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Research Paper

Growth and yield parameters of ginger as influenced by varying populations of maize intercrop

Lyocks S. W. J.[1]* • Tanimu J.[2] • Dauji L. Z.[1]

[1]Samaru College of Agriculture, Division of Agricultural Colleges, Ahmadu Bello University, Zaria, Nigeria.
[2]Department of Soil Science and Land Resources Management, Federal University Wukari Taraba State, Nigeria.

*Corresponding author. E-mail: swjlyocks@gmail.com. Tel: +2348023548026, +2347037695235.

Abbreviations: WAP, Weeks after planting; **SE,** standard error.

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Abstract. Intercropping of maize in ginger crop is a common practice among small scale farmers in southern Kaduna in Nigeria. However, the appropriate maize plant density to be applied on ginger crops is not known. A field experiment was conducted during the cropping seasons of 2009 and 2010 in Zaria, Nigeria to determine the most suitable maize population that would provide an appropriate advantageous shade to ginger without significantly affecting its yield or the yield of maize adversely. The field was planted with ginger at a uniform spacing of 20 cm × 20 cm (250000 plants ha^{-1}) into which the varying maize populations 72222, 36111, 24074 and 18055 $plantsha^{-1}$ were intercropped in addition with sole ginger, and sole maize crop at 72222 plants ha^{-1} as treatments 1 to 6, respectively. The experiment consisted of six treatments replicated four times in a randomized complete block design. Data for ginger and maize on growth parameters were obtained during the experiment period while the yield parameters were obtained at harvest. The results showed that the ginger growth parameters did not show any significant ($P \leq 0.05$) differences in the means among treatments in the trails. However, intercropping ginger with 24074 maize plants per hectare produced ginger rhizome yield of 10.84 tonnes ha^{-1} which was significantly ($P \leq 0.05$) comparable with highest rhizomes yields of 14.08 $tonnesha^{-1}$ obtained in sole ginger crop ($P \leq 0.05$). The 24,074 $plantsha^{-1}$ maize population density also produced the highest maize grain yield (3.98 $tonnesha^{-1}$) among the intercropped treatments. This treatment thus serves as the recommended intercropped populations of ginger and maize.

Keywords: *Zingiber officinale* Roscue*, Zea mays* L., population density, intercropping, shade, rhizome, northern guinea savanna.

INTRODUCTION

Crop diversification as displayed by intercropping has long being a prominent feature of small holder crop production in Sub-Sahara Africa. This is further promoted by the farmers concerns not only for enhancing farm productivity per unit land but also to ensure security against potential risks of monoculture alongside creating a platform for stabilizing the diversified needs of farming households whose production is greatly influenced by vagaries of nature (Tahir et al., 2003). It has been reported that ginger is a shade loving crop (Beets, 1990; Okwuowulu, 2005), which may explain why Southern Kaduna farmers, the traditional growing area of ginger in Nigeria are known to grow ginger under tree shades (Musa, 1991). This practice enables ginger to take advantage of the decaying leaves which drop from the trees to become a source of nutrients (humus) in addition to the shade provided by the trees like locust beans both of which help to improve ginger yields (Beets, 1990). Today, more land areas are cultivated with ginger and it is becoming impossible to provide enough tree shades to accommodate the expansion. Plots of land far less than a tenth of a hectare were previously cultivated under scattered trees around the farmers' houses. Before the end of the twentieth century, farmers were not known to practice intercropping on ginger farms with any other crop. This is understandable because not many crops perform well under tree shades together with the growing ginger, hence it will be an economic waste if the intercropped species is not shade tolerant. Now, that cultivation is expanding, it has been reported that the crop is being intercropped with other crops. The major intercrops used in large ginger growing countries like India are ginger + maize, maize + finger millet, maize + cassava, maize +buckwheat, and vegetables (Lachungpa, 2004). This practice appears more advantageous as it enables farmers to grow the normal crop (ginger) in addition to receiving bonus of another from the same field as reported by (Mkamilo, 2004). The magnitude of the agro-economic advantages depends upon the type of intercrop (Rao, 1991). Intercropping being a unique practice of tropical and sub-tropical areas is becoming more popular among small scale farmers as it offers the yield advantage relative to sole cropping through yield stability and improved yield (Bhatti et al., 2006). However, there is a paucity of information on the intercropping of ginger with other crops in Nigeria. This is because ginger as old as its cultivation has been in Nigeria, has not got the research attention that was given to other cash crops such as cocoa, cotton, groundnuts, oil palm, rubber, etc. Since maize is one of the major growing crops in Kaduna State. The study was carried out to determine the most suitable maize population that would give an appropriate advantageous shade to ginger without significantly affecting its yield or the yield of maize adversely. The result of the experiment will provide the farmers useful information as to the maize plant population to adopt for maximizing the use of environmental resources without losing out in the final yield of ginger, which is their major crop.

