EFFECT OF PIGEON PEA HEDGEROW ALLEY MANAGEMENT ON THE GROWTH AND PRODUCTIVITY OF GINGER IN A TROPICAL ULTISOL IN SOUTH EASTERN NIGERIA

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ABSTRACT

Growth, yield and yield attributes responses of ginger were assessed in a two-year (2010 and 2011 cropping seasons) field investigation conducted at the National Root Crops Research Institute, Umudike, South Eastern Nigeria. Treatments comprised three pigeon pea hedgerow alley populations of 20,000, 33,333 and 66,667 plants/ha in factorial combinations with three inter row alley spacings of 1m, 2 m and 3 m fitted into a randomized complete block design with three replications. Results showed that optimum performance in terms of plant height, number of leaves and number of tillers/plant and fresh rhizome yield of ginger were obtained with pigeon pea population of 20,000 plants/ha spaced 2 m apart. Although ginger plant height, number of leaves and number of tillers/plant, and fresh rhizome yield were relatively reduced in the pigeon pea treatments relative to the control, planting ginger within hedgerow alleys of pigeon pea resulted in an improvement in the productivity of the system in addition to significant reductions in the incidence of yellow leaf spot disease occurence of ginger.

Key words: Productivity, Response, Hedgerow, Alley, Management

INTRODUCTION

Crop production in peasant cropping systems in the tropics is generally constrained by poor soil fertility (low nutrient content and structural degradation), uncertain rainfall and lack of credit facilities to purchase inputs such as fertilizers and improved crop varieties (Weber et al., 1996; Bationo et al., 1993). In south Eastern Nigeria, low soil fertility ranks as the second most important abiotic constraint to crop production (Enwezor *et al*., 1990). Intensified land uses, and the rapid declines in fallow periods, coupled with extension agriculture into marginal lands, have contributed to rapid decline in soil fertility in this zone. The result is that N and P deficiencies are severe, constituting widespread biophysical contraints to smallholder ginger production in the zone (Okigbo, 2000) . Average ginger crop yield in South East Nigeria is low ranging from 10 - 15 t/ha (Njoku et al., 1995) compared to 35 – 40 t/ha obtainable in other ginger-producing countries of the world such as India and China (RMRDC,2005).

Crop rotations, intercropping, improved fallows, green manures, inorganic fertilizers and integrated nutrient management practices have all been developed as a means of replenishing soil fertility and increasing crop yields. Successes recorded using these intervention measures are variable depending on agro-ecological region, crop attributes and level of crop production management used. Inorganic fertilizer use has been reported to increase ginger rhizome yields in farmers' fields by more than 80 % relative to plots without fertilizer treatment (Anon 2009). But where smallholder farmers apply fertilizers, the quantities applied are usually too low that they contribute little on long term fertility management. The high rhizome to nutrient price ratios and high levels of production risk are two of the underlying factors for the low fertilizer use in ginger production. Besides, even when fertilizers are used in farmer's fields, the nutrient use efficiency is very low and this also reduces overall productivity of ginger. To address these constraints, hedgerow intercropping (also referred to as alley cropping) was developed by scientists at the International Institute for Tropical Agriculture (IITA). The technology consists of growing food crops in the alleys formed by hedgerows of multipurpose trees and shrubs that are usually N_2 fixing. Though alley cropping technology has contributed greatly in soil fertility maintenace in the tropics, the system performance is known to be location specific and greatly influenced by the choice of tree species and the type and level of management adopted (Mugendi et al., 1999).

Pigeon pea, a multi-purpose shrub species, is extensively used as food grain and green manure crop for soil fertility amelioration in local cropping systems (Yeboah et al., 2004). Despite its high potential as a good vehicle for Mg, K and Na cycling in soils (Yeboah et al., 2004), information is very sketchy on the effect of pigeon pea hedgerow alley population management on soil and ginger productivity in the tropics. This study therefore, seeks to determine the possibility of improving ginger productivity through micro-climate modification using pigeon pea hedgerow alley population and spacing adjustments.

MATERIALS AND METHODS

The study was conducted in 2010 and 2011 cropping seasons at the research farm of the National Root Crops Research Institute, Umudike (Latitude 05^0 29^1 N; and Longitude 07^0 33^1 E). Treatments consisted of three pigeon pea hedgerow populations of 20,000, 33,333 and 66,667 plants/plant equivalent to 33, 20 and 10 cm in between plants in factorial combinations with three pigeon pea hedgerow alley widths of 1m, 2m and 3m. A plot containing no pigeon pea hedgerow alley was also included as a control. The pigeon pea hedgerow alley was established 8 weeks before ginger was introduced.

