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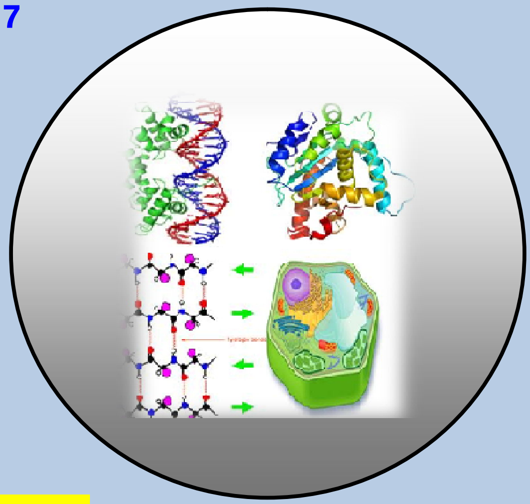

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RESEARCH PAPER

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Influence of Inorganic Fertilizer and Spacing on the Performance of Ginger *Zingiber officinale* Rose

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ABSTRACT

Field experiments were conducted at the National Horticultural Research Institute NIHORT, Ibadan, Nigeria in 2009 and 2010 to evaluate the effects of fertilizer and population density on growth and yield parameters of ginger Zingiber officinale Rose. The fertilizer was applied at the rate of 0, 150, 300, 450 and 600kg NPK 15-15-15/ha, while the population densities were 200, 250 and 303 x 10^3 plants/ha using 20cm x 25cm; 20cm x 20cm and 20cm x 16.5cm respectively. The experiment was laid out in a split-plot design in Randomized Complete Block Design RCBD, replicated three times. The parameters measured include plant height, number of leaves, number of shoots and rhizome yield. The result revealed that rhizome yield increased with increase in fertilizer and population density up to 300kg/ha at 250 x10^3 plants/ha. The lowest yields of 3.78 and 2.65 tons/ha were recorded in control with no fertilizer at the lowest density in 2009 and 2010 respectively. The result further revealed that though the plant population density of 303 x 10^3 gave no significant difference in most parameters when compared with 250 x 10^3, the partial budgeting revealed that highest net benefit NB and marginal rate of returns MRR came from the 250 x 10^3 plants/ha. This study therefore recommend the optimum fertilizer rate of 300kg/ha NPK at 250 x 10^3plants/ha for best rhizome yield of ginger.

Keywords: Density, Evaluation, Nigeria, Population, Rhizome and Spice.

INTRODUCTION

Ginger *Zingiber officinale* is a spice grown across many climates in the world. Originating in India and Malaysia, ginger is a hardy herbaceous plant that thrives in tropical and sub-tropical climates, particularly in humid and shady conditions (Hass, 1998, Adegboye, 2011 and Spore, 2012). It is valued for its flavour and pungency thus the food, perfumery and pharmaceutical industries are the main outlets for its use. Ginger is also known to have broad spectrum prophylactic and therapeautic functions explaining its value for medicinal purposes locally (Karikari, and Musa, 1985, Al-Amin et, al., 2006, Nya and Austin, 2009, Sang et, al., 2009, El-Ghorab et al., 2010, Sivasothy et al., 2011 and Spore, 2012). Most recently, ginger has been used in the protection of agricultural crops from pests and diseases in the field and during storage (Ukeh et al., 2012).
Nigeria produces an average of 152,106 tons per annum (FAO, 2009). About 10% of the produce is consumed locally as fresh ginger while the remaining 90% is dried for both local consumption and export (Ezeagu, 2006). In Nigeria, ginger was traditionally grown in the guinea savanna region (Onwueme, 1988), however, in recent times; ginger cultivation has been introduced into the South Eastern and South Western agricultural zones of Nigeria (Adegboye, 2011). Ginger is cultivated vegetative through its rhizome; modern micro propagation is also being used where new plants are cloned from cells taken from a plant (Rosilda et al., 2010). The crop required a good soil tilled for production of well-shaped rhizomes (NAERLS 2004). Rhizome weighing between 5-10 g with at least two good buds or growing points was recommended for planting (NAERLS 2004). Ginger has a high nutrient demand from the soil, hence the need for fertilizer application (Nishina et al., 1992). Among all the nutrients, nitrogen was the major limiting nutrient militating against massive production of ginger (Njoku, 1989) and application of inorganic N.P.K.15:15:15 fertilizer at the rate of 300kg/ha applied 6-8 weeks after planting in split applications has been recommended as being adequate (Adegboye, 2011) on the other hand, NAERLS (Adegboye, 2011) recommended 400 kg/ha of nitrogen, phosphorus and potassium N.P.K. 12:12:17 at planting and top dressing with 100 kg/ha urea at 12 weeks after planting for the northern savannah zone of the country. Despite the high usage of ginger in the southwestern Nigeria, its cultivation has not been popular as many farmers regard it as a spice crop for the drier area of the north. Often, the zone depends on the supply from other ecological zones of the country. However, the recent report by NAERLS (Adegboye, 2011) on the suitability of the Southwestern zone of the country for production of this important spice has necessitated the need for this study. This present study was carried out to determine the effect of NPK fertilizer and planting density on the growth and yield of ginger in rainforest agroecological zone of Nigeria.

