The African Journal of Plant Science and Biotechnology ©2012 Global Science Books

Influence of Cowpea Planting Date and Phosphorus Level on *Striga* Infestation and Performance of Pearl Millet in Mixture with Cowpea in a Nigerian Sudan Savanna

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ABSTRACT

Pearl millet is traditionally grown in mixture with cowpea in the savanna region of Nigeria. Field experiments were conducted to determine the response of pearl millet to varying dates of planting cowpea and phosphorus levels during the 2005 and 2006 rainy seasons. A randomized complete block design in factorial arrangement was used to evaluate five cowpea planting dates (0, 10, 20, 30 and 40 days after planting millet) and three phosphorus levels (0, 30 and 60 kg P_2O_5/ha), each replicated three times. The results showed that *Striga* counts and pearl millet plant height significantly increased with delay in planting cowpea, while number of grains/panicle, seed weight and grain yield/ha significantly decreased with delay in planting date. Increase in P levels significantly reduced *Striga* counts, but had no significant effect on grain yield/ha. Grain yield/ha was inversely associated with *Striga* counts ($r = -0.28$ to -0.42), but positively correlated with number of grains/panicle ($r = 0.52$ to 0.89) and seed weight ($r = 0.27$ to 0.35). The competitive effects of cowpea on pearl millet were balanced by substantial gain in cowpea grain yield for simultaneous or planting cowpea within 10 days after pearl millet. Therefore, both pearl millet and cowpea should be planted simultaneously or within 10 days after planting pearl millet as each proved beneficial to pearl millet and enhanced the productivity of the system in the Nigerian Sudan savanna.

Keywords: competitive effects, cowpea, grain yield, intercropping, pearl millet, planting date, *Striga hermonthica*

INTRODUCTION

Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is grown in mixture with legumes in the semi-arid region of West Africa. Henriet *et al*. (1997) reported the existence of up to 43 crop mixtures in the Sudan savanna of Nigeria with pearl millet and cowpea mixture being predominant. Pearl millet is cultivated on 16 million ha with average grain yield of 800-1000 kg/ha in West and Central (Izge *et al*. 2009). FAO (2007) reported that annual production was about 8.2 million tons in Nigeria in 2006, where 6.4 million tons were used directly as food and 1.8 million tons was used as seeds.

The main benefits derived from intercropping cereals with legumes are to produce additional crops without much effect on the base crop yield and to obtain higher total economic returns (Mkamilo 2005), reduction in *Striga* infestation (Webb *et al*. 1993; Dugje *et al*. 2010), relatively more profitable than sole cropping systems (Norman, 1974); precaution against total crop failure (Olufajo and Singh 2004) and the practice is consistent with the goal of food security (Mumilo 2004). *Striga hermonthica* density is significantly suppressed when cereals are intercropped with legumes (Carsky *et al*. 1994; Dugje *et al*. 2003).

Farmers in the Sudan savanna of Nigeria traditionally plant pearl millet at the onset of rains and cowpea is planted 3-4 weeks latter between cereal rows when rains have stabilized (Singh and Ajeigbe 2002). Apart from *Striga* infestation, the production ecology of the pearl millet based system is characterized by poor soil fertility, inadequate and short duration of rainfall (Payne *et al*. 1990), which provides narrow amplitude for choice of planting date for the intercropping systems practiced.

Willey (1979) reported that differential sowing improves productivity and minimizes competition for the growth limiting factors because crop occupies the land throughout the growing season. The onset of competition between intercrops can be delayed by judicious choice of relative planting dates (Midmore 1993). Since the soils of the millet growing zone of Nigeria are predominantly sandy, low in organic matter, effective cation exchange capacity and inherent soil fertility (Ajayi *et al*. 1998), it is therefore possible to obtain crop response to small addition of P due to low to medium P sorption property of the soils (Uyovbisere and Chude 1995).