Rhizome setts weighing about 20g were cut from large, healthy and disease-free mother rhizomes of UG 1 ginger variety and planted up on seed beds measuring 1m x 6m made on a tractor-slashed, ploughed and harrowed land. The rhizome seeds were sown at an intra-row spacing of 0.20m and inter row spacing of 0.20m. The inter-plot distance was maintained at 2m to reduce excessive shading from the pigeon pea. The treatments were laid out in a randomized complete block design with three replications. Planting of ginger was done on 19^{th} April and 10^{th} May for 2010 and 2011 cropping seasons respectively. A plot containing sole pigeon pea was also included for purposes of evaluating productivity of the system. Sole pigeon pea was planted the same time ginger component was planted.

Pre-trial determinations of relevant physico-chemical properties of the soil were undertaken using standard methods. Total N was analyzed using the semi-micro Kjeldahl method as reported by Bremner and Mulvany (1982). Available P was determined by Bray and Kurtz -2 as modified by Olsen and Sommers (1982).

Exchangeable K,Ca, and Mg were measured by the 1N neutral NH_4OAc saturation method of Grant (1982). While K was measured flame photometrically using atomic absorption spectrophotometer, Ca and Mg were done using the EDTA complexometric titration method. Organic matter was estimated by the Walkley and Black wet oxidation method of (1934). Soil pH was determined by the combined glass electrode pH meter method of Mclean (1982) at a soil:solution ratio of 1:2.5. Particle size distribution measurement was carried out using the Bouyoucous hydrometer method as reported by Tel and Hagarthy (1984) using sodium hexametaphosphate as the dispersant.

The plots were fertilized with NPK 15:15:15: fertilizer at the rate of 300kg/ha. Fertilizer application was by broadcasting in two split doses: half dose during ginger planting and half 12 weeks after ginger planting. The plots were mulched two days after ginger planting using 20t/ha of mature and wilted *Panicum maximum* grass. All other important agronomic practices for ginger production were observed.

Disease score was made using visual observation and ranking according to the following format described by Ford and Herwitt (1980):

Severity estimation (%)	Scale	Interpretation
0	0	No infection
1-20	1	Slight infection
21-40	2	Moderate infection
41-60	3	Extensive infection
61-80	4	Very extensive infection
81-100	5	Leaves completely infected

Data on establishment, plant height, number of leaves per plant, fresh rhizome yield, number of tillers/plant, number of primary and secondary rhizome fingers/plant and yellow leaf spot disease score were collected. Productivity of the system was assessed using the land equivalent ratio index. The data generated from the study were analyzed using analysis of variance (ANOVA). Differences among treatment means with significant effects were detected using Least Significant Difference at 5 % probability level.

RESULTS AND DISCUSSION

The Soil Used for the Study

Pre-cropping soil analysis carried out indicated that the soil used for the trial was a sandy loam and had N, P and K values ranging from 0.10 – 0.14 % (N), 6.1 – 9.3mg/kg (P) and 0.10 – 0.11 cmol/kg (K). These values are of low fertility and are therefore, inadequate for ginger production in the rainforest ecology of Nigeria according to soil fertility classification for ginger by Njoku et al, (1995). The soil was strongly acidic thus indicating the possibility of high concentrations of exchangeable Al (Lal, 1994). Exchangeable bases (Ca, Mg, and K) were low and fall below the critical levels set by Enwezor *et al* (1990) for sustainable root and tuber crops production in the zone.
Although ginger can grow very well in soils having sandy loam textural characteristics (RMRD, 2005), but the low level of native organic matter content of the experimental soil implied that sustainable crop production could only be achieved with adequate organic and inorganic fertilization (Table 1).

Table 1: Selected physico-chemical properties of the soils of the study area before commencement of trial

	N	P	K	Ca	Mg	pH	OM	BD	Texture
	(%)	(mg/k)	....(cmol/kg)....				(%)		
2010	0.14	9.3	0.11	0.8	0.40	5.5	1.50	1.36	Sandy loam
2011	0.10	6.1	0.10	0.6	0.20	5.3	1.2	1.32	Sandy loam

Effect of Treatment on Ginger Establishment

Both pigeon pea hedgerow alley population and alley row width spacing did not significantly affect ginger establishment relative to the control in both years. Numerically, establishment was higher at lower pigeon pea hedgerow alley population of 20,000 plants/ha than at 33,333 and 66,667 plants/ha.

