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Effect of Organic Phosphorus Fertilizer and Plant Density on the Growth, Yield and Nutritional Value of Ginger (*Zingiber officinale*)

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ABSTRACT

A field experiment was conducted at the Ladoke Akintola University of Technology, Ogbomoso in the Guinea savannah zone of South Western Nigeria. Phosphorus fertilizer and plant density required for the optimum growth and yield of ginger were investigated. The treatments involved five phosphorus fertilizer (alesinloye organic fertilizer) rates applied at 0, 15, 30, 45 and 60 $kgPha^{-1}$ and three different spacing (25×50, 35×50 and 45×50 cm). These were assigned into a factorial experiment and fitted into a randomized complete block design and replicated thrice. The parameters taken were the plant height, number of leaves, number of shoots, length of rhizome and rhizomes yield. These traits showed significant increase to the application of P rate with optimum value obtained at 60 $kgPha^{-1}$ and at 45×50 cm planting distance. The combined effect of spacing and fertilizer rate significantly influenced in most of the characters. The percentage of crude protein, total ash, calcium, phosphorus, total starch, moisture content and crude fibre interaction was not significantly affected by all the measured nutritional values. The highest phosphorus fertilizer applied (60 kg ha^{-1}) at widest spacing of 45×50 cm had the highest value in all the nutrition component observed in ginger.

Key words: Ginger, phosphorus fertilizer, plant density, nutritional value

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) a spice crop is a member of the family Zingiberaceae and sub-family Zinigeradeae. It is a monocotyledonous crop which produces rhizomes that serve as the ginger of commerce. The rhizome which is pungent and aromatic and used for confectionary purposes in ginger bread, biscuits and cakes. Ginger was introduced in the international markets in the form of fresh (green) ginger, preserved ginger and dried ginger. The ginger spice is prepared by harvesting and drying the mature rhizome while the fresh ginger are consumed as a vegetable. The most important commercially is the dried product. The trade in preserved ginger is next in importance while that in fresh ginger is of least significance. The dried ginger is used as a spice in soup and also for the preparation of ginger oil (ginger oleoresin). Phosphorus is very important in plants and medicinal plants, the important function is the storage and transfer of energy through the plant. Adenosine Diphosphate (ADP) and Adenosine Triphosphate (ATP) are the energy phosphate compounds that control most processes in plants including photosynthesis, respiration, protein, nucleic acid synthesis and nutrient transport through the plant's cells (Sharpley *et al.*, 1996). Plants require phosphorus for growth, utilization of sugar and starch, photosynthesis and nucleus formation. Phosphorus is readily transfer within the plants from older to younger tissues as the plant forms cells and develops roots, stems and leaves. Effective supply of phosphorus has been described with the increased in root growth which means the plant can be able to explore more soil for nutrients. Phosphorus deficiency results in stunted crop growth, purpling or browning colour appearing first on the lower leaves and base of the stem and working upward on the plant. Despite the importance and nutritional properties of ginger in Nigeria diet, there is scarce information on its cultivation practices that will enhance the growth and its yield. The objectives of this study is therefore, To determine the optimum level of phosphorus fertilizer that will give best yield of ginger rhizomes and best plant population for the growth, yield and the nutritional component of ginger plant.