The canopy characteristics of pearl millet appear to be unaffected by competition from the cowpea component due largely to the staggered sowing which gives the millet a competitive edge (Grema and Hess 1994). However, this does not lead to yield advantages over simultaneous sowing in spite of the competitive edge (Ofori and Stern 1987), but Ntare and Williams (1992) reported yield reduction in pearl millet when both pearl millet and cowpea were planted simultaneously in Sahel savanna in Niger Republic probably due to low resource pool and plant competition. Thus, much variation of response to planting date could occur depending on the magnitude of resource pool available in the production ecology. Inappropriate planting geometry as practiced by most African farmers, leading to competition for site resources, is the principal reason for the low productivity (Hauggaard-Nielsen *et al*. 2006). However, cowpea genotypes grown in association with cereals adopting planting patterns that optimize complementary interactions may improve land use efficiency (Hauggaard Nielsen *et al*., 2001) and land equivalent ratio (Jahansooz *et al*. 2007).

Although cowpea planting date may have varying influence on the performance of pearl millet, cowpea grain yield has been reported to significantly reduce when intercropped with cereals such as pearl millet (Blade *et al*. 1997; Dugje *et al*. 2012). However, we hypothesize that inclusion and delaying cowpea planting into pearl millet and application

Received: 13 July, 2011. Accepted: 20 January, 2012.

Original Research Paper

of P fertilizer may reduce *Striga* infestation and improve the performance of pearl millet in the system. The aim of this study was to determine the response of pearl millet to varying cowpea planting dates and application of P levels in a Nigerian savanna. The responses of the cowpea component to these factors are discussed in a subsequent paper (Dugje *et al*. 2012).

MATERIALS AND METHODS

A field study was conducted at the University of Maiduguri Teaching and Research Farm (latitude 11° 47.82' N and longitude 13° 12.01' E; 320 m above sea level) during 2005 and 2006 rainy seasons. The aim of the study was to determine the response of pearl millet to varying dates of planting cowpea and phosphorus levels in pearl millet and cowpea intercrop. Five cowpea planting dates: simultaneous planting (0), 10, 20, 30 and 40 days after pearl millet planting (DAMP) and 3 phosphorus levels: 0, 30 and 60 kg P_2O_5/ha were evaluated in randomized complete block design (RCBD) in factorial arrangement and replicated three times.

The experimental site was sick with *Striga hermonthica* and was harrowed with tractor driven disc. Analysis of the top (0-15 cm) soil sampled from the site in 2005 prior to planting showed that the texture was sandy loam with 63% sand, 19.1% silt and 17.9% clay. Total N (0.13%) and available P (7.0%) were moderate, available Ca (17.2 meq./100 g) and Mg (3.60 meq./100 g) was high, and K (0.24%) was low, while organic carbon (0.22%) and organic matter (0.37%) were very low. Thus, the nutrient content of the soil was low according to the FAO rating (FAO 1980). The total amount of rainfall recorded for Maiduguri in 2005 was 869 mm and 569.3 mm in 2006.

Seeds of pearl millet var. 'SOSAT-C-88' were sourced from Lake Chad Research Institute, Maiduguri. The seeds were dressed with Apron Star 42 WS (a multi-crop seed treatment developed by Syngenta) at the rate of 10 g sachet/4 kg seeds for protection against soil- and seed-borne pests and diseases. The seeds were planted at 75 cm × 50 cm in a plot 3 m × 4 m on 21st and 25th July, 2005 and 2006, respectively. Seedlings were thinned to 3 per stand at 2 weeks after sowing (WAS). The improved cowpea variety IT89KD-288 was sourced from International Institute of Tropical Agriculture (IITA), Kano. The seeds were also dressed with Apron Star 42 WS at the rate of 10 g sachet/8 kg seeds. The variety is semi-erect, excellent for relay with cereals, medium maturing and photosensitive. Two seeds were planted per hole on the stipulated treatment dates midway between pearl millet rows and 25 cm within the row in 1:1 alternate row arrangement with pearl millet.