MATERIAL AND METHODS

The study was conducted in the year 2009 and 2010 at the National Horticultural Research Institute NIHORT, Ibadan, Nigeria 7°23′N and 3°54′E 168 m a.s.l., located in the humid forest zone. The rainfall for the location is bi-modal Table 1 while the experimental site was a sandy loam Table 2. Ginger rhizomes were cut into small sets having two nodes and planted out according to the population treatments on raised beds prepared after manual clearing. The study was set up as a factorial experiment with fertilizer rate 0, 150, 300, 450 and 600 Kg NPK/ha and population density 200, 250 and 303 x 10^3 plants/ha serving as the two factors giving a total of 15 treatment combinations. The whole experiment was arranged using split plot in randomized complete block design RCBD. The fertilizer rates were applied in three split application at 9, 15 and 20 weeks after sowing WAS using N.P.K. 15:15:15. Population density was the main plot while fertilizer rate served as the sub-plot. The treatments were replicated four times. Each plot size was 2m x 2m. Hand weeding was done using hoe at 3, 4 and 5 months after planting MAP. Data were collected on plant height, number of shoot, number of leaves at two weeks interval. Harvesting was done at 36 weeks after planting. Number and fresh weight of rhizomes were collected at harvest. Statistical analysis was done by Analysis of Variance ANOVA using the SAS programme (SAS Institute 1989) to determine the effects of treatments. Comparison of significant means was done by the use of LSD at 5% probability level. To consolidate the statistical analysis of agronomic data, Partial budget analysis of the experiment was carried out to assess the profitability of using each fertilizer and population treatment combination (CIMMYT, 1988 and Akinyemi et al., 2006). Open market price in the experimental area in 2010 was used in calculating all the costs and benefits. The net benefit NB, which considered only the variable costs in each treatment and marginal rate of return MRR was calculated as:

Net benefit NB = Gross field benefit – Total variable costs TVC.

$$\text{Marginal Rate of Returns MRR \%} = \frac{\text{NB stepB} - \text{NB stepA}}{TVC_{TB} - TVC_{TA}} \times \frac{100}{1}$$

Where step A = first treatment A

Step B = next treatment B.

RESULTS

Vegetative Growth

The combined result of the two seasons on growth parameters revealed that ginger plant height was significantly $p < 0.1$ influenced by application of inorganic fertilizer starting from the fourth week after sowing WAS Table 3. The application of 300Kg NPK/ha gave the highest height throughout the trial with the exception of the values recorded at 12 WAS. The values obtained from this rate was however not significant different from those of 400Kg NPK/ha.

At 16 weeks after sowing WAS, which correspond to the peak of active growing stage of ginger, the tallest plant was 33.42 cm at 300 Kg/ha NPK 15-15-15. This was 38% higher than the value obtained for the control which gave the least height. The leaf count also revealed similar significant response but at P>0.5 to fertilizer application with the highest number of leaves being observed at 300 and 450 Kg/ha in all period of observation with the exception of 16 WAS.

The result further revealed that the population density did not have significant effect on plant height but the number of leaf produced per plant significantly p > 0.5 increased with increase in population density as from 8WAS. The highest number of leaves 12.1 was produced at the highest density tested 303 x 10^3 plants/ha at 16 WAS Table 1. Contrarily, the interaction between the two factors Fertilizer x Population was not significant.

Rhizome yield

Rhizome yield of ginger was significant influenced by fertilizer in both years with the 2009 yield being higher than that of 2010 Table 4. The rhizome yield of 2009 was 34.7, 27.8, 65, 46.2 and 59.6% higher than that of 2010 in 0, 150, 300, 540 and 600 Kg NPK/ha respectively. Generally, ginger yield increased with increase in fertilizer application up to 300 kg/ha before decreasing as from 450 to 600 kg NPK/ha in both years. Though, yield produced by plants under 450 Kg NPK/ha was comparable to that of 600Kg NPK /ha but in 2010 the former was significantly higher than the later Table 4. No significant difference existed between the control and 150 Kg NPK/ha in both years. The rhizome yield also increased significantly with increase in population density in both years. The optimum yield was obtained at 250,000 plants/ha. This density gave an increase of 28.6 and 44.5% over the 200,000 plants/ha and 13 and 18% over 303,000 plants/ha in 2009 and 2010 respectively Table 4. The highest Net benefit was obtained at 300 Kg NPK/ha under 250,000 plants/ha combination Table 5. This combination also gave the highest marginal rate of return MRR when compare with other fertilizer rates and population densities.