Table 2. Effect of Pigeon Pea Hedgerow Alley Population and Width on Ginger Plant Establishment at 6 WAP in a Tropical Humid Ultisol in South Eastern Nigeria

Hedgerow Alley Width	2010				2011			
	Hedgerow Population (plants/ha)				Hedgerow Population (plants/ha			
	20,000	33,333	66,667	Mean	20,000	33,333	66,667	Mean
1 m	87.8	80.3	90.7	86.3	98.0	87.8	83.2	89.7
2 m	91.4	88.2	84.7	88.1	90.3	84.3	79.4	84.7
3 m	92.5	85.5	74.8	84.3	86.6	77.8	83.2	82.5
Mean	90.6	84.7	83.4	-	91.6	83.3	81.9	-
Control	-	-	-	89.9	-	-	-	92.2
	LSD (0.05): Alley width = NS; Alley Population = NS; Alley Width x Alley Pop. = NS				LSD (0.05): Alley Width = NS; Alley Population = NS; Alley Width x Alley Pop. = NS			

Effect of Treatment on Ginger Plant Height and Number of Tillers

Taller plants were recorded at lower populations of pigeon pea than at higher. For example, increasing the pigeon pea population from 20,000 to 66,667 plants/ha significantly reduced mean ginger plant height by 41 and 36 % for 2010 and 2011 respectively. At each of the pigeon pea population levels, the reduction in ginger plant height due to increase in hedgerow alley population was significant.

Highest mean plant height of 76.9 and 87.4 cm was recorded in the control in 2010 and 2011 respectively. Pigeon pea hedgerow alley spaced 2 m apart produced the tallest ginger plants among the three alley row width spacings evaluated. Below or above this spacing, there was a significant reduction in mean plant height. The reduction in plant height at alley row width spacing less than 2 m apart and pigeon pea population greater than 20,000 plants/ha could be attributed to inter and intra specific competition for space, soil moisture, nutrient and light between the pigeon pea hedgerow alley plants and ginger plants.

Another reason may be due to increased shading arising from the high pigeon pea population. Although ginger is reported to tolerate light shading of about 21 % for optimal field performance s(Meerabai et al., 2001), excessive shading is bound to reduce photosynthetic active radiation (PAR) thereby negatively affecting plant growth response (Fageria, 1992). A similar result was obtained by Nwaogu et., al (2010) who observed a significant reduction in ginger plant height following inclusion of rows of soybean plants in a ginger-based system. This result therefore, appears to corroborate the decreased mean number of leaves/plant observed with increasing hedgerow population (Table 4) and the significantly higher rhizome yield values recorded in the control treatment in Table 6. The interaction between hedgerow alley population and alley row width spacing in respect of plant height response was significant only in 2011.

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Table 3. Effect of Pigeon Pea Hedgerow Alley Population and Width on Ginger Plant Height (cm) in a Tropical Humid Ultisol in South Eastern Nigeria measured at 4 MAP

Hedgerow Alley Width	2010				2011			
	Hedgerow Population (plants/ha)				Hedgerow Population (plants/ha			
	20,000	33,333	66,667	Mean	20,000	33,333	66,667	Mean
1 m	68.7	48.9	32.3	50.0	77.2	53.9	50.1	60.4
2 m	84.8	62.2	50.4	65.8	96.4	76.7	62.4	78.5
3 m	78.2	52.1	43.2	57.8	86.8	64.5	54.8	68.7
Mean	77.2	54.4	45.3	-	86.8	65.0	55.8	-
Control	-	-	-	79.9	-	-	-	87.4
	LSD (0.05):				LSD (0.05):			
	Alley width = 4.66				Alley Width = 5.86			
	Alley Population = 5.42				Alley Population = 5.33			
	Alley Width x Alley Pop. = NS				Alley Width x Alley Pop. = 1.23			

Effect of Treatment on the Number of leaves and Number of Tillers/plant

Mean ginger leafiness and tillering capacity was more in the two years at lower hedgerow populations than at higher ones.This indicated that the inter row competition between pigeon pea hedgerow alley and ginger for available soil resources such as light, water and nutrient was most optimum at lower pigeon pea population of 20,000 plants/ha. Increasing the alley population to 33,333 and 66,667 plants/ha resulted in more competition between the hedgerow alley crops and ginger.