The phosphorus fertilizer rates were applied in form of single super phosphate (18% P_2O_5) in furrow drilled close to the cowpea rows at one week after emergence. Also, the recommended NPK rate of 60:30:30 (FPDD 2002) was applied to pearl millet. The first dose of 30 kg N and 30 kg K_2O/ha were applied in form of urea (46% N) and muriate of potash (60% K_2O), respectively, as side placement to the pearl millet component at one week after emergence. The balance of 30 kg N/ha was applied to the millet component in the form of urea (46% N) at 5 WAS. Two manual hoe weeding were conducted at 2 and 6 WAS, while cowpea was sprayed with Best Action (Cypermetrin + Dimethoate) an insecticide marketed by African Agro at the rate of 1 l/ha at 35, 50 and 65 days after planting for each planting date. The 3 middle rows of pearl millet and 2 middle rows of cowpea were harvested leaving 2 stands at both ends of each row at maturity for grain yield determination.

Data on pearl millet agronomic parameters and *S. hermonthica* plant counts were collected. Emerged *Striga* plants were counted from 1 m^2 quadrat randomly chosen from 3 places in each plot. The *Striga* counts were transformed using square root transformation. The competitive effect of cowpea on the pearl millet component was assessed as a compensation ratio (T), defined as the ratio of the yield in a treatment to the loss of the millet yield as a result of competition from the cowpea as described by Ntare and Williams (1992) thus:

$$T = Ci/ (Ms – Mi)$$

where Ci = yield of cowpea in the intercrop treatment, Ms = yield of sole pearl millet and Mi = yield of pearl millet in the intercrop treatment.

Data collected were subjected to analysis of variance (ANOVA) using Statistix 8.0 (Statistix 2005) Analytical Software Package, year wise and for the 2 years combined. Differences between treatment means were compared using Least Significant Difference (LSD) at 5% level of probability, while significant interaction effects were compared using Duncan Multiple Range Test (DMRT) also at 5% level of probability. Linear correlation coefficients were also calculated to determine the degree of association among the pearl millet agronomic parameters and *Striga* counts.

RESULTS AND DISCUSSION

Effects of cowpea planting date and P levels on *Striga* infestation of pearl millet

The *Striga* species sampled in experimental area comprised about 70% *S. hermonthica* (Del.) Benth., and 30% *S. gesneriodes* (Willd.) Vatke., as described by Ramaiah *et al.* (1983). *S. hermonthica* counts significantly increased ($P < 0.001$) with a delay in planting cowpea (**Table 1**). The level of infestation of sole millet was significantly higher ($P < 0.001$) than millet intercropped with cowpea. *Striga* count was significantly lower ($P < 0.001$) for simultaneous planting (0 DAMP) of pearl millet and cowpea than the other intercrop treatments. Increase in P level significantly ($P < 0.05$) reduced *Striga* counts in 2006 and slightly lower

Table 1 Effect of cowpea planting date and phosphorus levels on pearl millet plant height, *Striga* count and dry weight/plant at 12 WAS in millet + cowpea intercrop.

Treatment	Plant height (cm)			*Striga* count/m^2			*Striga* dry weight/plant (g)		
	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean
Cowpea planting date (D)									
0 DAMP	169.1	160.8	164.9	1.9	1.2	1.6	2.5	1.8	2.2
10 DAMP	155.3	157.7	156.5	3.4	2.0	2.7	0.83	0.68	0.76
20 DAMP	156.8	164.4	160.6	6.2	2.5	4.3	0.87	0.65	0.76
30 DAMP	159.1	160.1	159.9	6.5	2.9	4.7	0.84	0.66	0.75
40 DAMP	169.3	168.9	169.1	6.1	3.0	4.5	0.58	0.46	0.52
SE±	9.3	9.1	6.06	0.73	0.22	0.36	0.35	0.19	0.19
LSD (0.05)	NS	NS	12.1	1.5	0.45	0.73	0.72	0.39	0.38
Phosphorus (P) levels (kg/ha)									
0	158	155.6	156.8	4.8	2.7	3.7	1.1	0.96	1.0
30	157.7	160.8	159.3	5.1	2.3	3.7	0.96	0.77	0.87
60	169.9	171.7	170.8	4.5	2.1	3.3	1.3	0.81	1.1
SE±	7.21	7.03	4.69	0.56	0.17	0.28	0.27	0.15	0.15
LSD (0.05)	NS	14.41	9.37	NS	0.35	NS	NS	NS	0.30
D × P interaction	NS	NS	NS	NS	NS	*S	NS	NS	*S

