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Effects of Cowpea Planting Date and Phosphorus Level on *Striga* Infestation, Growth and Yield of Cowpea Intercropped with Pearl Millet in a Nigerian Sudan Savanna

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ABSTRACT

Grain yield of cowpea (*Vigna unguiculata* (L.) Walp is usually reduced when intercropped with pearl millet (*Pennisetum glaucum* (L.) R. Br.)) in the low fertility soils in the Sudan savanna of Nigeria. Field experiments were conducted to determine the influence of cowpea planting date and phosphorus (P) levels on *Striga gesenerioides* infestation and grain yield of cowpea grown in mixture with pearl millet during 2005 and 2006 rainy seasons. Five cowpea planting dates: 0, 10, 20, 30 and 40 days after millet planting (DAMP) and three P levels: 0, 30 and 60 kg P_2O_5/ha, were evaluated in randomized complete block design in a factorial arrangement. Each treatment was replicated three times. The results showed that cowpea growth, yield and yield component parameters and *Striga* infestation of cowpea were significantly reduced with delay in planting cowpea. Increase in P levels significantly increased vegetative and yield parameters of cowpea and reduced *Striga* infestation. There were significant positive linear relationships among cowpea agronomic parameters (r = 0.25 to 0.96). Seed yield/ha was negatively correlated with *Striga* count (r = -0.51) and 100-seed weight (r = -0.38). The simultaneous planting of cowpea and pearl millet or planting cowpea within 10 days after pearl millet and each combined with 30-60 kg P_2O_5/ha improved cowpea grain yield and reduced *Striga* infestation in cowpea when intercropped with pearl millet in the Sudan savanna.

Keywords: intercropping, phosphorus, simultaneous planting, *Striga gesenerioides*, yield components

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) is a major component of the cropping system and is mainly grown in association with sorghum, pearl millet and maize in the semi-arid region of West Africa (Magloire 2005; Izge *et al*. 2009). Nigeria and Niger Republic are the leading producer countries in the world with about 2.0 and 0.6 million metric tons realized from 5 and 3 million ha of land, respectively (FAO 2000; Singh 2007).

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, representing 22% of the fields sampled. The importance of cowpea in the cropping system of the dry savanna is indicated by the occurrence of cowpea in 71.4% of the fields sampled (Henriet *et al*. 1997). However, the average grain yield of cowpea in mixture with cereals range from 0 to 132 kg/ha with a maximum grain yield of 417 kg/ha compared with a sole crop yield potential of 1500 to 3000 kg/ha under optimum management (Muleba and Ezumah 1985; Kerala 2004).

Norman (1974) suggested that, it was relatively more profitable to grow crops in mixtures rather than sole, because there was no significant difference between the marginal value product of resources used and the opportunity cost of the resource. Grema and Hess (1994) rationalized that farmers in the pearl millet (*Pennisetum glaucum* (L.) R. Br.)-growing region of Nigeria often seek to have a near 'full' yield from the pearl millet and some additional yield from the legume component in the mixture. This is especially important in view of shortage of rainfall and crop growth duration in the zone. The major factors limiting crop productivity in the zone are low soil fertility, untimely cultural practices, infestation by numerous insect pests and the parasitic weed - *Striga* (Ntare *et al*. 1989; Singh 2002; Dugje *et al*. 2006). Pearl millet being a staple food crop is planted 3-4 weeks later between the millet rows when rains have stabilized (Blade *et al*. 1997). However, the delay in planting cowpea in mixture with pearl millet reduce grain yield due to decrease in crop growth duration and radiation interception (Ntare *et al*. 1993; Reddy and Visser 1997), and competition from the pearl millet component.

Ntare (1990) reported that cowpea in the intercrop with pearl millet need to be sown not later than 2 weeks after the pearl millet in order to obtain reasonable yields of cowpea in Niger. Infestation of cowpea by *S. gesenerioides* (Willd) Vatke, an obligate root parasitic flowering plant can cause yield reduction of 83 to 100% in susceptible cultivars (Emechebe *et al*. 1991; Singh 2002). This is further aggravated by the fact that pearl millet is generally grown on less fertile soils with little or no fertilizer application (Von Ek *et al*. 1997).

