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EVALUATION OF PIGEONPEA [*Cajanus cajan* (L.) Millsp.] GENOTYPES FOR INTERCROPPING WITH TALL SORGHUM (*Sorghum bicolor* (L.) Moench) IN SOUTHERN GUINEA SAVANNA OF NIGERIA

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ABSTRACT

Improved pigeonpea [*Cajanus cajan* (L.) Millsp.] genotypes of short (≤ 150 days, usually erect, medium (151-180 days) and long (≥ 181 days) duration with semi-spreading or spreading habits were intercropped with traditional red sorghum [*Sorghum bicolor* (L.) Moench]. The aim was to identify the suitable genotype (s) of pigeonpea for intercropping with the traditional red sorghum and to determine the productivity of pigeonpea/sorghum intercropping systems in Southern Guinea Savanna of Nigeria (SGS). The treatments consisted of three cropping systems {sole pigeonpea, sole sorghum and intercropping (pigeonpea and sorghum) }as main plot, combined with 15 pigeonpea genotypes [ICPL 85010, ICPL 84031, ICPL87, ICPL 161 (short duration), ICPL 8863, ICPL 85063, ICPL 87119, ICPL 7120, ICEAP 00068 (medium duration), ICPL 8094, ICPL 7035, ICPL 87051, ICPL 9145, ICEAP 00040 (long duration) and 'Igbongbo' (traditional cultivar-control)] as sub-plot, laid out as a split-plot in randomized complete block design with three replications. The experiments were established at the National Root Crops Research Institute Sub-station, Otobi, Benue State, Nigeria, in 2002 and 2003. Intercropped sorghum were taller (≥ 180 cm) than both intercropped and sole cropped pigeonpea (≤ 150 cm) at 12 weeks after planting (WAP), except ICPL 8094 and ICEAP 0068, which maintained similar heights with sorghum component. Intercropped pigeonpea produced significantly lower mean number of branches. Plant-1 (21.32) and mean dry pod weight (2.82 t.ha^{-1}) and mean dry grain yield (1.59 t.ha^{-1}), as compared to sole cropped pigeonpea with 25.09 (branches. plant^{-1}), 4.58 t.ha^{-1} (dry pod weight) and 2.72 t.ha^{-1} (dry grain yield) in 2002 and 2003 combined. The high land equivalent ratio (LER) values (1.47-2.07) exhibited by the improved pigeonpea genotypes under intercropping with the traditional red sorghum clearly proved the suitability of these pigeonpea genotypes for intercropping with the traditional red sorghum.

Keywords: pigeonpea, sorghum, intercropping, genotypes, productivity, Nigeria.

INTRODUCTION

Pigeonpea (*Cajanus cajan* (L.) Millsp) is a multipurpose leguminous crop that can provide food, fuelwood and fodder for the small-scale farmer in subsistence agriculture (Tabo *et al*., 1995; Rao *et al*., 2002). Little seems to be known about its level of production in Nigeria, but surveys conducted by Remanandan and Asiegbu (1993) and Egbe and Kalu (2006) indicated that pigeonpea is widely cultivated in Nigeria and it appears that the intensity of pigeonpea cultivation is influenced by the culture and food habits of its people. Farmers in Southern Guinea Savanna of Nigeria (Kowal and Knabe,1972) maintain varying degrees of sole and mixed cultures of pigeonpea with such other crops as sorghum, maize, millet, yam, cassava and sweet potatoes (Egbe and Kalu,2006;Egbe and Adeyemo,2006).

The main pigeonpea cultivars intercropped with the traditional red sorghum (*Sorghum bicolor* (L.) Moench) take 5-10 months to mature and usually have spreading or semi-erect canopy structure with woody stems. The traditional sorghum cultivar commonly intercropped or mixed with pigeonpea is tall (> 4m), red-seeded, photoperiod-sensitive and matures in 6-7 months after planting. The sorghum is also drought-tolerant, produces over 3.0 t.ha^{-1} of dry grain, used for human food and livestock feeds (BNARDA, 2000). In traditional cropping systems where pigeonpea is intercropped or mixed with sorghum, both crops are planted on ridges and the yields of pigeonpea on such fields are low (0.45-0.54 t ha^{-1}), mainly due to such constraints as poor management of intercropping systems with regards to unimproved genotypes suitable for intercropping, spatial arrangement, etc. Pigeonpea/sorghum intercropping has numerous advantages (Ali, 1990; Rubaihayo *et al*., 2000), but it is also known that pigeonpea genotypes that give high yields in sole cropping may not necessarily be the highest yielding in intercropping.

Identification of suitable pigeonpea genotypes for intercropping with the widely cultivated long duration tall sorghum is therefore imperative for improving the productivity of this intercropping system in the SGS agro-ecological zone of Nigeria. This study was carried out to evaluate the suitability of fourteen improved pigeonpea genotypes from International Crops Research Institute for Semi-arid Tropics (ICRISAT) and one traditional cultivar from Otobi, Nigeria under intercropping with the traditional sorghum (also obtained from Otobi, Nigeria) and also to assess the productivity of the pigeonpea/sorghum intercropping systems in Southern Guinea Savanna of Nigeria.