WAS = weeks after sowing, DAMP = days after millet planting, NS = not significant
* Significant interaction ($P < 0.05$)

Table 2 Effects of cowpea planting date and phosphorus levels on pearl millet yield components and grain yield (kg/ha) in millet + cowpea intercrop

Treatment	No. grains/panicle			1000-seed weight (g)			Grain yield (kg/ha)		
	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean
Cowpea planting date (D)									
0 DAMP	3880	4201	4040	9.9	8.6	9.3	1353.1	1163.8	1258.4
10 DAMP	3052	3245	3153	9.1	8.9	9.0	1192.7	1076	1134.3
20 DAMP	3041	3022	3031	8.6	8.8	8.8	876.6	1097.9	987.2
30 DAMP	2166	2396	2270	8.8	8.4	8.6	671.6	967.6	819.5
40 DAMP	2050	2188	2124	8.2	8.9	8.5	699.7	836.1	767.8
SE±	613	627	405	0.52	0.37	0.33	218.48	193.7	148.14
LSD (0.05)	1257	1286	810	1.06	NS	0.66	447.54	NS	NS
Phosphorus (P) levels (kg/ha)									
0	2560	2885	2720	9.0	8.6	8.8	876.5	923.1	900.8
30	3180	3250	3225	9.0	8.8	8.9	1040.6	981.7	1011.2
60	2765	2976	2836	8.9	8.9	8.9	957.1	1180	1068.3
SE±	475	486	313	0.40	0.28	0.25	169.24	150.05	114.75
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
D × P interaction	NS	NS	*S	NS	NS	NS	NS	NS	NS

WAS = weeks after sowing, DAMP = days after millet planting, NS = not significant
* Significant interaction ($P < 0.05$)

values were observed in 2005 and for the combined mean. *Striga* plant weight significantly ($P < 0.001$) decreased with a delay in planting cowpea (**Table 1**). The higher the *Striga* population, the lower the individual *Striga* plant weight probably due to inter plant competition.

Effects of cowpea planting date and phosphorus levels on pearl millet growth and yield

Plant height was significantly ($P < 0.05$) higher for pearl millet when cowpea planting was delayed by 40 days compared to early planting dates for the combined mean (**Table 1**). However, significantly lower plant height was observed at 30 DAMP, probably due to the significantly higher *Striga* population and biomass observed for this treatment. Plant height also significantly ($P < 0.01$) increased with increase in P level (**Table 1**).

The influence of cowpea planting date on pearl millet yield components showed that number of grains/panicle and seed weight each significantly ($P < 0.05$) decreased with delay in sowing date (**Table 2**). Grain yield/ha significantly decreased with delay in planting cowpea in 2005. The simultaneous planting of pearl millet with cowpea was significantly superior to the other planting dates. Similarly, planting cowpea 10 days after planting millet gave significantly ($P < 0.01$) higher grain yield than later planting dates. Both simultaneous planting and 10 DAMP slightly realized superior grain yield in 2006 and for the combined mean (**Table 2**).

Although increase in P level slightly increased grain yield, there was no significant difference among the P levels. The current P recommendation for sole crop of pearl millet to realize and average yield of 1,500-2,000 kg/ha is 30 kg P_2O_5 /ha broadcast at planting (FPDD 2002). However, the low response of peal millet to P application in the medium P level soils in the present study may be due to P fixation as reported in the same ecology by Kwari and Batey (I991). This is because Uyovbisere and Chude (1995) reported the possibility of obtaining crop responses to small addition of P fertilizers due to low to medium phosphorus sorption property of the soils in the region.