Although late planting of cowpea reduce *Striga* infestation (Parker and Riches 1993; Toure *et al*. 1996), a major disadvantage is that yields are usually reduced, which nullify the beneficial effect of the decrease in *Striga* infestation (Bebawi 1987). However, the application of phosphorus fertilizer has multiple effects on nutrition (Muleba and Ezumah 1985) as it increases nodulation and seed yield (Coulibaly 1984; Dugje *et al*. 2010) and reduce *Striga* infestation since P fertilization is negatively correlated with *Striga* counts (Dugje *et al*. 2010). There is amplitude for manipulating these cultural practices for improving the productivity of cowpea when grown in association with pearl millet. Therefore, the aim of this study was to determine the appropriate cowpea planting date and phosphorus levels for reducing *Striga* infestation and improving cowpea grain yield in pearl millet and cowpea intercrop in a Nigerian

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Original Research Paper

Sudan savanna. This paper explains the response of cowpea to planting date and P application when intercropped with pearl millet while a subsequent paper (Dugje and Ngala 2012) explains the response of the pearl millet component.

MATERIALS AND METHODS

Experimental site

The field study was conducted at the University of Maiduguri Teaching and Research Farm during 2005 and 2006 rainy seasons on a *Striga* sick plot. Maiduguri is located between latitude 11° 47.82′ N and longitude 13° 12.01′ E; 320 meters above sea level) in northeast Nigeria. 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 in 2005 was 869 mm and 569.3 mm in 2006.

Treatments and experimental design

The treatments comprised 5 cowpea planting dates: simultaneous planting (0 - control), 10, 20, 30 and 40 days after pearl millet planting (DAMP) and 3 phosphorus levels: 0, 30 and 60 kg P_2O_5/ha evaluated in randomized complete block design (RCBD) in factorial arrangement and replicated three times. Sole plots of cowpea were also provided in each block. The sole plots were planted on the same date with pearl millet and 60 kg P_2O_5/ha were applied.

Seeds of pearl millet variety SOSAT-C-88 were planted at 75 cm × 50 cm in a plot 3 m × 4 m on 21st and 25th July, 2005 and 2006, respectively. The seedlings were thinned to 3 per stand at 2 weeks after sowing (WAS). The improved cowpea variety IT89KD-288 was also dressed with Apron Star 42 WS at the rate of 10 g sachet/8 kg seeds. 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 cowpea variety IT89KD-288 was derived from the cross between IT87F-1772-2 (*Kananado* selection) and IT84S-2246-6 (Singh 1993). It is semi-erect, excellent for relay with cereals, medium maturing and photosensitive. It has medium sized white seeds and requires at least 2-3 sprays (Onyibe *et al*. 2006).

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 the pearl millet. Two manual hoe weeding were conducted at 2 and 6 WAS, while cowpea was sprayed with Cypermetrin + Dimethoate insecticide at the rate of 1 l/ha at 35, 50 and 65 days after planting for each planting date. The 2 middle rows of cowpea were harvested leaving 2 stands at both ends of each row, giving a net plot of 2 m × 2.25 m (4.5 m^2) at maturity for grain yield determination. These operations were repeated during each year of the study.

Data collection and analysis

Data on cowpea agronomic parameters and *Striga gesenerioides* bunch counts were collected. Emerged *Striga* bunches were counted from 1 m^2 quadrat randomly chosen from 3 places in each plot. The *Striga* counts were transformed using square root transformation. All data collected were subjected to Analysis of Variance (ANOVA) using Statistix 8.0 Analytical Software Package (Statistix 2005), 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 cowpea agronomic parameters and *Striga* counts determined.

RESULTS

Effects of cowpea planting date and phosphorus level on *Striga* infestation

The *Striga* species sampled in the experimental area comprised about 30% *S. gesenerioides* (Willd) Vatke, and 70% *S. hermonthica* (Del.) Benth., as described by Ramaiah *et al*. (1983). This report is with respect to *S. gesenerioides* sampled in the cowpea component. There were significant differences among the cowpea planting dates on *S. gesenerioides* infestation (**Table 1**). Early planting of cowpea whether sole or in mixture with pearl millet significantly (P < 0.001) increased *Striga* count than later planting across the 2 years of the study. The lowest *Striga* count was observed among cowpea planted 40 days after pearl millet. However, there was no significant difference between sole cowpea and simultaneous planting (0 DAMP) of cowpea with pearl millet. Increase in phosphorus fertilizer rate significantly (P < 0.001) reduced *Striga* counts (**Table 1**). While the highest *Striga* count was observed for 0 kg P_2O_5/ha, there was no significant difference between 30 and 60 kg P_2O_5/ha that significantly reduced *Striga* infestation.