The three alley row width spacings produced statistically same number of tillers/plant at 6 months after planting in both years (Table 5). Pigeon pea hedgerow alley planted at 20,000 plants/ha yielded the highest number of tillers relative to other populations. The number of tillers/plant recorded with 20,000 pigeon pea plant/ha did not differ significantly from the value obtained in the control.

Table 4. Effect of Pigeon Pea Hedgerow Alley Population and Width on the number of Leaves/plant of Ginger in a Tropical Humid Ultisol in South Eastern Nigeria Measured at 4 MAP

Hedgerow Alley Width	2010				2011			
	Hedgerow Population (plants/ha)				Hedgerow Population (plants/ha			
	20,000	33,333	66,667	Mean	20,000	33,333	66,667	Mean
1 m	12.0	14.3	19.7	15.3	17.3	17.0	14.3	16.2
2 m	24.3	18.9	13.2	18.8	22.5	26.3	12.7	20.5
3 m	28.7	20.4	18.9	22.7	20.3	14.3	13.0	15.9
Mean	21.7	17.9	17.3	-	20.0	19.2	13.3	-
Control	-	-	-	20.3	-	-		25.6
	LSD (0.05):				LSD (0.05):			
	Alley width = NS				Alley Width = NS			
	Alley Population = NS				Alley Population = NS			
	Alley Width x Alley Pop. = NS				Alley Width x Alley Pop. = NS			

Table 5. Effect of Pigeon Pea Hedgerow Alley Population and Width on the Number of Tillers/plant of Ginger in a Tropical Humid Ultisol in South Eastern Nigeria Measured at 6 MAP

Hedgerow Alley Width	2010				2011			
	Hedgerow Population (plants/ha)				Hedgerow Population (plants/ha			
	20,000	33,333	66,667	Mean	20,000	33,333	66,667	Mean
1 m	9.3	12.7	11.6	11.2	25.3	8.4	12.2	15.3
2 m	28.2	14.5	11.4	18.0	22.2	11.8	12.8	15.6
3 m	17.2	7.3	7.4	10.6	18.6	10.7	14.2	14.5
Mean	18.2	11.5	10.1	-	22.0	15.0	13.1	-
Control	-	-	-	18.3	-	-	-	21.1
	LSD (0.05):				LSD (0.05):			
	Alley width = NS				Alley Width = NS			
	Alley Population = 1.06				Alley Population = 1.00			
	Alley Width x Alley Pop. = NS				Alley Width x Alley Pop. = NS			

Effect of treatment on Fresh Rhizome Yield

Table 6 shows the effect of pigeon pea hedgerow alley population and width on fresh rhizome yield response of ginger. For the two years of study, the yield values obtained from application of the treatment ranged from 3.2 to 9.6 t/ha in 2010 and from 4.8 to 8.2 t/ha in 2011. These yield values are low compared to the average rhizome yield value of 20 - 25 t/ha reported to have been obtained by farmers using improved production technologies in Kaduna State in the Guinea Savanna zone of Nigeria (RMRD, 2005). Population of pigoen pea significantly affected rhizome yield only in 2010. In 2011 however, the various population rates evaluated gave yields that were statistically same (Table 6). Compared across the various pigeon pea populations and widths, highest mean rhizome yields of 8.4 and 13.6 t/ha were recorded by the control for 2010 and 2011 cropping seasons respectively. Mean rhizome yields were relatively higher at hedgerow population of 20,000 plants /ha than at 33,333 and 66,667 plants/ha. No significant difference was found in the yield value recorded when hedgerow alley was spaced 2m apart and when it was spaced 3m for the two years.

The relatively lower rhizome yields obtained in the pigeon pea-treated plots compared to the control across all the hedgerow spacings studied indicated that the atmospheric N fixed by the pigeon pea was not probably made available to ginger crop within the critical period of nutrient demand (tuberization). Pigeon pea has a gestation period of about 6-7 months while ginger has a gestation period of 7 – 8 months (Njoku et al., 1995; Yeboah et al., 2004). It is therefore likely that greater part of the N that was fixed by the pigeon pea crop in the course of its growth would be more beneficial to the succeeding crop planted in rotation after pigeon pea must have been harvested. The result of this study therefore, implicates the need for further research to determine the best time of introduction of ginger in a pigeon pea alley planted to ginger in the rainforest ecology of Nigeria. Optimum yield was obtained with 3m hedgerow spacing.