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MATERIALS AND METHODS

Field experiments were conducted during the wet seasons (June-November) of 2002 and 2003 at the National Root Crops Research Institute Sub-station, Otobi (Latitude $07^0 10'$N, Longitude 08^0 39′E, elevation 105m) in Benue State, Nigeria. This location lies in the SGS agro-ecological zone of Nigeria (Kowal and Knabe, 1972). Total precipitations during the cropping seasons were 1712mm and 1665.6mm in 2002 and 2003, respectively. Thirty-two core samples collected from 0-30 cm depth before land preparation were bulked air-dried and ground. Samples were sieved through 2mm and 0.05mm screens for determination of particle size, total nitrogen (N), % organic carbon, available phosphorus (P) and the level of potassium (K). The various procedures used for soil analysis were as outlined by Jackson (Jackson, 1967). Soil sample analysis characterized the soil as sandy loam with a pH of 7.40. The organic carbon was 2.27%, total N 0.88%, available P. 0.54 cmol kg^{-1}soil and K 0.16 cmol kg^{-1}soil. The soil of the experimental site was classified as Typic Paleustalf (USDA).

The experimental site had been left fallow with weeds for 3-4 years. The experiment was laid out as split-plot in randomized complete block design with three replications. Main plot treatments were three cropping systems [sole pigeonpea, sole sorghum and intercropping (pigeonpea and sorghum)]. The sub-plot treatments were 15 pigeonpea genotypes (14 improved and one traditional cultivar), grouped into three maturity classes discriminated by days to maturity. They included four short duration (ICPL 85010, ICPL 84031, ICPL 87 and ICPL 161), five medium duration (ICPL 8863, ICPL 85063, ICPL 87119, ICPL 7120 and ICEAP 00068), five long duration (ICPL 8094, ICPL 7035, ICPL 87051, ICPL 9145, and ICEAP 00040) and one traditional cultivar (‘Igbongbo’). The improved genotypes were obtained from International Crop Research Institute for Semi-arid Tropics (ICRISAT), Kano station, in Nigeria, while the traditional cultivar was obtained from a local market in Otobi, Benue State, Nigeria. The characteristics of the improved pigeonpea genotypes used in the study (according to ICRISAT, Kano) are shown in Table-1.

Pigeonpea and sorghum were sown either as sole crop or intercrop on ridges [which is the dominant practice used by pigeonpea farmers in SGS of Nigeria (6)]. The ridges, spaced 100 cm apart (crest to crest) were 50 cm wide with a 50 – cm furrow separating one from the other. Each sub-plot consisted of three ridges of 4m length (3m x 4m). All crop arrangement was on the sides of the ridge to ensure good access to moisture. The details of the planting pattern and spacing are given in Table-2.

Intercropping had a 1:1 (pigeonpea: sorghum) row proportion, such that one row of pigeonpea alternated with one row of sorghum. Intercrop plots had 50% of the full population of each of the component crops (33,333 plants ha^{-1} (pigeonpea) and 20,000 plants ha^{-1} (sorghum). Two seeds of each crop (pigeonpea or sorghum) were sown per hill and thinned to one plant per hill eight days after sowing as recommended by BNARDA (2000).The soil in each year of experimentation was ploughed three weeks before being harrowed once and then ridged. All plots received a basal application of 30kg N, 12.90 kg P and 24.90 kg K ha^{-1} supplied as 200 kg of NPK 15:15:15 compound fertilizer broadcast and incorporated before sowing of both crops on 24^{th} and 21^{st} June, 2002 and 2003, respectively. Sole and intercropped sorghum were top-dressed four WAP with 46kg N ha^{-1} by manual operation. Two hoe-weeding were done at three and seven WAP for all plots.

At first flower opening, pigeonpea plants were respectively sprayed with Perfekthion (dimethoate) at a dose of 60 ml in 10 liters of water (equivalent to 0.24g active ingredient per liter) for the control of pigeonpea pod borers and pod sucking bugs as recommended by BNARDA (BNARDA, 2000). This was repeated three times at fortnightly intervals. On five plants in the central rows of each pigeonpea genotype, in both intercrop and sole crop plots, observations were made on plant height at 4, 8 and 12 WAP.At final harvest in pigeonpea [(20-21 WAP) in short duration genotypes, (25-26 WAP) in medium duration, and (27-32 WAP) in long duration genotypes), respectively], the following observations were recorded from 12 plants in the inner 2m x 2m ($4m^2$) of each sub-plot:(i)number of branches per plant (ii) dry pod weight (iii)dry grain yield. Productivity of the various pigeonpea genotypes intercropped with sorghum in this work was determined by using the land equivalent ratio (LER) as described by Rao and Willey (1980).The productivity was further evaluated by the use of the area-time equivalent ration (ATER) described by Hiebisch (1980).

All data generated were analysed using GENSTAT 5 Release 3.2 (copyright 1995, Lawes Agricultural Trust Rothansted Experimental Station) and statistical tests for mean differences and treatment effects followed standard analysis of variance procedures for split-plot in randomized complete block design. Wherever differences between treatment means were significant, means separation was by FLSD at 5% level of probability (Obi, 1990).