Effects of cowpea planting date and phosphorus levels on cowpea agronomic parameters

The number of cowpea branches/plant significantly (P < 0.001) decreased with delay in planting date (**Table 1**). Sole cowpea had relatively higher number of branches than cowpea intercropped with pearl millet. There was no significant difference between 20 and 30 DAMP, while the lowest values were observed at 40 DAMP. Also, branch length was significantly higher for sole cowpea and early planting dates than latter cowpea planting dates. Beyond 10 DAMP, branch lengths were generally lower than 10 cm compared to >20 cm observed for 0 and 10 DAMP and sole cowpea. Significantly greater number of branches were observed when P fertilizer was applied compared to no application (**Table 1**). The highest number of branches was recorded at 60 kg P_2O_5/ha. Cowpea number of pods/plant significantly (P < 0.001) decreased with delay in planting date (**Table 2**). Sole cowpea recorded significantly higher number of pods than cowpea intercropped with pearl millet. The simultaneous planting of cowpea with pearl millet significantly recorded higher values than the other planting dates under intercropping. However, number of pods increased with increase in P rates. There was no significant difference between 0 and 30 kg P_2O_5/ha, while the highest value was observed for 60 kg P_2O_5/ha. These results further confirm the high response of cowpea to P application in spite of the moderate level of P observed in the experimental area.

There was significant (P < 0.05) variation in pod weight, as values were significantly higher at 40 DAMP than 20 DAMP. The significantly lower values for number of pods/plant at 30 and 40 DAMP probably enhanced pod weight for these treatments. Pod weights were slightly higher at 60 kg P_2O_5/ha and the lowest values were observed for 0 kg P_2O_5/ha. The number of seeds/pod were significantly (P < 0.001) higher for sole cowpea, 0, and 10 DAMP than 20 and 40 DAMP (**Table 2**). Although number of seeds/pod was slightly increased with increase in P application, there was no significant variation among the P levels.

Pod yield/plant significantly (P < 0.001) decreased with delay in planting date (**Table 3**). Sole cowpea had significantly higher pod yield than cowpea planted in mixture with pearl millet. Simultaneous planting of cowpea with pearl millet significantly (P < 0.001) out yield the latter planting dates. Application of 60 kg P_2O_5/ha significantly (P < 0.001) increased pod yield/plant than 0 or 30 kg P_2O_5/ha. However, there was no significant difference between 0 and 30 kg P_2O_5/ha. Similarly, pod yield/ha significantly (P < 0.001) decreased with delay in planting date (**Table 3**). Pod yield of sole cowpea was significantly higher than those from cowpea planted in mixture with pearl millet. Pod yield

Table 1 Effect of cowpea planting date and phosphorus levels on cowpea number of branches/plant, branch length and *Striga* count/m^2 at 12 WAS in millet and cowpea intercrop.

Treatment	*Striga* count/m^2			No. of branches/plant			Branch length (cm)		
	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean
Cowpea planting date (D)									
Sole cowpea	2.1	2.0	2.1	7.6	8.0	7.8	2.6	3.0	2.8
0 DAMP	2.1	1.9	2.0	6.2	6.3	6.2	2.3	2.4	2.4
10 DAMP	1.5	1.5	1.5	4.5	4.9	4.7	2.0	2.1	2.1
20 DAMP	1.8	1.6	1.7	2.7	3.1	2.9	0.6	0.8	0.7
30 DAMP	1.3	1.1	1.2	2.2	2.4	2.3	0.3	0.5	0.4
40 DAMP	0.8	0.9	0.9	1.4	1.7	1.5	0.2	0.7	0.4
S.E ±	0.19	0.15	0.13	0.38	0.36	0.24	0.09	0.24	0.13
LSD (0.05)	0.39	0.29	0.27	0.78	0.74	0.48	0.19	0.51	0.26
Phosphorus (P) levels (kg/ha)									
0	1.4	1.1	1.7	2.7	3.2	2.9	1.0	1.2	1.1
30	1.3	1.2	1.3	3.3	3.5	3.4	1.1	1.5	1.3
60	1.2	1.2	1.2	4.1	4.3	4.2	1.2	1.2	1.2
S.E ±	0.15	0.11	0.10	0.29	0.28	0.18	0.07	0.19	0.10
LSD (0.05)	NS	0.23	0.21	0.61	0.57	0.37	NS	NS	NS
D × P interaction	*S	*S	**S	*S	**S	***S	*S	NS	*S

DAMP = days after millet planting, NS = not significant, * = significant ($P < 0.05$), ** = significant ($P < 0.01$), *** = significant ($P < 0.001$).