MATERIALS AND METHODS

A field experiment was carried out during the period of April to December 2011 at the Teaching and Research farm, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, (8°10'N and 4°10'E) a location in the guinea savannah zone of South-west Nigeria. The region has two rainy periods with more than 1000 mm of rainfall per annum. Soil sample of the experimental site were collected with soil Auger. The soil samples were air dried and sieved with wire mesh of 0.02 mm sieve. The particle size were determined by using the Bouyoucos (1962) hydrometer method. The experimental design used was Randomized Complete Block Design (RCBD) laid out in a split plot design with three replications. The main plot were different spacing (25×50, 35×50 and 45×50 cm), while different phosphorus fertilizer rates at 0, 15, 30, 45, 60 kg ha^{-1} (alesinloye organic fertilizer) were the subplot. Each plot size was 2×2 cm. Ginger rhizomes was cut into sett and planted at the depth of 5 cm and at three different planting distances at their respective plots. The recommended cultural practices were applied uniformly for all treatments according to KAU (1996). Harvesting was done when the leaves begin to change colour from green to yellow while the rhizomes was separated from the ginger plant. The response of Ginger to P fertilizer was assessed using the number of leaves, plant height (cm) and rhizome length. Data collection started immediately sprouting occurred and continued at 2 weeks interval for 15 weeks. The moisture content was determined using drying to the constant loss of the weight. Crude protein content was determined by the macrokjeldahl procedure as described by AOAC (1975). Phosphorus content was determined by the vanadomolybdate yellow colorimetry method (Jackson, 1964). Samples for starch determination were treated with dilute hydrochloric acid (PENTA, Chrudim). After clarification and filtration the optical rotation of the solution was measured by polarimetry. Routine concentration in all samples was determined using a modified method according to Deineka *et al.* (2004) and Gokarn *et al.* (2010). Other proximate analysis of ginger was done chemically according to the official methods of analysis described by AOAC (1990,1998,1984). All data collected were subjected to ANOVA and significant means were separated by the Least Significant Differences (LSD) at 5% probability level.

RESULTS AND DISCUSSION

The chemical and physical properties of the soil used for the experiment before planting are presented on Table 1. The soil is sandy loam with a slightly acidic pH with total N, available P,

Table 1: Chemical and physical properties of the soil

Parameters	Value
pH (HO)	6.0
Total N (%)	0.10
Available P (ppm)	5.77
Organic Carbon (g kg^{-1})	2.39
Exchangeable cations (c mol kg^{-1})	
Ca^2	2.25
Mg^2	1.12
K	0.24
Na	0.40
Physical characteristics	
Sand %	86.70
Silt %	9.20
Clay %	4.10
Textural class	Sandy loam

Table 2 : The mean plant height(cm) of ginger plant as affected by phosphorus fertilizer at different sampling period

		Week after planting				
Spacing (cm)	Treatment rate (kg)	7	9	11	13	15
25×50	0	18.1	18.3	19.9	21.6	41.5
	15	21.4	22.2	23.2	24.9	57.4
	30	19.6	19.7	20.4	22.6	57.4
	45	19.7	20.8	21.4	23.1	60.4
	60	18.3	18.9	19.6	21.4	62.4
35× 50	0	18.0	18.8	19.8	21.4	59.4
	15	19.4	20.3	21.4	22.1	50.6
	30	18.6	23.1	23.9	25.6	60.2
	45	19.5	20.1	21.1	22.3	52.2
	60	20.9	21.5	22.8	24.5	58.2
45×50	0	19.6	20.2	21.1	22.8	61.1
	15	20.3	21.2	22.2	25.2	56.8
	30	19.2	19.9	21.1	24.0	59.9
	45	20.9	21.8	23.3	26.8	59.4
	60	21.3	22.3	23.8	26.7	65.1
L.S.D. (0.05)		0.99	0.46	0.17	0.17	0.15
C.V (%)		3.02	1.33	0.47	0.44	0.16
Fertilizer		**	**	**	**	**
Spacing		**	**	**	**	**
Fert.× Spac.		**	**	**	**	**

*Significantly different at the p<0.05 level; **Significantly different at the p<0.01 level; NS: No significant difference

exchangeable K and organic carbon at 0.10%, 5.77%, 0.24 cmolkg^{-1} and 2.39 gkg^{-1}, respectively. The result of the soil test values indicated the nutrient status of the soil before plant.