MATERIALS AND METHODS

This experiment was conducted in the 2009 and 2010 cropping seasons on the research farm of the Samaru College of Agriculture, Ahmadu Bello University, Zaria, Nigeria located on latitude 11°11″ N and longitude 07°38″ East in the Northern Guinea Savanna ecological zone of Nigeria.

Soil analysis

The soil samples of the two locations were analysized by

the following methods: The particle size distribution was determined by the standard hydrometer method (Klute, 1986). The soil pH was determined in water and 0.01 M $CaCl_2$ with a pH glass electrode using soil: solution ratio of 1:2.5. Organic carbon was determined by wet oxidation method of Walkley-Black (Nelson and Sommers, 1982). Exchangeable bases were determined by extraction with neutral 1N NH_4OAC saturation method. Potassium and Na in the extract were determined by flame photometer, while Ca and Mg were determined by atomic absorption spectrophotometer (Juo, 1979). Available P concentration in the extract was determined calorimetrically. Total N was determined by the Kjeldahl procedure (Bremner, 1982) (Table 1).

Cow dung analysis

The cow dung samples were digested using wet oxidation method, K and Na in digest was determined by flame photometer, while Ca and Mg were determined using atomic absorption spectrophotometer. Phosphorus content was determined by the vanadomolybdate yellow colour method (Juo, 1979); while N was determined by the micro-kjeldahl wet digestion method outlined by Bremner (1982). Organic carbon was determined by the Walkley-Black method (Nelson and Sommers, 1982) (Table 2).

The ginger variety used was UG1 popularly known in the growing area as "Tafin Giwa" and the maize variety that was intercropped with the ginger was "Samaz 17" with a maturity period of 90 days, tolerant to striga and resistant to streak.

The land was ploughed, harrowed and laid out into six plots (treatments) and replicated four times in a randomized complete block design. The ginger was planted in a uniform spacing of 20 × 20 cm apart. A uniform amount of cow dung was broadcasted and incorporated in the soil at the rate of 30 tonnes per hectare as recommended by Ayuba et al. (2005). Sowing was carried out in the first week of May when rains were established, and weeds were controlled by mulching and hand pulling at 5, 8 and 11 weeks after planting. Only the sole maize treatments plots were not planted with ginger. The various maize populations within the ginger plots constitute the treatments, which were: 1) consortium ginger with 72222 plants ha^{-1} corn; 2) consortium ginger with 36111 plants ha^{-1} corn; 3) consortium of ginger with 24074 plants ha^{-1} corn; 4) consortium of ginger with 18055 plants ha^{-1} corn; 5) Sole ginger crop with 250000 plants ha-^{1}; 6) Sole maize crop to 72222 plants ha^{-1}. The six treatments established in 9.0 m^2 gross area plots and a net area of 5.76 m^2.

Growth parameters recorded for the growing ginger crop under varying shades densities of maize were: height per plant, number of leaves per plant, leaf area per plant, dry matter accumulation/production per plant and number of tillers per plant. The yield parameters recorded included number of rhizomes per plant, length per rhizomes, width per rhizome and fresh rhizome yield per hectare.

