African Journal of Agricultural Research Vol. 7(5), pp. 747-754, 5 February, 2012
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR11.1341
ISSN 1991-637X ©2012 Academic Journals

Full Length Research Paper

Comparative responses of cowpea breeding lines to *Striga* and *Alectra* in the dry savanna of northeast Nigeria

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Accepted 31 October, 2011

The parasitic flowering plants *Striga gesnerioides* (Willd.) Vatke and *Alectra vogelii* (Benth.) are formidable cowpea production constraints in the West and Central African savanna. The two parasites cause substantial yield reduction in cowpea in the dry savannas. A field study was conducted to screen some of the cowpea breeding lines that have been developed for resistance to *Striga* and *Alectra* under natural infestation. Results showed significant variations in the susceptibility of genotypes to infestations. The cowpea lines B301, IT03K-338-1 and IT99K-573-2-1 were consistently free of emerged *Striga* and *Alectra* shoots in both years while IT98K-1092-1 and IT97K-205-8 were resistant to *Striga* but supported some emerged *Alectra* shoots. Other lines supported varying numbers of emerged *Striga* and *Alectra* shoots. The combined effect of *Striga* and *Alectra* resulted in low yield of the susceptible cultivars compared with most of the resistant cowpea lines. The differential response to *Striga* and *Alectra* confirmed that the genes controlling these parasites are non-allelic and independent of each other. A strong negative correlation was observed between grain yields and *Striga and Alectra* counts. The cowpea breeding lines identified with a high level of resistance to both *Striga* and *Alectra* infestation indicate the possibility of breeding cowpea varieties that combine resistance to both parasites.

Key words: Cowpea, *Striga, Alectra,* Comparative responses, screening, breeding lines, genotypes.

INTRODUCTION

Cowpea (*Vigna unguiculata (*L.*)* Walp.) is an important grain legume in the sub-Saharan African countries. The relatively high protein content (23%) makes cowpea an important supplement to the diet of many African people (Bressani, 1985) who consume cereals, roots, and tubers high in carbohydrate and low in protein. The cowpea haulm provides valuable animal feed during the dry season. However, despite the importance of cowpea in sub-Saharan Africa and its wide spread high potential, its growth and yield are constrained by several biotic and abiotic factors. These include insect pests and diseases, parasitic flowering plants and nematodes. Among the biotic stresses, *Striga gesnerioides* (Willd) Vatke and *Alectra vogelii* (Benth*),* obligate, root-parasitic flowering plants of the family Orobanchaceae, are formidable constraints to cowpea production, especially in the dry savanna. Cowpea yield losses associated with *S. gesnerioides* have been reported to range between 83 and 100% (Cardwell and Lane, 1995). On susceptible local varieties, Emechebe et al. (1991) reported 100% yield losses on farmer's fields in the northern Guinea savanna of Nigeria. Yield losses associated with *Alectra voge1ii* range between 70 and 100% (Kureh et al., 1999; Parker, 1991).

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In a recent survey of the level of *S. gesnerioides* infestation on farmers' fields, Dugje et al. (2006) reported that more than 81% of the fields grown to cowpea in northeast Nigeria were infested with *S. gesnerioides* and subject to serious crop losses. Various control measures, including cultural practices, chemical and biological means, and host plant resistance, have been suggested (Dube and Olivier, 2001; Boukar et al., 2004) but no single field method seems to be fully adequate. One practice, genetic control via host plant resistance, appears to have merit since it is affordable by resource-poor farmers who lack the financial means to use high input management practices and other options.

Lane et al. (1994, 1997) tested some selected cowpea varieties against *Striga* seeds collected from different parts of West and Central Africa. The studies revealed the presence of races of *S. gesnerioides* (race 1, found in Burkina Faso, 2 in Mali, 3 in Nigeria and Niger, 4 in Benin Republic, and 5 in Cameroon).Three of these races (1, 3, and 5) have been reported in Nigeria (Singh and Emechebe, 1997). In a more recent study using a molecular marker profile, two additional previously unknown races of *S. gesnerioides* parasitizing cowpea have been reported in Benin and Senengal (Botanga and Timko 2006). The *Striga* race found generally in Benin Republic was designated as race SG4 while that found specifically in Zakpota of Benin, was designated as race SG4z. In Senegal, a new race (race 6) has been identified bringing the total number of races of *S. gesnerioides* that parasitize cowpea to seven. Currently, none of the most widely grown resistant cowpea varieties has resistance to all the races of *S. gesnerioides* (Lane et al., 1993; Carsky et al., 2003). The differential virulence of the races of *S. gesnerioides* further confounds the problem of developing stable resistant cultivar to the parasitic weed in the sub-region. These findings thus emphasize the need to develop cowpea varieties with multiple resistance genes.