Table 2 Effect of cowpea planting date and phosphorus levels on number of pods/plant, pod weight and number of seeds/pod in millet and cowpea intercrop.

Treatment	No. of pods/plant			Pod weight (g)			No. of seeds/pod		
	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean
Cowpea planting date (D)									
Sole cowpea	59.95	60.1	60.0	1.5	1.6	1.6	13.5	14.0	13.5
0 DAMP	27.5	29.4	28.5	1.5	1.4	1.6	13.5	13.8	13.6
10 DAMP	17.9	20.4	19.2	1.6	1.5	1.5	13.8	14.5	14.2
20 DAMP	10.9	12.7	11.8	1.3	1.2	1.3	10.7	11.6	11.2
30 DAMP	5.8	6.9	6.3	1.5	1.5	1.5	12.9	13.4	13.2
40 DAMP	1.9	2.1	2.0	1.8	1.5	1.6	10.9	11.3	11.1
S.E ±	1.99	2.01	1.28	0.15	0.18	0.10	0.85	0.72	0.51
LSD (0.05)	4.09	4.11	2.56	0.32	NS	0.21	1.75	1.48	1.01
Phosphorus (P) levels (kg/ha)									
0	10.4	12.3	11.4	1.51	1.4	1.45	12.2	12.7	12.4
30	12.2	13.3	12.8	1.52	1.4	1.46	12.2	12.7	12.5
60	15.8	17.3	16.5	1.55	1.5	1.52	12.7	13.4	13.0
S.E ±	1.54	1.55	0.99	0.12	0.14	0.08	0.66	0.56	0.39
LSD (0.05)	3.17	3.19	1.99	NS	NS	NS	NS	NS	NS
D × P interaction	*S	*S	***S	*	NS	*S	*S	NS	NS

DAMP = days after millet planting, NS = not significant, * = significant ($P < 0.05$), ** = significant ($P < 0.01$), *** = significant ($P < 0.001$).

Table 3 Effect of cowpea planting date and phosphorus levels on pod yield/plant, pod yield/ha and shelling percentage in millet and cowpea intercrop.

Treatment	Pod yield/plant (g)			Pod yield/ha (kg)			Shelling percentage		
	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean
Cowpea planting date (D)									
Sole cowpea	87.2	82.5	8.5	4361.1	4540	4450	77.2	79.0	78.1
0 DAMP	39.3	38.6	38.9	1963	1908.9	1935.9	77.3	78.8	78.1
10 DAMP	28.0	28.0	28.0	1401.2	1354.3	1377.8	77.5	71.7	74.6
20 DAMP	14.4	14.3	14.4	722.2	785.2	753.7	75.0	74.6	74.8
30 DAMP	8.5	9.2	8.9	425.9	476.5	451.2	72.9	73.5	73.2
40 DAMP	2.9	2.8	2.9	148.1	183.3	165.7	66.3	75.2	70.8
S.E ±	3.06	3.03	1.89	153.11	156.47	97.29	3.71	4.31	2.71
LSD (0.05)	6.27	6.22	3.78	313.64	320.51	193.91	7.60	NS	NS
Phosphorus (P) levels (kg/ha)									
0	15.6	15.9	15.8	779.6	758.7	769.1	75.6	73.7	73.1
30	17.1	16.9	16.9	853..7	921.8	887.8	75.5	77.5	76.5
60	23.3	23.0	23.1	1163.0	1144.5	1153.7	73.4	73.1	73.3
S.E ±	2.37	2.35	1.47	118.60	121.20	75.34	2.87	3.34	2.09
LSD (0.05)	4.85	4.82	2.93	242.94	248.26	150.21	NS	NS	NS
D × P interaction	*S	*S	**S	*S	*S	*S	NS	NS	NS

DAMP = days after millet planting, NS = not significant, * = significant ($P < 0.05$), ** = significant ($P < 0.01$), *** = significant ($P < 0.001$).

was higher for simultaneous planting (0 DAMP) by 40.5, 157.1, 328.3 and 1066% compared to 10, 20, 30 and 40 DAMP, respectively. The shelling percentage of cowpea pods significantly ($P < 0.05$) decreased with delay in planting date (**Table 3**). The shelling percentage at 40 DAMP was significantly lower than the other planting dates. Also, slightly lower values were observed for 10 DAMP. The superior pod weight observed for cowpea planted at 40 DAMP (**Table 2**) did not translate into higher shelling percentage, probably because the critical mass was attributed to the pod than the seeds in the pod.