Table 1. Some physico-chemical properties of the soil of the experimental site at commencement of study.

Particle size distribution 0-30 cm depth	2009	2010
Sand (g kg^{-1})	580	560
Silt (g kg^{-1})	300	310
Clay (g kg^{-1})	120	130
Soil texture class	Sandy loam	Sandy loam
Chemical properties		
PH in H_20 (1:2.5)	5.90	5.80
PH in 0.01 M $CaCl_2$	4.80	4.90
Organic carbon (g kg^{-1})	37.8	36.8
Available phosphorus (mg kg^{-1})	5.25	5.16
Total nitrogen (g kg^{-1})	3.50	3.48
C:N ratio	10.8	10.6
Calcium (cmol kg^{-1})	4.40	4.38
Magnesium (cmol kg^{-1})	0.84	0.82
Potassium (cmol kg^{-1})	0.15	0.13
Sodium (cmol kg^{-1})	0.40	0.40

Table 2. Some chemical properties of the cow dung manure used in the experiment at commencement of the study.

Chemical composition	Amount in manure	
	2009	2010
Nitrogen (g kg^{-1})	17.5	16.5
Phosphorus (g kg^{-1})	4.5	4.7
Potassium (g kg^{-1})	14.4	14.6
Calcium (g kg^{-1})	28.6	27.5
Magnesium (g kg^{-1})	4.2	4.2
Sodium (g kg^{-1})	0.7	0.8
Organic carbon (g kg^{-1})	19.2	19.3
C:N ratio	1.10	1.17

The data collected for the two years were combined then subjected to analysis of variance (ANOVA) and the treatment means were separated using the Duncan's Multiple Range Test (DMRT) at 5% level of probability.

RESULTS AND DISCUSSION

The physical and chemical properties of the soil and cow dung before the commencement of the study are presented in Tables 1 and 2 while the climatic conditions for the study periods are also presented in Figures 1 and 2.

Results of the experiment showed that there were no significant differences among the treatments used in the study on all the growth parameters (Table 3). The ginger plant heights increased as the maize population increased in the intercrop. The highest height was obtained when 24074 maize plants were intercropped in ginger. Sole cropped ginger showed the lowest plant height possibly due to the absence of any shading effect. These differences were however not statistically significant ($P \leq 0.05$).

Number of leaves per plant did not show any specific pattern. The highest number of leaves per plant was obtained in the treatment with lowest maize plants in the intercrop. Like the plant height, the sole ginger also had the lowest number of leaves. These differences were also not statistically significant ($P \leq 0.05$).

The leave area parameter difference was not statistically significant ($P \leq 0.05$). The highest leave area was recorded from the sole ginger treatment while the 24074 maize intercrop had the least. This suggests that as maize plant population was increased in the intercrop, the leave area decreased.

Dry matter production per plant was significantly ($P \leq 0.05$) high (2.0 g) in the treatment that had the highest maize density in the intercrop. This indicates that the