Interaction effects of cowpea planting date and phosphorus levels

There were significant interaction effects ($P < 0.05$) of cowpea planting date and phosphorus levels on *Striga* count/m^2, *Striga* biomass and number of grains/panicle (**Table 3**). *Striga* count was significantly lower for simultaneous planting of cowpea and pearl millet and irrespective of P level applied. This implies that delay in planting cowpea significantly increased *Striga* infestation of pearl millet. The lower *Striga* population at simultaneous planting significantly

Table 3 Interaction effects of cowpea planting date and phosphorus levels on *Striga* count/m^2 , *Striga* biomass and number of grains per panicle of pearl millet for combined mean 2005 and 2006 in millet + cowpea intercrop.

Cowpea planting date × P levels	*Striga* count/m^2	*Striga* dry weight/plant (g)	No. of grains/panicle
0 × 0	2.13 ghi	2.18 b	4659 a
0 × 30	1.32 i	1.46 c	4336 ab
0 × 60	1.39 hi	2.86 a	3128 bcd
10 × 0	3.0 d-g	0.97 cd	2587 de
10 × 30	2.7 e-h	0.69 d	4056 abc
10 × 60	2.4 f-i	0.60 d	2806 cde
20 × 0	4.2 a-d	0.58 d	2836 cde
20 × 30	4.9 ab	0.83 cd	2270 de
20 × 60	3.9 b-e	0.87 cd	4023 abc
30 × 0	4.2 a-d	0.82 cd	1904 de
30 × 30	4.6 abc	0.87 cd	2762 cde
30 × 60	5.2 a	0.57 d	2152 de
40 × 0	4.9 ab	0.59 d	1624 e
40 × 30	5.0 ab	0.49 d	2670 cde
40 × 60	3.6 c-f	0.46 d	2050 de
SE±	0.64	0.33	701

Means followed by the same letter(s) in a column are not significantly different according to Duncan's multiple range test at $P < 0.05$

increased *Striga* biomass than for treatments where cowpea was introduced much latter. Number of grains/panicle was also significantly ($P < 0.05$) higher for simultaneous than the other planting dates. The values did not significantly differ from 10 and 20 DAMP in combination with 30 and 60 kg P_2O_5/ha, respectively. Thus early planting of cowpea in combination with P fertilizer application increased number of grains of pearl millet.

Linear relationships among pearl millet agronomic and *Striga* parameters

The linear relationships showed that *Striga* counts was inversely associated plant height (r = -0.22 to -0.33), while grain yield/ha significantly increased with increase in plant height (r = 0.27) (**Table 4**). Thus increase in *Striga* population reduced plant height and the photosynthetic parameters and consequently photosynthetic efficiency. Stewart *et al.* (1991) reported that increase in *Striga* infestation impairs photosynthetic efficiency. *Striga* biomass was negatively correlated with *Striga* counts (r = -0.35 to -0.59) due to increase in interplant competition. Grain yield/ha was negatively correlated with *Striga* counts (r = -0.28 to -0.42), but positively associated with number of grains/panicle (r = 0.52 to 0.89) and seed weight (r = 0.27 to 0.35), while number of grains was positively correlated with seed weight (r = 0.39). Thus increase in plant height, number of grains and

Table 4 Linear correlation coefficients (r) among pearl millet agronomic and *Striga* parameters at five planting dates and three phosphorus levels in millet + cowpea intercrop

Parameter	Plant height (cm)	*Striga* count/m^2	*Striga* dry weight/plant (g)	Grain yield (kg/ha)	No. grains/plant
2005					
Striga count	-0.33*	-	-	-	-
Striga dry weight (g)	0.18	-0.55**	-	-	-
Grain yield (kg/ha)	-0.27	-0.42**	0.15	-	-
No. grains	0.13	-0.28	0.16	0.89***	-
1000-seed weight (g)	-0.02	-0.35**	0.17	0.35**	0.39**
2006					
Striga count	-0.14	-	-	-	-
Striga dry weight (g)	-0.02	-0.59***	-	-	-
Grain yield (kg/ha)	0.26	0.02	-0.18	-	-
No. grains	-0.11	-0.33*	0.36**	0.09	-
1000-seed weight (g)	0.16	-0.12	-0.26	0.17	-0.15
2005 and 2006 combined					
Striga count	-0.22*	-	-	-	-
Striga dry weight (g)	0.09	-0.35	-	-	-
Grain yield (kg/ha)	0.27**	-0.28**	0.02	-	-
No. grains	0.01	-0.25**	0.21*	0.52***	-
1000-seed weight (g)	0.04	-0.18	0.06	0.27**	0.15

*Significant (P < 0.05), ** Significant (P < 0.01), *** Significant (P < 0.001). Values without asterisk(s) have no significant linear correlation.