Seed yield/plant and seed yield/ha each significantly decreased with delay in planting date (**Table 4**). While sole cowpea maintained its superiority in seed yield when compared to intercropped cowpea, the simultaneous planting was significantly ($P < 0.001$) superior to the other planting

Table 4 Effect of cowpea planting date and phosphorus levels on seed yield/plant, seed yield/ha and 100 seed weight in millet and cowpea intercrop.

Treatment	Seed yield/plant (g)			Seed yield/ha (kg)			100-seed weight (g)		
	2005	2006	Mean	2005	2006	Mean	2005	2006	Mean
Cowpea planting date (D)									
Sole cowpea	67.22	65.2	66.2	3361.1	3450	3455	12.78	13.5	13.24
0 DAMP	30.0	31.0	30.7	1515.4	1551.7	1533.5	15.2	15.5	15.3
10 DAMP	21.3	20.5	20.9	1067.9	1074.2	1071	15.3	15.7	15.5
20 DAMP	10.8	11.2	11.0	541.4	593.8	567.6	17.9	18.1	18.0
30 DAMP	6.2	6.2	6.2	308.6	291.4	300	17.2	17.9	17.5
40 DAMP	1.9	1.6	1.7	96.3	112.6	104.4	18.4	18.9	18.6
S.E ±	2.39	1.94	1.38	119.48	92.60	68.47	1.26	1.24	0.78
LSD (0.05)	4.91	3.98	2.76	244.74	189.69	136.47	2.59	2.55	NS
Phosphorus (P) levels (kg/ha)									
0	11.9	11.6	11.8	596.3	681	638.7	16.5	16.5	16.5
30	13.0	13.4	13.2	650.4	650.9	650.6	16.9	17.6	17.3
60	17.4	17.3	17.3	871.1	842.3	856.7	16.9	17.4	17.2
S.E ±	1.85	1.50	1.07	92.54	71.7	53.04	0.98	0.96	0.61
LSD (0.05)	3.80	3.08	2.13	189.57	146.93	105.71	NS	NS	NS
D × P interaction	*S	*S	**S	*S	*S	*S	NS	NS	NS

DAMP = days after millet planting, NS = not significant, * = significant ($P < 0.05$), ** = significant ($P < 0.01$), *** = significant ($P < 0.001$).

Table 5 Interaction effects of cowpea planting date and phosphorus levels on *Striga* count and cowpea parameters in millet and cowpea intercrop..

Planting date × P level	*Striga* count/m^2	No. of branches/plant	Branch length	Pods/plant	Pod weight (g)	Seed yield/ plant	Pod yield/ plant	Pod yield/ Ha (kg)	Seed yield/ha (kg)
0 × 0	2.0abc	4.7c	2.4ab	20.4c	1.7abc	27.3b	34.6b	1692.9b	1498.7a
0 × 30	2.1ab	5.9b	2.3abc	31.5a	1.2def	31.5ab	39.4ab	1990.7ab	1481.5a
0 × 60	1.9abc	8.2a	2.5a	33.4a	1.3c-f	33.2a	42.9a	2124.2a	1620.5a
10 × 0	1.8bc	3.9c	1.9bc	17.9cd	1.4b-f	18.1c	23.8c	1148.1c	963b
10 ×30	1.2def	4.5c	2.3abc	13.9de	1.6a-e	15.9cd	20.8cd	1101.8cd	833.5bc
10 × 60	1.6cd	5.6b	1.9c	25.8b	1.7a-d	28.6ab	39.5ab	1883.3ab	1416.7a
20 × 0	2.3a	2.9d	0.7de	10.7efg	1.1f	7.7fgh	11.2ef	574.1e-g	420.3de
20 ×30	1.3de	2.9d	0.8d	12.7e	1.2ef	12.3def	15.6de	811.1de	629.7cd
20 × 60	1.5cd	2.9d	0.7de	11.9ef	1.5a-f	13.0de	16.3de	875.9c-e	652.7cd
30 × 0	1.3def	1.7e	0.3e	6.5gh	1.4b-f	4.3f	6.5fg	296.3gh	219.5ef
30 × 30	1.1ef	2.3de	0.3e	4.8hi	1.4b-f	4.8ghi	7.3fg	394.4f-h	217.6ef
30 × 60	1.3de	2.9d	0.5de	7.8fgh	1.8ab	9.4efg	12.7ef	663ef	463d
40 × 0	0.9ef	1.5e	0.2e	1.4i	1.6a-d	1.5i	2.7g	134.3h	91.9f
40 × 30	0.9ef	1.6e	0.7de	1.0i	1.8a	1.3i	1.8g	140.7h	90.8f
40 × 60	0.8f	1.5e	0.4de	3.7hi	1.4b-f	2.4i	4.2g	222.2h	130.6f
S.E ±	0.23	0.42	0.23	2.23	0.18	2.40	3.28	168.52	118.6