Effect of plant spacing: This results of the effect of different plant spacing on various morphological, yield and yield contributing characters of ginger are shown in the following tables below. Table 2 indicated the mean plant height (cm) of ginger plant as affected by phosphorus fertilizer at different sampling period. Table 3 identified the mean number of leaves of ginger plant

Table 3: The mean number of leaves of ginger plant as affected by phosphorus fertilizer application at different sampling period

		Week after planting				
Spacing (cm)	Treatment rate (kg)	7	9	11	13	15
25×50	0	5.3	6.9	9.7	11.6	13.4
	15	6.6	8.8	21.2	14.4	16.5
	30	6.2	7.7	10.4	12.5	14.5
	45	6.0	8.0	11.0	13.4	15.3
	60	6.3	8.1	10.9	12.9	14.9
35× 50	0	6.0	7.4	9.9	12.1	13.9
	15	6.3	7.9	10.4	12.4	14.7
	30	6.7	8.9	11.5	13.7	15.4
	45	5.3	6.7	8.9	10.5	12.2
	60	5.9	7.4	9.6	11.4	13.3
45×50	0	7.2	9.0	11.6	13.9	15.8
	15	6.1	8.3	11.1	12.7	13.9
	30	5.9	8.0	10.6	12.6	15.1
	45	5.4	7.5	10.4	12.4	14.7
	60	6.8	8.3	11.9	13.6	15.0
L.S.D. (0.05)		0.14	0.48	0.17	0.14	0.17
C.V (%)		1.35	3.59	0.89	0.65	0.68
Fertilizer		**	**	**	**	**
Spacing		**	**	**	**	**
Fert.× Spac.		**	**	**	**	**

*Significantly different at the p<0.05 level; **Significantly different at the p<0.01 level; NS: No significant difference

as affected by phosphorus fertilizer application at different sampling period while Table 4 presented the mean number of shoot, length of rhizome and total yield of rhizome as affected by phosphorus fertilizer. The plant height, number of leaves, number of shoots, length of rhizome and total yield (t ha^{-1}) differed significantly with different plant spacing. Plant height and length of the rhizome were significantly improved in the wider spacing compared with closer spacing. The widest spacing (45×50 cm) produced the tallest plant (65.1 cm) and longest rhizome (26.3 cm). This was probably due to better availability of plant nutrients, moisture and light in wider spaced plant. The highest number of leaves was obtained when plants were spaced closer (25×50 cm). Likewise, the highest yield (26.8 t ha^{-1}) and number of shoot (10.2) were obtained when plants were spaced closer (20×50 cm). At widest spacing (45×50 cm) yield was the lowest (12 t ha^{-1}). The former two treatments did not differ significantly. The significant increase in yield under closer spacing may solely be ascribed on the function of higher plant density per unit area of land. Similarly finds were observed by many research work (Rahman and Faruque, 1974; Shashidhar *et al.*,1997; Loknath and Das 1964; Aiyadurai 1966). These indicate that plant population is one of the most important factor for yield in ginger. Similar results were found by Ahmed *et al.* (1988) in ginger.

Response of phosphorus: The level of phosphorus showed a marked influence on different plant characters, plant height, number of leaves, number of shoot, length of rhizome and total yield (Table 2-4).The plant height was found to be increased significantly with the increase of the level of phosphorus and the tallest plant (65.1 cm) was obtained from the dose of 60 kg ha^{-1} P. The shorter plant was found from the dose of 0 and 15 kg ha^{-1} P. Number of shoot and length of rhizome do not varied widely due to spacing or levels of P in ginger. The tallest plant height,

Table 4: The mean number of shoot, length of rhizome and total yield of rhizome as affected by Phosphorus fertilizer

Spacing (cm)	Treatment rate (kg ha^{-1})	No. of shoot	Length of Rhizome (cm)	Yield of Rhizome (t ha^{-1})
25×50	0	6.9	20	22
	15	6.6	23.2	18.8
	30	7.1	17.6	16.8
	45	8.2	22.5	15
	60	10.2	21.8	26.8
35×50	0	6.3	21.3	14
	15	7.9	21.1	13.2
	30	8.6	21.0	15.2
	45	9.3	21.1	16
	60	9.5	20.8	20.8
45×50	0	6.1	19.2	12
	15	9.1	18.7	16.8
	30	9.6	21.6	16.8
	45	9.7	20.1	16
	60	10	26.3	22
L.S.D (0.05)		0.18	0.48	0.76
C.V (%)		1.32	1.37	4.52
Fertilizer		**	**	**
Spacing		**	*	**
Fert.×Spac.		**	**	**

*Significantly different at the $p<0.05$ level; **Significantly different at the $p<0.01$ level; NS: No significant difference

highest number of shoot and total yield of ginger were produced with the application of 60 kg ha^{-1}P. The shortest plant height, lowest number of shoot and lowest number of the total yield were produced at the plots that received no P. Increasing trend of plant height with increasing dose of P was also reported by Kumar *et al.,* (2002) in phaseolus trilobus. Anilkumar *et al.,* (2001) reported application of P was significantly higher in plant height of mustard.