RESULTS

At 4 WAP, both intercropped and sole cropped pigeonpea were taller (≥ 40 cm) than intercropped sorghum (≤ 20 cm) (Figure-1). Figure-1 further showed that this height advantage of both intercropped and sole cropped pigeonpea over sorghum was only maintained up to 8 WAP in most pigeonpea genotypes. At 10-12 WAP, the sorghum component became taller (≥ 180 cm) than nearly all the pigeonpea genotypes (150 cm ≥) tested under sole cropping and intercropping, except ICEAP 00068 and ICPL 8094. These two pigeonpea genotypes (ICEAP 00068 and ICPL 8094) maintained similar heights with the component sorghum up to 12 WAP (approximately 200 cm). Intercropped and sole pigeonpea

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maintained similar heights from 4 WAP (≤ 50cm) to 12WAP (≤ 150 cm)

Table-3 presents the number of branches per plant of pigeonpea genotype at harvest as affected by intercropping with sorghum in 2002 and 2003. Intercropped pigeonpea genotypes produced significantly lower number of branches per plant (21.32) at harvest as compared to sole cropped pigeonpea (25.09) in 2002. A similar trend was observed in 2003, with a mean of 28.61 (sole cropping) and 25.63 (intercropping). The percentage reduction in the number of branches per plant of pigeonpea genotype intercropped with the traditional red sorghum (Table-3) varied from 3.04% (ICPL 8094) to 27.04% (ICPL 7035) with a mean of 12.55%. Two of the pigeonpea genotypes tested under intercropping with sorghum had no reduction in the number of branches per plant at harvest and these were ICPL 7120 and ICPL 87051 with an increase of 5.23% and 3.24%, respectively, over the sole cropped pigeonpea. Furthermore, while intercropped short duration pigeonpea genotypes gave significantly lower number of branches per plant (17.25) as compared to the medium duration (22.20) and the long duration (22.83) in 2002, the pigeonpea genotypes in the different maturity groups produced similar number of branches per plant at harvest (short duration (26.70), medium duration (24.27) and long duration (26.07) in 2003 (Table-3). The pooled results of 2002 and 2003 indicated that intercropping also caused a reduction in the number of branches per plant of the traditional pigeonpea cultivar (‘Igbongbo’), with a mean reduction figure of 13% at harvest. This percentage (13%) reduction in traditional pigeonpea cultivar intercropped with the red sorghum was higher than the mean percentage reduction (11.47 %) observed for the improved pigeonpea genotypes.

Intercropping also reduced the dry pod weight of pigeonpea genotypes at harvest (Table-4). Intercropped pigeonpea genotypes produced significantly lower dry pod weight (3.49 t ha^{-1}.) in both 2002 and 2003, as compared to sole cropped pigeonpea(5.28 t ha^{-1}). The mean percentage reduction in dry pod weight of pigeonpea genotypes intercropped with the traditional sorghum as compared to sole varied from 2.38% (ICPL 9145) to 61.11% (ICPL 87051). Intercropped ‘Igbongbo’ dry pod weight was reduced by 49.87% as compared to sole ‘Igbongbo’. This percentage reduction (49.87%) was higher than the mean percentage reduction (32.18%) for the improved pigeonpea genotypes intercropped with the traditional sorghum.

Similarly, intercropping pigeonpea with sorghum reduced the dry grain yield of pigeonpea, irrespective of the genotype in both years of experimentation with a mean of 1.59 t ha^{-1} compared to 2.72 t ha^{-1} for sole cropped pigeonpea (Table-5). The mean percentage reduction of dry grain yield by intercropping as compared to sole cropping was 41.54 (Table-5). Again, ‘Igbongbo’ dry grain yield was reduced by 47.27% by intercropping as compared to sole cropping. This percentage reduction (47.27%) was higher than the mean percentage reduction (40.80) observed for the dry grain yield of the improved pigeonpea genotypes.

Under intercropping, ICPL 87 consistently produced the highest dry grain yield (2.12 t ha^{-1} (2002) and 2.81 t ha^{-1} (2003), in both years of experimentation, but ICPL 87119 (2002) and ICPL 87051 with a yield of 0.90 t ha $^{-1}$ gave the lowest yields. These lower yields of ICPL 87119 (2002) and ICPL 87051 (2003) were not significantly different from those produced by ‘Igbongbo’ in these years.

Mean LER values varied between 1.50 and 2.23 in 2002 and 1.08 and 2.04 in 2003 with a combined mean of 1.74 for both years. While several intercropped pigeonpea genotypes (ICPL 85010, ICPL 87, ICPL 161, ICEAP 00068, ICPL 7035, ICPL 9145, ICEAP 00040 and ‘Igbongbo’) produced LER values of 2.0 and above in 2002, only ICPL 87 did so in 2003 (although this was not significantly different from LER obtained by ICPL 161, (1.68), ICPL 85063 (1.76), ICEAP 00068 (1.52) ICPL 9145 (1.79) (Table-6)

ATER value ranged from 1.43 to 2.32 in 2002 and 0.99 to 1.90 in 2003, with a combined mean of 1.64 for both years of experimentation (Table-7). No statically significant difference was observed in ATER values between the pigeonpea genotypes intercropped with sorghum in 2002, but significant differences ($p \leq 0.05$) occurred between the treatments in 2003. All intercrop pigeonpea produced ATER values above 1.0 in both years combined, except ICPL 84031 in 2003.

Table-1. Key characteristics of pigeonpea genotypes used in the study.