Means followed by the same letter(s) in a column are not significantly different according to Duncan's Multiple Range Test (DMRT) at $P < 0.05$

dates. Seed yields were also significantly ($P < 0.001$) higher for 60 kg P_2O_5/ha than the other P levels. There was no significant difference between 0 and 30 kg P_2O_5/ha (**Table 4**). The 100-seed weight was significantly ($P < 0.05$) lower for sole cowpea than intercropped cowpea planted at 20, 30 and 40 DAMP. Thus, seed weight increased with delay in planting date, and values for cowpea grown in mixture with pearl millet were superior to those of sole cowpea. Since cowpea grown sole or planted early had superior vegetative and yield parameters than late planted or intercropped cowpea, seed weight probably became low due to intra-plant competition.

Interaction effects of cowpea planting date and phosphorus levels

There was significant interaction effect of cowpea planting date on *Striga* count (**Table 5**). *Striga* count was significantly ($P < 0.05$) superior for cowpea planted at 20 DAMP and zero P application. However, this did not significantly differ from simultaneous planting of cowpea and pearl millet in combination with 0, 30 or 60 kg P_2O_5/ha. The lowest *Striga* count was observed for 40 DAMP and 60 kg P_2O_5/ha treatment combination. Thus, delay in planting cowpea and increase in P application both reduced *Striga* infestation.

Cowpea number of branches/plant was significantly ($P < 0.05$) higher for simultaneous planting and application of 60 kg P_2O_5/ha. Thus, both early planting and increase in P fertilization promote branching in cowpea. However, delay in planting cowpea exerted more negative influence on cowpea branching than phosphorus fertilization. Cowpea branch length was significantly ($P < 0.05$) higher for simultaneous planting (0 DAMP) and irrespective of P level (**Table 5**). However, this did not significantly ($P<0.05$) differ from 10 DAMP and application of 30 kg P_2O_5/ha.

The number of pods/plant significantly ($P < 0.001$) decreased with delay in planting date. Significantly superior value was observed for cowpea planted at 0 DAMP and application of 30-60 kg P_2O_5/ha. However, pod weight was significantly ($P < 0.05$) higher for cowpea planted at 40 DAMP and application of 30 kg P_2O_5/ha. This did not significantly differ from 10, 20 and 30 DAMP with application of 60 kg P_2O_5/ha and 0 DAMP with application of 0 kg P_2O_5/ha treatment combinations. Thus, both planting date and P level exerted significant influence on number of pods and pod weight.

Seed yield/plant ($P < 0.05$) and pod yield/plant ($P < 0.001$) had similar response as each was significantly higher at 0 DAMP in combination with 60 kg P_2O_5/ha (**Table 5**). However, these did not significantly differ from 0 DAMP in combination with 30 kg P_2O_5/ha and 10 DAMP in combination with 60 kg P_2O_5/ha. Significantly lowest values were observed at 40 DAMP and irrespective of P levels. Delay in planting cowpea was therefore the major factor responsible for the low plant yields realized.

Pod yield/ha and seed yield/ha were significantly ($P < 0.05$) high for cowpea planted at 0 DAMP in combination with 60 kg P_2O_5/ha (**Table 5**). These were statistically similar with values realized for 0 DAMP in combination with 30 kg P_2O_5/ha. Thus, simultaneous planting of cowpea with pearl millet in combination with 30-60 kg P_2O_5/ha significantly produced superior pod and seed yields/ha. The low-

Table 6 Linear correlation coefficient (r) among cowpea agronomic parameters and *Striga* count at five planting dates and three phosphorus levels in millet and cowpea intercrop.