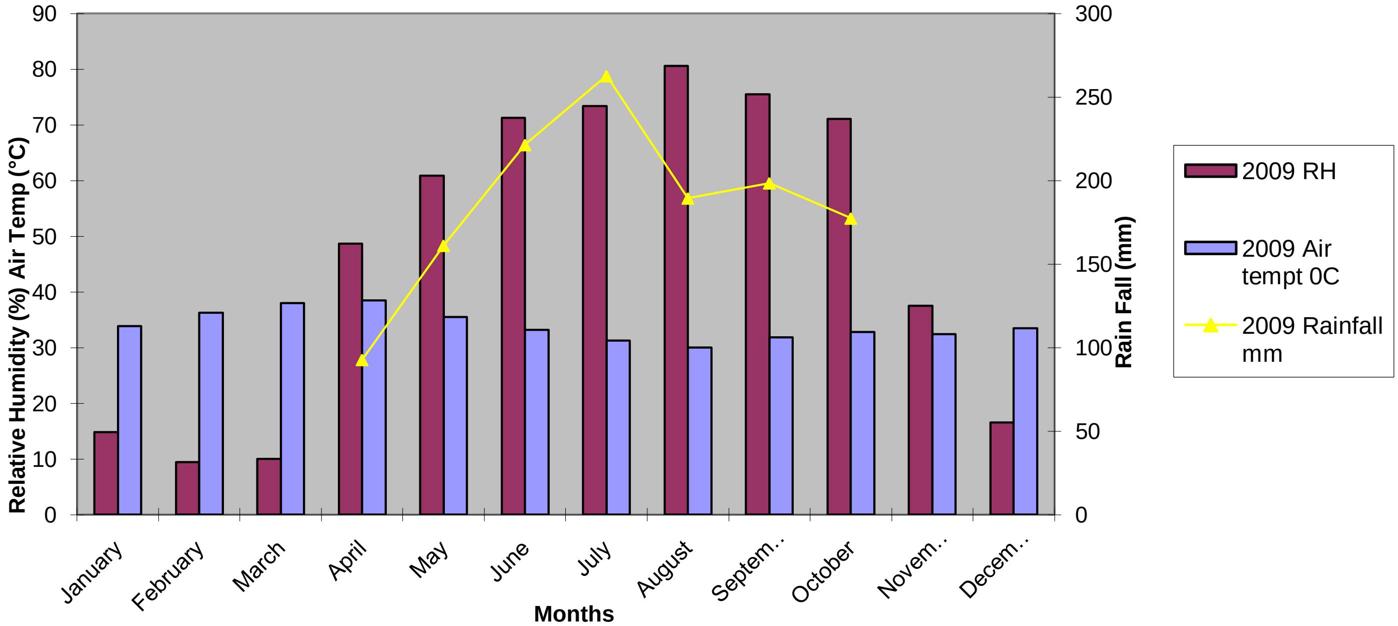

Figure 1. Weather condition of Samaru during 2009 study period.