DISCUSSION

The need to augment the nutrient status of the soil with application of fertilizers that do supply essential nutrients such as nitrogen, phosphorous and potassium for adequate plant growth and optimum yield is becoming more popular (De Grazia et al., 2003). In this study, ginger responded significantly and positively to the fertilizer application in all growth and yield parameters, this may be due to the fact that ginger, like other root and tuber crops, has a high nutrient demand on soils as observed by Lujiu Li, *et. al. 2010*. Similar trends had been observed by several workers (Chukwu and Emehute, 2001 and Ohiri, 1990). In fact, it was further stated that ginger do give a good yield when planted on a farmlands that are newly opened from long fallows because it makes use of nutrients reserves accumulated during the fallow period (Chukwu and Emehute, 2001 and Attoe, and Osodeke, 2009).

Table 1. Weather data of the experimental site 2009 and 2010

Month	2009				2010			
	Max. Temp. ^0C	Min. Temp. ^0C	Relative Humidity %	Rainfall cm	Max. Temp. ^0C	Min. Temp. ^0C	Relative Humidity %	Rainfall cm
January	33.58	22.06	87.10	32.8	35.33	23.17	89.03	7.50
February	34.61	24.18	88.07	7.9	35.90	24.10	85.85	27.30
March	34.39	24.13	89.00	20.76	34.93	24.70	86.73	11.10
April	33.07	23.40	88.93	23.73	34.31	24.69	85.69	20.41
May	31.50	23.03	87.90	14.99	31.933	23.70	88.33	10.64
June	30.83	23.00	87.45	14.08	31.10	23.93	87.86	8.19
July	29.53	23.03	90.90	9.81	29.10	22.70	88.57	13.87
August	28.20	22.63	90.23	2.8	28.63	22.67	89.93	18.10
September	29.90	22.41	90.17	21.52	29.93	22.69	89.07	12.27
October	30.23	24.80	88.93	13.57	31.29	23.24	87.88	9.96
November	32.14	22.14	87.28	11.28	33.25	23.75	87.50	0.00
December	34.50	23.10	88.87	0.00	34.03	22.10	84.67	0.00

Table 2. Physical and chemical properties of the soil at the experimental site.

Soil	Value
pH	6.6
Organic carbon g/kg	1.35
Total N g/kg	0.13
Available P mg/kg	3.25
Exchangeable bases Cmol/kg	
Ca	4.73
Mg	1.21
Na	0.13
K	0.41
Exchangeable bases mg/kg	
Mn	1.16
Fe	31.4
Cu	2.09
Zn	12.8
Particle size analysis	
Sand	78.3
Silt	17.6
Clay	3.8

Table 3. Shoot height and number of leaves of ginger as affected by fertilizer rates and population density.

Treatment	**4WAS**		**8WAS**		**12WAS**		**16WAS**	
Fertilizer levels NPK kg/ha	**Plant Height**	**No. of leaves**	**Plant Height**	**No. of leaves**	**Plant Height**	**No. of leaves**	**Plant Height**	**No. of leaves**
	cm ←							→
O	5.06c	4c	11.86d	5.8c	18.6d	6.8c	25d	8.4d
150	6.09bc	4.8b	14.58c	6.9b	22.91c	8.4b	28.93c	9.9c
300	11.63a	5.8c	22.02a	8.4a	26.96ab	10.6a	33.42a	11.7b
450	10.5a	5.7a	21.96a	8.2a	27.94a	10.7a	32.58ab	13a
600	7.14b	5.3ab	18.37b	7.7ab	25.73b	10.2a	30.23bc	14a
cv	22.82	12.03	13.11	14.24	9.49	15.97	8.39	11.24
Significance	**	*	**	*	**	*	**	*
Population plants/ha 10^3								
200	8.13a	5a	17.85a	6.8b	24.8a	8.9b	29.28a	10.9b
250	7.78a	5.1a	17.41a	7.7a	23.87a	9.5a	30.07a	11.2ab
303	8.35a	5.3a	18.00a	7.7a	24.49a	9.6a	30.76a	12.1a
Significance	Ns	Ns	Ns	*	Ns	*	Ns	*
F x P	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

Within a treatment group, means in a column followed by the same letters are not significantly different at 5% level using LSD. Ns = not significant; * = significant at p<0.5, ** = significant at p<0.1.