Parameter	1	2	3	4	5	6	7	8	9	10	11	12
1. *Striga* count	-	-	-	-	-	-	-	-	-	-	-	-
2. No. branch/plant	-0.47***	-	-	-	-	-	-	-	-	-	-	-
3. Branch length	0.48***	0.76***	-	-	-	-	-	-	-	-	-	-
4. No. pods/plant	0.53***	0.87***	0.75***	-	-	-	-	-	-	-	-	-
5. No. seeds/pod	0.05	0.50***	0.43***	0.43***	-	-	-	-	-	-	-	-
6. Pod weight	-0.27**	-0.07	-0.09	-0.20	0.11	-	-	-	-	-	-	-
7. Seed yield/pod	0.19	0.04	0.01	-0.08	0.17	0.88***	-	-	-	-	-	-
8. Shelling %	0.19	0.20*	0.22*	0.23*	0.15	-0.28**	0.19	-	-	-	-	-
9. Pod yield/plant	0.48***	0.87***	0.78***	0.95***	0.51***	-0.03	0.08	0.22*	-	-	-	-
10. Pod yield/ha	0.47***	0.86***	0.79***	0.94***	0.51***	-0.04	0.07	0.24*	0.99***	-	-	-
11. 100-seed weight	-0.33**	0.41***	-0.44***	-0.31**	-0.39***	-0.02	0.02	0.08	-0.37***	-0.36***	-	-
12. Seed yield/plant	0.52***	0.88***	0.80***	0.92***	0.49***	-0.07	0.05	0.26**	0.95***	0.95***	-0.38***	-
13. Seed yield/ha	-0.51***	0.87***	0.81***	0.92***	0.48***	-0.04	0.09	0.25**	0.97***	0.96***	-0.38***	0.96***

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

est pod and seed yields were realized when cowpea was planted at 40 DAMP and irrespective of P level.

Linear relationships among cowpea agronomic parameters and *Striga* counts

The response of the parameters sampled to changes in cowpea planting date and P levels showed that cowpea seed yield/ha was negatively correlated with *Striga* count (r = -0.51) and 100-seed weight (r = -0.38) (**Table 6**). However, seed yield/ha was positively associated with number of branches/plant, branch length, number of pods/plant, number of seeds/pod, shelling percentage, pod yield/plant, seed yield/plant and pod yield/ha (r = 0.25 to 0.96) (**Table 6**). Seed weight was negatively correlated with *Striga* count, branch length, number of pods/plant, number of seeds/pod, pod yield /plant and pod yield/ha (r = -0.31 to -0.44).

DISCUSSION AND CONCLUSIONS

Early planting of cowpea whether sole or in mixture with pearl millet significantly increased *Striga* count than later planting (**Table 1**). The lowest *Striga* count was observed among cowpea planted 40 days after pearl millet. *Striga* count generally decreased with delay in 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. This is further corroborated by similar reports which stated that late sowing reduced *Striga* infestation in sorghum (Lagoke *et al*. 1991), in pearl millet (Hess and Williams 1994), and in cowpea (Toure *et al*. 1996). Bebawi (1987) suggested that it is connected with soil temperature, as after the full onset of the rains soil temperatures are generally lower than at the beginning of the rainy season, when soils are not continuously wet. The disadvantage of late sowing compared with early sowing is reduction in yield, which nullify the benefits from reduction in *Striga* infestation (Bebawi 1987).

There was a slight reduction in *Striga* infestation due to intercropping, since 4.8% reduction was observed in the intercropped compared to sole cowpea. However, delay in planting cowpea had more significant effect than intercropping with pearl millet, since *Striga* counts were reduced by 28.6, 19.04, 42.9 and 57.1% at 10, 20, 30 and 40 DAMP compared to sole cowpea or simultaneous planting of cowpea with pearl millet. Therefore, pearl millet may not be a major stimulant of *S. gesenerioides* seeds germination as was reported by Berner and Williams (1998) for sorghum. However, Dugje and Ngala (2012) reported that *S. hermonthica* infestation increased with delay in planting cowpea in pearl millet. The report further indicated that the level of infestation of sole millet was significantly higher than millet intercropped with cowpea. 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 delaying planting cowpea into pearl millet may promote *S. hermonthica* infestation, while early introduction of cowpea into pearl millet will promote *S. gesnerioides* infestation as observed in the present study. *Striga* counts also reduced with increase in P levels. Dugje *et al*. (2010) reported negative linear correlation between *Striga* counts and P levels in farmers' cowpea fields in Sudan and northern Guinea savanna of north eastern Nigeria. Muleba and Ezumah (1985) reported that application of P fertilizer is critical especially for the production of multiple effects on nutrition.