Genotype	Days to 50% flowering	Seed colour	Maturity group
ICPL 85010	65	Brown	Short duration
ICPL 84031	68	Brown	Short duration
ICPL 87	69	Brown	Short duration
ICPL 161	81	Brown	Short duration
ICPL 8863	89	Brown	Medium duration
ICPL 85063	96	Brown	Medium duration
ICPL 87119	98	Brown	Medium duration
ICPL 7120	96	Cream	Medium duration
ICEAP 00068	94	Brown	Medium duration
ICPL 8094	101	Brown	Long duration
ICPL 7035	106	Brown	Long duration
ICPL 87051	104	Brown	Long duration
ICPL 9145	107	Brown	Long duration
ICEAP 00040	162	Cream	Long duration
'Igbongbo' (traditional cultivar)*	120	Brown	Long duration

Source: Internal Crops Research Institute for Semi-Arid Tropics (ICRISAT), Kano Station, Nigeria.
* Personal observation and records.

Table-2. Pigeonpea and sorghum planting pattern, spacing, ratio and plant population studies in 2002 and 2003.

Treatment	Spacing		Ratio		Plant population	
	Pigeonpea	Sorghum	Pigeonpea	Sorghum	Pigeonpea	Sorghum
Sole cropping						
Pigeonpea	50cm x 30 cm x 1	-	100	0	66,666	0
Sorghum		100cm x 50cm x 1	0	100	0	40,000
Intercropping						
Pigeonpea + Sorghum	100cmx30cmx1	100cm x 50cm x 1	50	50	33,333	20,000

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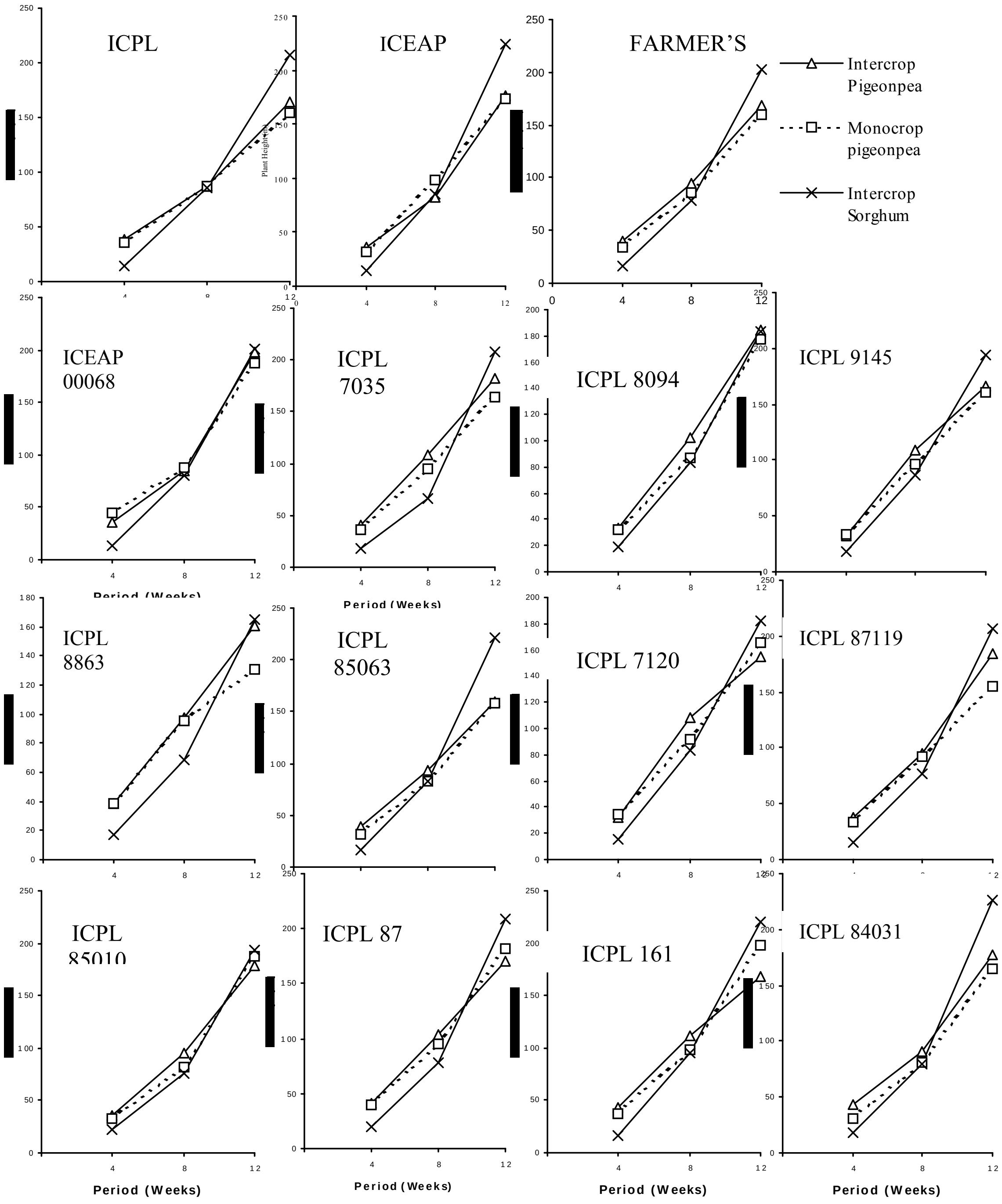

Figure-1. Plant height of sole crop pigeon pea, intercropped pigeon pea and sorghum at 4, 8, 12 weeks after planting (2002 and 2003 data pooled).