Table 5 Effect of cowpea planting date and phosphorus levels on cowpea: millet compensation ratios (T) for grain yield (kg/ha) of millet and cowpea intercrop.

Treatment	2005 Grain yield (kg/ha)		T	2006 Grain yield (kg/ha)		T	Mean Grain yield (kg/ha)		T
	Millet	Cowpea		Millet	Cowpea		Millet	Cowpea	
Cowpea planting date									
Only millet	2011.1	-	-	1975.2	-	-	1993.2	-	-
Only cowpea	-	2361	-	-	2450	-	-	2405.5	-
0 DAMP	1353	1515.4	2.30	1163.8	1551.7	1.91	1258.4	1533.5	2.09
10 DAMP	1192.7	1067.9	1.30	1076.1	1074.2	1.19	1134.3	1071	1.25
20 DAMP	876.6	541.4	0.48	1097.9	593.8	0.67	987.2	567.6	0.56
30 DAMP	671.6	308.6	0.23	967.6	291.4	0.29	819.5	300	0.26
40 DA MP	699.7	96.3	0.07	836	112.6	0.09	767.8	104.4	0.09
Phosphorus levels (kg/ha)									
0	876.6	596.3	0.53	923.1	681	0.65	900.8	638.7	0.58
30	1040.6	650.4	0.67	987.7	650.9	0.66	1011.2	650.6	0.66
60	957.1	871.1	0.83	1180	842.3	1.06	1068.3	856.7	0.93

T = compensation ratio

seed weight contributed positively to grain yield, while *Striga* infestation was the major factor responsible for reduction in grain yield of pearl millet in the present study.

Competitive effects of cowpea on pearl millet base component

The competitive effects of cowpea on pearl millet measured as crop compensation ratio are presented in **Table 5**. Both pearl millet and cowpea grain yield declined with delay in introducing cowpea into pearl millet. While *Striga* infestation was the major factor responsible for the decline in grain yield of pearl millet, reduction in growth duration and competition from pearl millet - the dominant component, reduced cowpea grain yield as cowpea planting was delayed. Relatively large values of compensation ratio were observed for the simultaneous and planting cowpea 10 days after pearl millet with yield advantages ranging from 91-130% and 19-30% for the simultaneous and 10 DAMP treatments, respectively (**Table 5**). While delay in planting cowpea reduced cowpea competitive effects probably due to increase in shading from the pearl millet component, increase in P fertilizer level increased the competitive effects since a grain yield advantage of 6% was observed for 60 kg P_2O_5/ha.

DISCUSSION AND CONCLUSIONS

It is apparent that simultaneous or early introduction of cowpea into pearl millet reduced *Striga* infestation. The early introduction of cowpea increased cowpea vegetative cover that suppressed *Striga* emergence. Carsky *et al.* (1994) reported that any spatial arrangement that increases cowpea ground cover at the base of sorghum can reduce *Striga* density. Shading appears the most likely mechanism by which cowpea suppresses *Striga* growth. These observations corroborate earlier reports by Carson (1989), which stated that *S. hermonthica* density is significantly suppressed when cereals are intercropped with legumes. The nitrogen (N) fixed and released by the cowpea (Eaglesham *et al*. 1981), may also contribute to *Striga* suppression since the amount of available N apparently affects *Striga* density (Peterse and Verkleij 1991). Although the amount of N fixed was not measured in the present experiment, this may be unlikely because cowpea does not release much N into the soil during its growth and because large amount of N are usually required to reduce *Striga* density (Mumera and Below 1993).