The significant decrease in number of branches and branch length of cowpea showed that the pearl millet component probably suppressed cowpea growth and development since planting was delayed (**Table 1**). This is because plant competition for growth factors is more acute under intercropping and favours the dominant species such as pearl millet in the mixture (Nelson and Robichaux 1997). Similarly, Reddy and Visser (1997) reported that delaying cowpea sowing to 7 weeks after pearl millet led to significantly lower growth rates, grain and dry matter yields of cowpea. Shading by the pearl millet component appear to be the major reason for the significant reduction in branch length due to reduced radiation interception since cowpea is grown as an under storey crop with pearl millet (Ntare 1990). Ntare *et al*. (1993) also reported that delayed sowing of cowpea from 1-3 weeks after sowing pearl millet reduced seed yield due to decrease in crop growth rate, vegetative and reproductive durations.

Thus delay in planting of cowpea and competition from pearl millet significantly reduced pod yield in the present study. Pod yield was higher for simultaneous planting (0 DAMP) by 40.5, 157.1, 328.3 and 1066% compared to 10, 20, 30 and 40 DAMP, respectively. Since farmers practice cereal and legume intercropping in order to realize full yield from the cereal crop and some yield from the legume component in the savannas (Grema and Hess 1994), simultaneous planting of pearl millet with cowpea may avail such benefits. Ntare and Williams (1992), Reddy and Visser (1997) and Blade *et al*. (1997) also recommended simultaneous planting of pearl millet with cowpea in Sahel savanna of Niger. Consequently simultaneous planting (0 DAMP) significantly realized the highest pod yield among the intercropped cowpea treatments. These results further confirm the positive response of cowpea to P application in the study area. The fact that pod yield increased linearly with increase in P level up to the maximum rate suggests that further increase in P level beyond the 60 kg P_2O_5/ha used in the present study may result in further increase in pod yield/ha.

Therefore, cowpea should be planted simultaneously with pearl millet to optimize growth duration and realize maximum grain yield of cowpea under intercropping with pearl millet in Sudan savanna. Planting cowpea should not be delayed beyond 10 days after planting pearl millet. The time of planting cowpea into pearl millet is more critical for realizing near optimum cowpea seed yield than P fertilization. Application of 30-60 kg P_2O_5/ha will further enhance both growth and seed yield of cowpea planted simultaneously or 10 days after planting pearl millet in the mixture. It is also apparent that the linear relationships revealed that, apart from seed weight all the agronomic parameters sampled contributed positively to both plant and plot yields. However, *Striga* infestation reduced both seed weight and seed yield of cowpea in the present study.

The influence of varying the time of planting cowpea into pearl millet intercrop revealed that cowpea growth, yield and yield components decreased with delay in planting date. Sole cowpea was superior in the expression of these parameters than cowpea planted in mixture with pearl millet. *Striga* infestation also decreased with delay in planting date. However, simultaneous planting of cowpea with pearl millet in mixture showed superior performance of cowpea compared to late planting. Similarly, application of phosphorus improved both vegetative and yield parameters of cowpea and suppressed *Striga* infestation. The combination of simultaneous planting of cowpea with pearl millet and application of 60 kg P_2O_5/ha realized the best seed yield (1,631 kg/ha) of cowpea. The best seed yield was close to the maximum yield potential of 1500-3000 kg/ha under optimum management as reported by Muleba and Ezumah (1985) and Kerala (2004). However, delaying cowpea planting by 10 days after pearl millet combined with application of 60 kg P_2O_5/ha realized cowpea seed yield of 1,417 kg/ha which was comparable with simultaneous planting. Therefore, simultaneous or planting cowpea within 10 days after planting pearl millet, and each combined with application of 30-60 kg P_2O_5/ha is recommended for improving cowpea grain yield and suppressing *S. gesenerioides* infestation in cowpea under intercropping with pearl millet in the Sudan savanna of Nigeria.

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