Table 4. Rhizome yield t/ha of ginger as affected by fertilizer rates and population density.

Treatment	**2009**	**2010**
Fertilizer rates Kg/ha		
0	3.26	2.13
150	2.94	2.30
300	7.59	4.60
450	5.70	3.90
600	5.22	3.27
LSD 0.05	0.67	0.60
Population plants/ha 10^3		
200	3.78	
250	5.86	
303	5.20	
LSD 0.05	0.67	
Population P	**	*
Fertilizer F	**	**
P x F Interaction	**	*
CV %	14.0	19.0

Table 5. Partial budget of Ginger under different fertilizer rates and population densities

TREATMENTS															
Fertilizer Rates	**0**			**150**			**300**			**400**			**600**		
Population	**P1**	**P2**	**P3**	**P1**	**P2**	**P3**	**P1**	**P2**	**P3**	**P1**	**P2**	**P3**	**P1**	**P2**	**P3**
Av. yield (t/ha)	2.14	2.91	3.03	2.51	2.97	2.41	4.17	7.53	6.57	3.71	5.72	4.98	3.54	5.1	4.1
Ginger @ ₦500 per kg (xN10^4)	107	145.5	151.25	125.5	148.25	120.25	208.25	376.25	328.25	185.5	285.75	249	177	255	205
Gross Field benefit (x ₦ 10^4)	107	145.5	151.25	125.5	148.25	120.25	208.25	376.25	328.25	185.5	285.75	249	177	255	205
Variable Cost															
Cost of fertilizer @N120 per kg (x ₦ 10^4)	0	0	0	1.53	1.53	1.53	3.06	3.06	3.06	4.59	4.59	4.59	6.12	6.12	6.12
Cost of labor for fertilizer application (x ₦ 10^4)	0	0	0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Cost of labor for harvesting @ N500 manday (x ₦ 10^4)	0.6	0.65	0.6	0.6	0.7	0.65	0.65	0.7	0.7	0.6	0.6	0.6	0.7	0.6	0.7
Total VC (x ₦ 10^4)	0.6	0.65	0.6	2.43	2.53	2.48	4.01	4.06	4.06	5.49	5.49	5.49	7.12	7.02	7.12
Net benefit (x ₦ 10^4)	106.4	144.85	150.65	123.07	145.72	117.77	204.24	372.19	324.19	180.05	280.26	243.51	169.88	247.98	197.88
MRR %	-	**79000**	-	-	**22650**		-	**335900**	-	-	-	-		-	-

Within a treatment group, means in a column followed by the same letters are not significantly different at 5% level using LSD. Ns = not significant; * = significant at p<0.5, ** = significant at p<0.1

The application of 300 Kg NPK/ha gave the highest yield in both years. Further increase beyond this rate resulted in yield decrease. This non-correspondence in yield increase implies luxury consumption of nutrient, it is therefore not advisable to apply fertilizer beyond 300 Kg NPK/ha for optimum yield in humid forest zone where the experiment was conducted. This rate was higher than that of Attoe and Osodeke, 2009, who recommended that the optimum NPK treatment combination of 200:80:100 kg/ha is most suitable for ginger production in Cross River state of Nigeria.

However, the rate from this study was lower than that of Lujiu Li, *et. al. 2010*, who reported the rates of 400-90-400 kg N-P2O5-K 2O/ha and 450-120-450 kg N-P2O5-K 2O/ha for two different locations in Southern China.

The trend in growth and yield parameters in this study revealed that ginger generally performed better in 2009 than 2010. Several factors could be responsible for this difference in yield, part of which could be the weather condition as it was observed that the maximum temperature was lower and rainfall spread was better in the first year than the second.

The savings in the cost of input fertilizer in all densities in control treatments contributed to the higher Marginal rate of return MRR of the control over that of 150 Kg NPK/ha. However, the higher income from the rhizome yields from 300 Kg NPK/ha at 250,000 plants/ha resulted in the highest MRR making it the most economical treatment.

CONCLUSION

The use of fertilizer is essential for the production of spices like ginger especially where the soil nutrient might not be adequate. There is however the need for caution so as to prevent luxury consumption without corresponding output. This study therefore recommend the optimum fertilizer rate of 300 kg NPK 15:15:15/ha at 250,000 plant/ha as the most suitable and profitable rate for ginger production in this humid forest zone.

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