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Table-3. Number of branches per plant of pigeonpea genotype at harvest as affected by intercropping with sorghum in 2002 and 2003.

Pigeonpea genotype	Maturity group	2002		2003		Mean		
		Sole	Inter	Sole	Inter	Sole	Inter	Reduction (%)
ICPL 85010	S	16.50	18.67	29.00	22.47	22.75	20.57	–9.60
ICPL 84031	S	19.67	19.50	28.27	26.83	23.97	23.17	–3.34
ICPL 87	S	15.0	9.50	31.17	26.93	23.09	18.22	–21.09
ICPL 161	S	23.50	21.33	36.57	30.57	30.04	25.95	–13.61
Mean		18.67	17.25	31.25	26.70	24.96	21.98	–11. 91
ICPL 8863	M	21.50	19.33	31.50	25.97	26.50	22.65	–14.53
ICPL 85063	M	27.83	20.50	25.33	26.33	26.58	23.42	–11.89
ICPL87119	M	37.67	24.17	34.37	25.23	36.02	24.7	–31.43
ICPL 7120	M	22.67	26.50	26.27	25.00	24.47	25.75	+5.23
ICEAP 00068	M	25.17	20.50	17.40	18.80	21.29	19.65	–7.71
Mean		26.97	22.20	26.97	24.27	26.97	23.23	–12.07
ICPL 8094	L	16.50	19.83	29.53	24.80	23.02	22.32	–3.04
ICPL 7035	L	31.33	18.17	32.50	28.40	31.92	23.29	–27.04
ICPL 87051	L	32.50	30.17	23.57	27.73	28.04	28.95	+3.24
ICPL 9145	L	35.67	24.83	27.30	24.80	31.49	24.82	–21.18
ICEAP 00040	L	20.33	21.17	27.40	24.63	23.87	22.90	–4.06
Mean		27.27	22.83	28.06	26.07	27.67	24.46	–10.42
Igbongbo		30.50	25.67	28.90	26.00	29.70	25.84	–13.00
Mean		25.09	21.32	28.61	25.63	26.85	23.48	–12.55
F – LSD (0.05)								
CS		1.14		0.38				
GE		3.01		2.69				
CS X GE		4.28		3.79				

Sole: Sole crop
Inter: Intercrop
CS: Cropping system
GE: Genotype
S: Short duration
M: Medium duration
L: Long duration
Minus (–) sign before figure for % reduction indicate presence of reduction
Plus (+) sign before figure for % reduction indicates increase rather than reduction

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Table-4. Dry pod weight (t ha^{-1}) of pigeonpea genotypes and affected by intercropping with sorghum.

Pigeonpea genotype	Maturity group	2002		2003		Mean		
		Sole	Inter	Sole	Inter	Sole	Inter	Reduction (%)
ICPL 85010	S	3.51	2.83	5.38	5.38	4.45	4.11	– 7.64
ICPL 84031	S	4.85	3.13	6.60	2.16	5.73	2.65	– 53.75
ICPL 87	S	5.67	4.72	10.22	9.44	7.95	7.08	– 10.94
ICPL 161	S	4.10	3.23	6.92	3.69	5.51	3.46	– 37.21
Mean		4.53	3.48	7.28	5.18	5.91	4.33	– 27.39
ICPL 8863	M	3.20	3.52	9.68	3.65	6.44	3.59	– 44.25
ICPL 85063	M	4.38	2.55	6.74	3.27	5.56	2.91	– 47.66
ICPL87119	M	4.05	2.10	7.19	5.47	5.62	3.79	– 32.56
ICPL 7120	M	5.92	3.93	5.04	3.47	5.48	3.7	– 32.48
ICEAP 00068	M	5.22	4.88	5.96	5.22	5.59	5.05	– 9.66
Mean		4.55	3.39	6.92	4.22	5.74	3.81	– 33.32
ICPL 8094	L	2.95	2.20	6.09	3.70	4.52	2.95	– 34.73
ICPL 7035	L	4.18	2.83	8.19	4.39	6.19	3.61	– 41.68
ICPL 87051	L	4.13	1.60	5.94	2.32	5.04	1.96	– 61.11
ICPL 9145	L	2.05	1.92	4.66	4.63	3.36	3.28	– 2.38
ICEAP 00040	L	3.10	3.02	4.47	1.58	3.79	2.3	– 39.31
Mean		3.28	2.31	5.87	3.32	4.58	2.82	– 35.84
Igbongbo		2.72	2.13	5.27	1.87	3.99	2	– 49.87
Mean		4.00	2.97	6.56	4.02	5.28	3.49	– 33.91
CV (%)								
CS		16.79		1.90				
CS X GE		15.43		6.30				
F – LSD (0.05)								
CS		1.52		0.76				
GE		0.62		0.38				
CS X GE		1.01		0.55				

CS: Cropping system
GE: Genotype
Sole: Sole crop
Inter: Intercrop
S: Short duration
M: Medium duration
L: Long duration
Minus (-) before figure for % reduction: presence of reduction
Plus (+) before figure for % reduction indicates increase rather than reduction

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Table-5. Dry grain yield (t ha^{-1}) of pigeonpea genotypes as affected by intercropping with sorghum.