Table 6. Effect of Pigeon Pea Hedgerow Alley Population and Width on the Fresh Rhizome Yield (t/ha) of Ginger in a Tropical Humid Ultisol in South Eastern Nigeria

Hedgerow Alley Width	2010				2011			
	Hedgerow Population (plants/ha)				Hedgerow Population (plants/ha			
	20,000	33,333	66,667	Mean	20,000	33,333	66,667	Mean
1 m	4.6	4.1	3.2	4.0	5.3	5.3	4.8	5.1
2 m	5.7	8.7	4.9	6.4	6.1	8.0	6.5	6.9
3 m	9.6	5.2	4.7	6.5	8.2	4.9	6.8	6.6
Mean	6.6	6.0	4.3	-	6.5	6.1	6.0	-
Control	-	-	-	8.4	-	-	-	13.6
	LSD (0.05):				LSD (0.05):			
	Alley width = 1.03				Alley Width = 1.82			
	Alley Population = 1.12				Alley Population = NS			
	Alley Width x Alley Pop. = NS				Alley Width x Alley Pop. = NS			

Effect of Treatment on Yellow Leaf Spot Disease Incidence of Ginger

Although rhizome yield was significantly lower in the pigeon pea plot treatments relative to the control, planting ginger within hedgerow alley of pigeon pea resulted in significant reductions in the incidence of yellow leaf spot disease occurence (Table7). This reduction increased with increasing hedgerow populations up to 66,667 plants/ha but decreased with increasing inter-row spacing indicating that perhaps shading may be antagonistic to the disease pathogen. It is also suspected that perhaps the pigeon pea plants may be producing some root exudates inhibitory to the survival of the disease pathogen. There was a significant interaction between pigeon pea population and inter- row spacing in terms of ginger yellow leaf spot disease incidence. Least yellow leaf spot disease infestation was recorded with pigeon pea population of 66,667 plants/ha spaced 1m apart. Earlier work by Ihejirika and Nwufo, (2002) had reported reduced incidence and severity of yellow leaf spot disease in groundnut intercropped with maize. They attributed such reduction to the fact that intercropping provides a complementary use of resources such as water, nutrients and sunlight coupled with reduced soil erosion by the dense and diversified maize root system. They maintained that all these provided barrier against disease penetration, attack and symptom manifestation.This finding is very important in ginger development in Nigeria considering the fact that this disease causes enermous yield reductions in ginger (Anon,2009). Future research efforts should therefore, be geared towards discoverying the actual mechanism by which the incidence of yellow leaf spot disease is significantly reduced when ginger is planted in between gedgerow alleys provided by pigeon pea.

Table 7. Effect of Pigeon Pea Hedgerow Alley Population and Width on the Yellow Leaf Spot Disease Incidence (No. of diseased Leaves/plant) of Ginger in a Tropical Humid Ultisol in South Eastern Nigeria Measured at 5 MAP

Hedgerow Alley Width	2010				2011			
	Hedgerow Population (plants/ha)				Hedgerow Population (plants/ha			
	20,000	33,333	66,667	Mean	20,000	33,333	66,667	Mean
1 m	27.4	24.7	18.9	23.7	28.8	21.2	15.9	22.0
2 m	34.3	21.5	20.6	25.5	46.7	32.5	30.4	36.5
3 m	42.7	38.6	33.3	38.2	54.6	41.3	38.8	44.9
Mean	34.8	28.3	24.3	-	43.4	31.7	28.4	-
Control	-	-	-	56.8	-	-	-	61.8
	LSD (0.05):				LSD (0.05):			
	Alley width = 3.66				Alley Width = 4.88			
	Alley Population = 2.22				Alley Population = 2.36			
	Alley Width x Alley Pop. = 1.54				Alley Width x Alley Pop. = 1.12			

Effect of Treatment on Pigeon Pea Yield

The seed yield of pigeon pea increased with increase in pigeon pea population (Table 8). For the three inter row spacings investigated, optimum mean seed yield performance of 1.71 t/ha (2010) and 1.92 t/ha (2011) was recorded with pigeon pea inter row spacing of 2 m while the least mean seed yield of 0.94 t/ha (2010) and 1.44 t/ha (2011) was obtained on plots that received 3m inter row spacing. Sole pigeon pea out yielded all the other treatment combinations evaluated.

Table 8. Effect of Pigeon Pea Hedgerow Alley Population and Width on Pigeon Pea Grain Yield (t/ha) in a Tropical Humid Ultisol in South Eastern Nigeria Planted with Ginger.