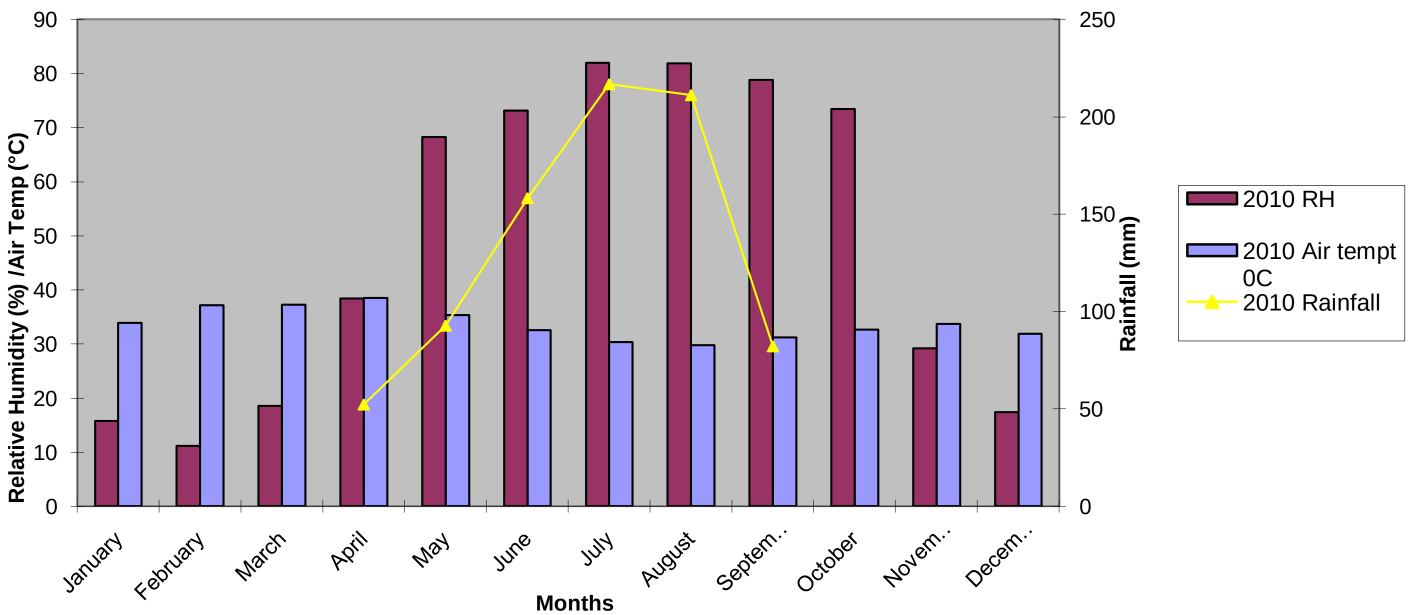

Figure 2. Weather condition of Samaru during 2010 study period.

plants grew taller in the intercrop in attempt to absorb direct sun rays and thus accumulate dry matter in the process.

The results also showed that intercropping 18055 maize plants in ginger increased production of tillers. The tiller production was only different significantly ($P \leq 0.05$) between treatment 4 (18055- the lowest maize population in the trial) and treatment 1 (72222- the highest plant population in the experiment) with the later yielding the least tiller number. Since the growth parameters did not show significant ($P \leq 0.05$) differences even with the sole ginger plots, it could imply that the ginger crop might still be able to tolerate higher maize plant population density shading effect without causing harm to its growth ability.

Studies have shown that ginger can tolerate shade of up to 25-40% and still yield very well (Friday, 2006).

Experience over the years has helped the traditional ginger growers to grow the crop even under tree shades. According to Boller and Hani (2004), the ginger crop in a mixture with taller crops gets the shade it requires, which

Table 3. Growth parameters of ginger in varying levels of maize population densities in 2009 and 2010 (combined) cropping seasons.

	Treatments	Ginger height/plant (cm)	No. of leaves per plant	Leaf area per plant (cm^2)	Dry matter production per plant (g)	No. of tillers per plant
1	Ginger at 250000 + maize at 72,222 plants ha^{-1}	47.06	29.33	36.54	2.05^{a}	4.33^{b}
2	Ginger at 250000 + maize at 36,111 plants ha^{-1}	47.00	32.00	36.86	1.73^{ab}	5.00^{ab}
3	Ginger at 250000 + maize at 24,074 plants ha^{-1}	47.33	28.67	33.96	1.37^{b}	6.33^{ab}
4	Ginger at 250000 + maize at 18,055 plants ha^{-1}	44.97	37.00	34.23	1.34^{b}	7.33^{a}
5	Sole ginger crop 250000 plants ha^{-1}	44.66	28.00	37.97	1.48^{ab}	6.00^{ab}
	SE $\pm$	4.281	4.311	3.651	0.316	0.903

SE = Standard Error of means. Means within the same column followed by the same letter(s) are not significantly different using the Duncan's Multiple Range Test (DMRT) at 5 % level of probability.

Table 4. Yields and yield parameters of ginger rhizome and maize grain yield as affected by varying maize population densities (intercrop) in 2009 and 2010 (combined) cropping seasons.