Pigeonpea genotype	Maturity group	2002		2003		Mean		
		Sole	**Inter**	**Sole**	**Inter**	**Sole**	**Inter**	**Reduction** (%)
ICPL 85010	S	1.92	1.45	3.10	2.47	2.51	1.96	– 21.91
ICPL 84031	S	2.13	1.62	3.94	1.42	3.04	1.52	– 50.00
ICPL 87	S	2.80	2.12	4.82	3.49	3.81	2.81	– 26.25
ICPL 161	S	2.27	1.83	3.19	1.47	2.73	1.65	– 39.56
Mean		2.28	1.76	3.78	2.21	3.02	1.99	– 34.11
ICPL 8863	M	1.80	1.92	4.37	1.76	3.09	1.84	– 40.45
ICPL 85063	M	2.38	1.23	4.39	1.79	3.39	1.51	– 55.46
ICPL87119	M	1.98	1.02	5.05	1.93	3.52	1.48	– 57.95
ICPL 7120	M	2.27	1.50	2.38	1.38	2.33	1.44	– 38.20
ICEAP 00068	M	2.08	1.56	2.65	1.80	2.37	1.68	– 21.11
Mean		2.10	1.45	3.77	1.73	2.94	1.59	– 45.92
ICPL 8094	L	1.37	1.08	3.54	1.86	2.46	1.47	– 40.24
ICPL 7035	L	1.77	1.38	4.61	1.68	3.19	1.53	– 52.04
ICPL 87051	L	1.98	1.18	2.48	0.90	2.23	1.04	– 53.64
ICPL 9145	L	1.57	1.25	2.38	1.78	1.98	1.52	– 23.23
ICEAP 00040	L	2.20	1.65	1.71	0.86	1.96	1.26	– 35.71
Mean		1.78	1.31	2.94	1.42	2.36	1.36	– 42.37
Igbongbo		1.20	1.23	3.19	1.08	2.20	1.16	– 47.27
Mean		1.98	1.47	3.45	1.71	2.72	1.59	– 41.54
CV (%)								
CS		22.72		6.88				
CS X GE		18.63		7.87				
F – LSD (0.05)								
CS		1.02		0.51				
GE		0.37		0.24				
CS X GE		0.59		0.34				

CS: Cropping system
GE: Genotype
Sole: Sole crop
Inter: Intercrop
S: Short duration
M: Medium duration
L: Long duration
Minus (-) before % reduction figure indicates presence of reduction.
Plus (+) before % reduction figure indicates increase rather than reduction.

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Table-6. Land equivalent ratio (LER) for the different pigeonpea genotypes intercropped with sorghum.

Pigeonpea genotypes	Maturity group	2002	2003	Mean
ICPL 85010	S	2.05	1.54	1.80
ICPL 84031	S	1.86	1.08	1.47
ICPL 87	S	2.10	2.04	2.07
ICPL 161	S	2.45	1.68	2.09
Group				
Mean	-	2.12	1.59	1.86
ICPL 8863	M	1.93	1.28	1.61
ICPL 85063	M	1.50	1.76	1.63
ICPL 87119	M	1.76	1.38	1.57
ICPL 7120	M	1.68	1.49	1.59
ICEAP 00068	M	2.16	1.69	1.93
Group				
Mean	-	1.81	1.52	1.67
ICPL 8094	L	1.84	1.44	1.64
ICPL 7035	L	2.23	1.21	1.72
ICPL 87051	L	1.58	1.47	1.53
ICPL 9145	L	2.04	1.79	1.92
ICEAP 00040	L	2.19	1.42	1.81
Group				
Mean	-	1.98	1.47	1.73
Igbongbo	-	2.14	1.26	1.70
Year mean		1.97	1.50	1.74
CV (%)		15.87	19.68	
FLSD (0.05)		0.52	0.49	

S: Short duration
M: Medium duration
L: Long duration

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Table-7. Area-time equivalency ratio (ATER) of pigeonpea genotypes intercropped with sorghum.

Pigeonpea genotypes	Maturity group	2002	2003	Mean
ICPL 85010	S	1.80	1.35	1.58
ICPL 84031	S	1.63	0.99	1.31
ICPL 87	S	1.94	1.90	1.92
ICPL 161	S	2.32	1.59	1.96
Mean	-	1.92	1.46	1.69
ICPL 8863	M	1.91	1.27	1.59
ICPL 85063	M	1.50	1.76	1.63
ICPL 87119	M	1.84	1.37	1.61
ICPL 7120	M	1.60	1.45	1.53
ICEAP 00068	M	2.15	1.68	1.92
Mean	-	1.80	1.51	1.65
ICPL 8094	L	1.55	1.36	1.45
ICPL 7035	L	2.11	1.16	1.64
ICPL 87051	L	1.43	1.41	1.42
ICPL 9145	L	1.77	1.75	1.76
ICEAP 00040	L	1.88	1.36	1.62
Mean	-	1.75	1.41	1.58
Igbongbo	-	2.14	1.25	1.69
Grand mean		1.84	1.44	1.64
CV (%)		21.07	20.27	
FLSD (0.05)		NS	0.49	