Interaction effect: The combine effect of spacing and phosphorus was found to be significant for all the characters. Almost all the characters of ginger were found to be increased with the increasing level of phosphorus irrespective of spacing. Plant height was influenced by both spacing and phosphorus. The tallest plant being obtained from a plant spacing of 45×50 cm with 60 kgPha^{-1}. Except the number of leaves and length of rhizome other parameters showed superiority with a combination of plant spacing of 45×50 cm and phosphorus dose of 60 kg ha^{-1}. The closest spacing (25×50 cm) accompanied with a dose of 60 kg ha^{-1} gave the highest yield (26.8 t ha^{-1}) of ginger. The result obtained from this study indicates that there was a general trend of yield increase with the increase dose of phosphorus and plant population per unit area.

Nutritional component of ginger: The nutritional component of ginger as affected by phosphorus fertilizer is presented in Table 5.The percentage of crude protein, total ash, calcium, phosphorus, total starch, moisture content and crude fibre interaction was not significantly affected by all the measured nutritional values. Except for the spacing where significant different were observed in crude protein, calcium, total starch and moisture content. Likewise, in fertilizer rate significant different were observed in calcium and moisture content. In all the nutritional

Table 5: The nutritional component of ginger plant as affected by phosphorus fertilizer

Spacing (cm)	Treatment rate (kg ha^{-1})	Crude protein (%)	Total ash (%)	Ca (%)	P (%)	Total starch (%)	Moisture content (%)	Crude fibre (%)
25×50	0	7.69	2.94	16.30	23.80	3.60	8.70	2.03
	15	7.73	2.97	17.40	24.90	2.80	9.20	2.15
	30	7.78	2.99	17.85	14.98	2.91	9.25	2.18
	45	7.85	3.32	18.75	26.56	4.15	9.55	2.25
	60	7.77	3.08	17.96	25.80	3.90	9.40	2.17
35×50	0	8.85	3.24	18.74	26.94	3.98	9.60	2.19
	15	8.88	3.26	18.85	26.96	3.98	9.61	2.25
	30	8.91	3.31	18.92	26.96	3.99	9.67	2.25
	45	8.95	3.35	18.98	27.15	4.05	9.75	2.35
	60	8.99	3.36	18.98	27.18	4.08	9.77	2.40
45×50	0	8.89	3.30	18.90	27.40	4.30	9.80	2.21
	15	8.90	3.41	19.27	27.80	4.50	10.40	2.24
	30	8.95	3.45	19.45	27.85	4.55	10.45	2.26
	45	9.10	3.50	19.56	27.90	4.62	10.50	2.45
	60	9.18	3.55	19.63	27.95	4.65	10.54	2.51
L.S.D (0.05)		1.00	0.77	0.87	13.40	1.19	0.46	0.75
C.V(%)		6.96	14.16	2.79	30.81	17.78	2.81	19.84
Fert.		NS	NS	**	NS	NS	**	NS
Spacing		**	NS	**	NS	**	**	NS
Fer×Spa		NS	NS	NS	NS	NS	NS	NS

*Significantly different at the p<0.05 level; **Significantly different at the p<0.01 level; NS: No significant difference

component of ginger measured, it was observed that the highest phosphorus fertilizer applied (60 kg ha^{-1}) at widest spacing of 45×50 cm had the highest value in all the nutrition component observed in ginger.

CONCLUSION

As a conclusion, it was found that increase in phosphorus organic fertilizer at 60 kg ha^{-1} and plant spacing at 25×50 cm could be suggested for ginger cultivation in southwest Nigeria.

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