	Treatments	No of rhizomes per plant	Rhizome length (cm)	Rhizome width (cm)	Fresh ginger rhizome yieldha^{-1} (tha^{-1})	Maize grain yield (tha^{-1})
1	Ginger at 250000 + maize at 72,222 plants ha^{-1}	3.67^{a}	11.10^{ab}	5.95^{b}	7.82^{b}	3.93^{ab}
2	Ginger at 250000 + maize at 36,111 plants ha^{-1}	2.57^{b}	9.12^{ab}	6.65^{a}	8.94^{b}	2.74^{abc}
3	Ginger at 250000 + maize at 24,074 plants ha^{-1}	3.00^{ab}	12.41^{a}	6.40^{ab}	10.84^{ab}	3.98^{a}
4	Ginger at 250000 + maize at 18,055 plants ha^{-1}	2.45^{b}	6.55^{b}	6.55^{ab}	10.54^{ab}	2.05^{c}
5	Sole ginger crop (250000 plants ha^{-1})	2.33^{b}	6.51^{b}	6.51^{ab}	14.08^{a}	-
6	Sole maize crop (72,222 plants ha^{-1})	-	-	-	-	2.22^{bc}
	SE $\pm$	0.269	1.806	0.203	1.560	0.582

SE = Standard Error mean. Means within the same column followed by the same letter(s) are not significantly different using the Duncan's Multiple Range Test (DMRT) at 5 % level of probability

results in higher yields of ginger rhizomes and at the same time a second crop is also produced on the same piece of land using the same resources of labour and capital. Beets (1990) also reported that there is a mutual benefit between a maize/ginger intercrop, where the ginger serves as mulch to the maize to conserve moisture and nutrients in the soil, while maize shades the ginger. Both crops yields are boasted by this relationship. Therefore, farmers could be encouraged to grow their ginger intercropped with taller crops so as to gain the advantage of harvesting a double crop outside of the tree shades as reported by Mkamilo (2004). Results in Table 4 show the combined yield parameters of ginger (2009 and 2010). The yield of a sole ginger crop was statistically the same with the intercropped. All yield parameters of rhizomes number per plant, rhizome length per plant, and rhizome width per plant were not significantly different ($P \leq 0.05$) among. This result therefore suggests that irrespective of the maize population density intercropped within the ginger, these yield parameters were not affected. However, fresh ginger rhizome yield showed that the sole ginger crop produced the highest yield (14.08 tonnes ha^{-1}) which was statistically ($P \leq 0.05$) comparable to the yield of 10.84 and 10.54 tonnes ha^{-1} ginger when intercropped with 24074 and 18055 plants of maize per hectare respectively. Although this study did not measure shades as treatments, the population density technically introduces shading effects. This finding agrees with that of Beet (1990), who reported that ginger can derive advantages of the shade provided by the taller maize plants in the intercrop to increase its yield. Similarly, the results obtained in this study collaborates Kratky et al. (2013) finding that the highest yields of ginger occurred in treatment without shading when shading levels of 0, 30, 47 and 80% were compared. Kratky et al. (2013) found that the 30, 47, and 80% shade screen treatments reduced rhizome yields by 34, 52 and 67% in 2010. Comparing the effects of treatments on the yields between ginger and maize, it was observed that the maize intercropped at 24074 plants per hectare with ginger also produced the highest maize grain yield that was comparable with other higher maize population densities and it was significantly better than maize population density of 18,055 intercrop. Consequently, the lowest maize population density treatment in the intercrop produced significantly ($P \leq 0.05$) the least maize grain yield per hectare. Beets (1990) reported that taller crops in an intercrop could reduce wind speed above the shorter crop, thus, reducing desiccation. This reason may explain why the ginger crop still produced a high amount of rhizomes fresh yield despite the fact that the ginger crop which requires eight months of rainfall during its growing season to produce rhizome (Okwuowulu, 1997) which is not obtainable in the guinea savanna of Nigeria (Figures 1 and 2).

Maize requires high level nitrogen fertilizer for good yield in northern Guinea savanna of Nigeria because of low soil nitrogen resulting from lack of decomposable vegetation. This is evident in the result of soil analysis in Table 1.

CONCLUSION

Sole fresh ginger rhizome yield was comparable to that obtained when intercropped with maize at density of 24,074 plants per hectare (10.84 tha^{-1}). Therefore ginger intercropped with maize at 24,074 plants per hectare is recommended. This maize/ginger intercrop combination will enable farmers to obtain the benefits of the two crops in the intercrop without losing out.

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