DISCUSSIONS

Results from this study indicated that intercropped sorghum was taller than intercropped pigeonpea at 12 WAP and intercropping reduced the number of branches per plant of pigeonpea genotype at harvest. The reduction in the number of branches per plant was significant (P <0.05) for all genotypes of pigeonpea intercropped with sorghum except ICPL 7120 and ICPL 87051. Since the increase in plant height was more pronounced in sorghum component at 12 WAP, it could be inferred that sorghum was better equipped than pigeonpea to compete for light by elongating the stem and developing higher positioned leaves, thus casting shade on the pigeonpea. Fujita *et al.* (1990) had made similar observations in soybean/sorghum intercropping studies. The reductions in the number of branches.plant^{-1} of intercropped pigeonpea genotypes at harvest were probably due to effect of shade exerted on the intercropped pigeonpea by the taller sorghum. As with other crops, biomass accumulation in pigeonpea is essentially a linear function of the amount of photosynthetically active radiation intercepted by the canopy. Therefore shading by the taller sorghum component of the pigeonpea/sorghum intercropping might have reduced the amount of solar radiation available to the pigeonpea at the lower storey.

Thus, photosynthetic activities could not effectively take place to produce sufficient energy required to drive growth and developmental processes in the intercropped pigeonpea. The results of this study agreed with earlier findings (Rubaihayo *et al*., 2000; Lawn and Troedson, 1990) which reported significant reductions of the mean number of branches plant^{-1} of pigeonpea intercropped with sorghum. Lawn and Troedson (1990) had particularly noted that while most pigeonpea genotypes were freely branching, the extent of branching was substantially influenced by inter-plant competition, and was reduced at denser population, and when pigeonpea was grown as an intercrop. Intercropping also reduced the dry pod weight and the dry grain yield of pigeonpea genotypes intercropped with the local sorghum in Southern Guinean Savanna. The reduction might probably have resulted from decreased branching, which subsequently culminated in decreased dry matter accumulation. Generally, biomass production of shorter component crops is reduced by depression of photosynthesis due to reduction in solar radiation by slading of taller component crops. Ito *et a*l. (1997) had earlier reported significant reduction in total dry matter in pigeonpea intercropped to about 50% of the monocrop. The reductions in both dry pod weight and dry grain yield of intercropped pigeonpea genotypes might probability be also ascribed to long competitive interactions with the traditional red sorghum, which, is endowed with unique proliferation of robust fine root network equipped for better competition for below-ground growth resources. Earlier reports (Adu-Gyamfi *et al*., 1997; Ito *et a*l., 1997) had ascribed the reduction of dry grain yield of intercropped pigeonpea by sorghum to both above-and below-ground competition for growth resources. It must also be noted that, although Ali (1990), indicated intercropping cereals with early-maturing pigeonpea often led to drastic reductions in pigeonpea yield, the results of this study did not show any significantly lower yield performance of the early-maturing (short duration) genotypes when compared to the medium or the long duration genotypes. The mean percentage reduction of dry grain yield in the short duration genotypes were lower than those observed for both medium and long duration. Although the reason (s) for this can not be immediately established, but at the intercropped sorghum population of 20,000 plants ha^{-1}, the interplant competition might not have been intense enough to cause such drastic reductions in the short duration pigeonpea genotypes tested in this work. Also it might be because the short duration genotypes had nearly completed their life cycles (< 150 days) before the major growth period of the sorghum component which matured in 198 days after planting.

The use of LER as an agronomic measure of yield advantage is valid, whether or not an additive or a replacement design is used (Snaydon, 1996). The results of LER obtained in this study indicated complementarities in resource use by the intercrop components, resulting in yield advantages. Even though the yield of pigeonpea was depressed, but the system as a whole proved more productive than either sole pigeonpea or sole sorghum. The high LER values, indicative of presence of intercrop advantage, might have resulted from temporal complementarity as described by Willey (1996) who noted that temporal complementarity may not be so dramatic for it to be beneficial, but that the complementarily may stem from a relatively small difference between components in their timings of peak resource use which is sufficient to spread demand to beneficial effects. ATER values in this study suggested intercrop yield advantages. Values of ATER values greater than one are considered advantageous (Ofori and Stern, 1987). The results of this study indicated that more hectare-days would be required for monoculture than when these pigeonpea genotypes were grown as intercrop. This implied that it would save the pigeonpea farmer more time to grow both the pigeonpea and the sorghum as intercrops as compared to sole cropping.

CONCLUSIONS

The high LER values exhibited by the pigeonpea genotypes intercropped with the traditional red sorghum in Southern Guinea Savanna of Nigeria in 2002 and 2003 have clearly proved the suitability of these genotypes for intercropping with the traditional sorghum. The non-reduction of the number of $branches.plant^{-1}$ of intercropped ICPL 87051 from planting to harvest and the same responses by ICPL 87 and Igbongbo (farmer's cultivar) at 4-12 WAP, need further investigation to identify the mechanisms responsible for these intercrop differences.

REFERENCES

Adu-Gyamfi J.J., Ito O., Yoneyama, T. and Katayam K. 1997. Nitrogen management and biological nitrogen fixation in pigeonpea/sorghum intercropping on alfisols of semi-arid tropics. Soil Science Plant Nutrition. 43: 1061-1066.

