The findings from this study have shown that lime and plant density influence pepper performance and soil nutrient status. $CaCO_3$ lime has proved to be a good source of soil amendment for the improvement of soil chemical properties and by extension fostering the activities of soil organisms that in turn resulted in higher growth and yield of pepper. With this results farmers are therefore advised to use lime at rate of 160g (400 kg/ha) to maximize the needed good significant effect.

Conflicts of Interest

There is no conflict of interest regarding the publication of this article.

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