Although early introduction of cowpea into pearl millet significantly reduced *S. hermonthica* infestation, Dugje *et al*. (2012) reported that early planting of cowpea whether sole or in mixture with pearl millet significantly (P < 0.001) increased *S. gesenerioides* count than later planting across the period of study. Thus *S. gesenerioides* count generally decreased with delay in cowpea planting. This agrees with earlier reports by Parker and Riches (1993) which stated that, there was higher *Striga* infestation with early than late sown cereals and legumes in the West African savanna. These show the complexity of the *Striga* problem as both *S. hermonthica* and *S. gesenerioides* can occur side by side and a control measure adopted for one species may promote the preponderance of the other. This is because early introduction of cowpea into pearl millet will promote *S. gesnerioides*, while delaying introduction of cowpea into pearl millet will promote *S. hermonthica* infestation as observed in the present study.

There is beneficial effect of cowpea inclusion as an intercrop with pearl millet since it suppresses both emergence and development of *S. hermonthica*, which improves the productivity of the pearl millet component in the system. The presence of cowpea also suppressed *Striga* plant growth and development, which reduced *Striga* biomass compared to values observed under sole pearl millet. Carsky *et al*. (1994) reported that production of mature *Striga* capsules decreased with increasing cowpea ground cover, so that while cowpea may not reduce *Striga* emergence, it may hinder *Striga* development. Plant height was also reduced for the intercropped treatments than sole pearl millet due to competition from the cowpea component. This is because plant height for sole pearl millet was higher than those from the intercrop treatments. However, Grema and Hess (1994) reported that plant height was less affected because the canopy characteristics of pearl millet appeared to be unaffected by competition from cowpea due largely to the staggered sowing which gives the millet component a competitive edge. The plant population used was probably lower than in the present study.

Phosphorus is one of the limiting nutrients to crop production in northern Nigeria (Jones and Wild, 1975). Increase in P levels has been reported to reduce *Striga* infestation in maize (Dugje *et al*. 2008) and cowpea (Dugje *et al*. 2010). Since increase in P level has been reported to be negatively correlated with *Striga* counts and score on maize in Sudan savanna (Dugje *et al*. 2008), it is possible that increase in P level reduced *Striga* infestation of pearl millet and increased plant growth. There is increasing evidence from work done in Niger Republic that low availability of mineral nutrients particularly N and P, limit plant growth more than low and irregular rainfall (Manu *et al*. 1991). Application of adequate amounts of P could reduce the N requirement of the crop by half (Uyovbisere and Chude 1995), thus indicating multiple benefits from P fertilizer application in the savanna.

Early introduction of cowpea into pearl millet intercrop increased the secondary yield components of pearl millet. This could be attributed to decrease in *Striga* infestation that was associated with early planting of cowpea in mixture with the pearl millet. In addition, the ability of the cowpea component to fix N (Carsky *et al*. 1994) may have contributed to the overall fertility improvement of the system and especially in those treatments where cowpea was introduced early. The dual benefits of reduction of *Striga* infestation and possible N fixation by early planted cowpea may have contributed to the superior yield realized. Reddy *et al*. (1992) reported that cowpea production as sole or inclusion as intercrop would make extra soil N available to following cereal crops such as pearl millet.

The competitive effects of cowpea on pearl millet component were balanced by substantial gains in cowpea grain yield at the simultaneous and 10 DAMP. Ntare and Williams (1992) reported that values more than unity indicate balanced competitive effects and grain yield advantage, while value of unity indicates mere substitution of cowpea for millet and values less than unity indicate mutual inhibition. Thus the performance of the crop components beyond introduction of cowpea at 10 DAMP indicate mutual inhibition as substantial yield reductions were observed for each crop component relative to the sole crop yield. Although P fertilizer application increased pearl millet growth, the effects were not significant on *S. hermonthica* infestation and grain yield of pearl millet. It is therefore apparent that the simultaneous planting of pearl millet and cowpea or planting cowpea within 10 days after pearl millet is suitable for improving the performance of pearl millet and cowpea intercrop for enhancing food security in the region.

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