Ali M. 1990. Pigeonpea cropping systems In: Y.L Nene, S.D Hall, Y.K Sheila (editors). The pigeonpea. CAB International, Wallingford, UK. pp. 279-301

Ali M. 1996. Pigeonpea-based cropping systems in semi-arid tropics. In: Ito,O., Katayama K.,Johansen C., Kumar Rao, J.V.D.K., Adu-Gyamf, J.J., Rego, T.J. (Eds.) Roots and nitrogen in cropping systems of the Semi-Arid Tropics. JIRCAS International Agricultural Series No. 3, Ohwashi, Tsukuba, Ibaraki, Japan. pp. 41-58.

Benue State Agricultural and Rural Development Authority (BNARDA). 2000. Agricultural production recommendation for Benue State (Extension Bulletin No 3) Benue State Agricultural and Rural Development Authority, Makurdi, Nigeria. p. 76.

Chaykin S. 1969. Assay of nicotinamide dcaminase-determination of ammonium by the indophenols reaction. Anal Biochem. 32: 375-382.

Egbe O.M. and Kalu B.A. 2006. Farming systems study: Participatory Rural Appraisal of pigeonpea cropping systems in Sourthern Guinea Savanna of Nigeria. Abia State University Environment Review (ASUER). 5(1): 37-47.

Egbe O.M. and Adeyemo M.O. 2006. Estimation of the effect of intercropped pigeonpea on the yield and yield components of maize in Southern Guinea Savanna of Nigeria. Journal of Sustainable Development in Agriculture and Environment. 2: 107-119.

Fujita K., Ogata S., Matsumoto K., Masuda T., Ofusu-Budu K.G. and Kuwata K. 1990. Nitrogen transfer and dry matter production in soybean and sorghum mixed cropping system at different population densities. Soil Science and Plant Nutrition. 36: 233-241.

Gee G.W. and Bander. J.W. 1986. Particle-size analysis. In*:* A. Klute (Ed.). Methods of soil analysis; Part 1- physical and mineralogical methods SSSA book series: 5 Madison, Wisconsin, USA. pp. 383-411.

GENSTAT. 1995. GENSTAT- A general statistical program release 3.2. Lawes Agricultural Trust Rothamsted Experimental Station.

Hiebisch C.K. 1980. Principles of intercropping: effect of nitrogen fertilization, plant population and crop duration on equivalency ratios in intercrop versus monoculture comparisons, Ph. D Thesis. North Carolina State University, Raleigh, North Carolina.

Ito O., Matsunaga R., Tobita S., Adu-Gyamfi J.J., Rao T.P. and Gayatri Devi. 1997. Nitrogen fertilizer management in pigeonpea/sorghum intercropping on Alfisol in the semi-arid tropics. Plant Nutrition for sustainable food production and environment. 1: 689-690. Kluwer Academic Publishers, Japan.

Jackson M.L. 1967. Soil chemical analysis. Prentice Hall, Engle wood cliff, N.S. p. 498.

Kowal J.M. and Knabe D.T. 1972. An agroclimatological atlas of the northern states of Nigeria with explanatory notes. Ahmadu Bello University Press, Zaria.

Lawn R.J.and Troedson R.J. 1990. Pigeonpea: physiology of yield formation. In: Nene, Y.L., Hall, S.D and Sheila, Y.K. (Eds.) the pigeonpea. CAB International, Wallingford, UK. pp. 179-258.

Obi I.U. 1990. Statistical method of detecting differences between treatment means. SNAAP Press (Nig.) Ltd., Enugu, Nigeria. p. 14.

Ofori F.and Stern W.R. 1987. Cereal-legume intercropping systems. Advances in Agronomy. 41: 41-90.

Rao M.R. and Willey R.W. 1980. Evaluation of yield stability in intercopping studies on sorghum/pgeonpea. Experimental Agriculture. 16: 105-116.

Rao S.C., Coleman, S.W. and Maycux H.S. 2002. Forage production and nutritive value of selected pigeonpea ecotypes in southern Great Plains. Crop Science. 42: 1259-1263.

Remanandan P. and Asiegbu J.E. 1993. Pigeonpea germplasm collection in Nigeria ICRISAT Genetic resources report No. 79 ICRISAT., Patancheru, A.P India. p. 4.

Rubaihayo P.R., Osiru, D.S.O and Okware P. 2000. Performance of pigeonpea and its finger millet and sorghum intercrops. African crop Science Journal. 8(1): 49-62.

Snaydon R.W. 1996. Above-ground and below ground interactions in intercropping. In: Ito O., Katayama K., Johansen C., Kumar Rao, J.V.D.K. Adu-Gyamfi, J.J. Rego T.J. (Eds.) Roots and Nitrogen in Cropping Systems of the Semi-Arid Tropics. JIRCAS International Agricultural series No. 3, Ohwashi, Tsukuba, Ibaraki, Japan. pp. 73-92.

Tabo R., Ezueh M. I., Asiegbu J.E. and Singh L. 1995. Pigeonpea production and utilization in Nigeria. International chickpea and pigeonpea Newsletter. 2: 47-49.

Willey R.W. 1996. Intercropping in cropping systems: Major issues and research needs. In: Ito O., Katayama K., Johansen C., Kumar Rao, J.V.D.K., Adu-Gyamfi J.J. and Rego T.J. (Eds.) Roots and nitrogen in cropping systems of the semi-arid tropics. JIRCAS International Agricultural series No. 3, Ohwashi, Tsukuba, Ibaraki, Japan. pp. 93-102.