Hedgerow Alley Width	2010				2011			
	Hedgerow Population (plants/ha)				Hedgerow Population (plants/ha			
	20,000	33,333	66,667	Mean	20,000	33,333	66,667	Mean
1 m	1.20	1.43	2.24	1.62	0.96	1.88	2.34	1.73
2 m	1.14	1.66	2.33	1.71	1.87	1.99	1.89	1.92
3 m	0.87	0.94	1.02	0.94	1.22	1.45	1.64	1.44
Mean	1.01	1.34	1.86	-	1.35	1.77	1.96	-
Control P	-	-	-	2.12	-	-	-	2.42
	LSD (0.05):				LSD (0.05):			
	Alley width = 0.42				Alley Width = 0.12			
	Alley Population = 0.56				Alley Population = 0.22			
	Alley Width x Alley Pop. = NS				Alley Width x Alley Pop. = NS			

Control P = Sole Pigeon Pea

Effect of Treatment on Crop Productivity

The productivity of the system assessed using the concept of land equivalent ratio showed that all the intercrop mixtures in 2010 performed better than their sole crop components (Table 9) indicating that this cropping system is more productive than sole crops. In 2011 a similar trend was also recorded except with pigeon pea populations of 20,000 and 33,333 plants/ha spaced 1m apart which gave lesser productivity expressed by their low land equivalent ratios of 0.787 and 0.390 respectively. Optimum productivity was obtained using pigeon pea population of 33,333 plants/ha spaced 2m apart. The higher productivity obtained by planting ginger in pigeon pea hedgerow alleys relative to the control is attributed to improved nutrient utilization arising from the inclusion of the alleys in the system. Yeboah et al, (2004) found improved supply of N, P, K, Ca, Mg and organic matter in soils cultivated with pigeon pea relative to soil without pigeon pea cultivation. Pigeon pea has a high biomass accumulation ability which is suspected to have increased the organic matter content of the experimental soil thereby increasing the nutrient use efficiency of ginger. Another reason may be due to shading effect. Because ginger is known to be a relatively shade-loving plant (Meerabai et al., 2001), the inclusion of pigeon pea alley in the system provided some measure of shade that helped the plant to perfom relatively better under the system.

Table 9. Effect of Pigeon Pea Hedgerow Alley Population and Width on Ginger Rhizome and Pigeon Pea Seed Productivity (LER) in a Tropical Humid Ultisol in South Eastern Nigeria Planted with Ginger

Treatment Combination	2010			2011		
	Ginger Rhizome Yield (t/ha)	Pigeon Pea Seed Yield (t/ha)	LER	Ginger Rhizome Yield (t/ha)	Pigeon Pea Seed Yield (t/ha)	LER
S1P1	4.60	1.20	1.119	5.30	0.96	0.787
S1P2	4.10	1.43	1.169	5.30	1.88	0.390
S1P3	3.20	2,24	1.398	4.80	2.34	1.167
S2P1	5.70	1.14	1.222	6.10	1.87	1.222
S2P2	8.70	1.66	1.827	8.00	1.99	1.410
S2P3	4.90	2.33	1.693	6.50	1.89	1.259
S3P1	9.60	0.87	1.557	8.20	1.22	1.107
S3P2	5.20	0.94	1.067	4.90	1.45	1.187
S3P2	4.70	1.02	1.050	6.80	1.64	1.178
Ginger Sole	8.40	-	1.00	13.60	-	-
Pigeon Pea Sole	-	2.10	-	-	2.42	1.00

S1 = 1m; S2 = 2m; S3 = 3m; P1 = 20,000 plants/ha; P2 = 33,333 plants/ha;
P3 = 66,667 plants/ha; LER = Land Equivalent Ratio

CONCLUSION

The results of this study have shown that although both ginger plant height, number of leaves, number of tillers/plant, and fresh rhizome yield were relatively reduced in the pigeon pea treatments relative to the control, planting ginger in between hedgerow alleys of pigoen pea improved the productivity of the system relative to their sole crop components. In addition, planting ginger within hedgerow alley of pigeon pea resulted in significant reductions in the incidence of yellow leaf spot disease occurence. This reduction increased with increasing hedgerow populations up to 66,667 plants/ha but decreased with increasing inter row spacing. Research is therefore needed to investigate how best to cue into this discovery to solve the yellow leaf spot disease problem of ginger farmers in Nigeria.

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