Over the past years, significant effort has been put into the identification of natural sources of genetic resistance within cowpea cultivars and to the selection and breeding of improved lines with resistance to *Striga* and *Alectra* (Singh and Emechebe, 1997). Through these efforts, the International Institute of Tropical Agriculture (IITA) has developed cowpea breeding lines that combine resistance to both parasites. These varieties also combine diverse plant type and good agronomic traits (Singh, 2002). Unfortunately, the use of most resistant cowpea varieties, especially in the northeast, is limited for several reasons. For example, the varieties IT97K-499-35 and IT99K-573-2-1 are *Striga* resistant but there are serious concerns about the potential for their adoptability in the region because they have a medium size /and white color seed. Farmers in the area prefer large and brown seeds that fit into different cropping systems. Unfortunately, the traditional variety (Borno Brown) widely grown in the area possesses those consumers' preferred traits but is highly susceptible to *Striga* and *Alectra* (Omoigui et al., 2007; Kamara et al., 2008). Therefore, the development of cowpea cultivars that combine end-users' preferences, with resistance to multiple races of *S. gesnerioides* and *A. vogelii* is necessary to improve cowpea productivity and the adoption of these varieties by farmers in the region.

This study was undertaken to evaluate cowpea breeding lines having contrasting responses to *Striga* and *Alectra*. This information is critical not only to estimate the yield losses caused by *Striga* and *Alectra* infestation in the region but to identify potential sources of resistance to both parasites that could be used in a breeding programme.

MATERIALS AND METHODS

Study site and experimental materials

The field trials were conducted under rain-fed conditions in 2005 and 2006 at Tilla (10° 30.78' N, 12° 03.56' E 749 as l) in the northern Guinea savanna of northeast Nigeria. The soil in Tilla is sandy clay with 0.98% organic matter, 1.6 mg/kg P/ha, 0.51 Cmol (+) K/ha, and pH of 5.65 (Kwari, 2005). The trials were established in a field that has previously been observed to be heavily infested with *S. gesnerioides* and *Alectra vogelii* (Dugie et al., 2006). Thirty cowpea breeding lines including five varieties provided by IITA which had been shown to differ in reaction to *Striga* and *Alectra* resistance were screened to re-validate their reactions to *S. gesnerioides* and *A. vogelii* prevalent in the zone in a naturally infested plot. In 2005 the trial was established on 15 August while in 2006, planting was done on 10 August. The term resistance to *Striga* and *Alectra* in this study implies that the cowpea lines did not show any emerged *Striga/Alectra*, although the cowpea lines may stimulate germination and permit attachment of the parasite's radicles to their roots, the development of the haustorium is inhibited and there will be no visible *Striga/Alectra* shoots. The characteristics of the cowpea lines used in the evaluation are presented in Table 1.

Experimental design and cultural practices

The experiments were arranged in a randomized complete block design with three replications. Each plot consisted of four rows, 4 m long, at a spacing of 0.20 m intra-row and 0.75 m inter-row. Fertilizer was applied at planting at the rate of 100 ka ha^{-1} of NPK compound fertilizer, to give the equivalent of 15 kg ha^{-1} N, P_2O_5 and K_2O, respectively. Three seeds each of the cowpea genotypes were sown and were later thinned to two plants 2 weeks after emergence. Weeds were controlled manually at 2 and 4 weeks after planting (WAP) before *Striga* and *Alectra* plants emerged. The insecticide formulation, cypermethrin + dimethoate (Best Action) at the rate of 30 g + 250 g a.i/litre, was applied by using a knapsack sprayer to control insect pests. Insecticide was applied at regular interval at pre-flowering, flowering and podding stages to protect the plant from major insect pests.

At 9 WAP, the emerged shoots on each plot of the cowpea genotypes were counted to assess the host support for *Striga and Alectra* growth. All plots were harvested dry within the two central rows. The *Striga* and *Alectra* data were transformed using the natural log (x +0.5) where x was the number of emerged *Striga* and *Alectra* plants) to stabilize the variance and ensure a normal distribution. All data were subjected to an Analysis of Variance

Table 1. Characteristics of the cowpea lines used in the evaluation for resistance to *Striga* and *Alectra* in 2005 and 2006.

Cowpea line	Pedigree	Reaction to *Striga*	Remarks
IT99K-7-16-1	(IT93K-693-2 x IAR 1696) x IAR1696	S	Bred at IITA, Kano
IT99K-573-1-1	IT93K-596-9-12 x IT86D-880	R	Bred at IITA, Kano
IT99K-7-21-2-2	(IT93K-693-2 x IAR 1696) x IAR 1696	R	Bred at IITA, Kano
TVX 3236	TVu1509 x Ife Brown	S	Bred at IITA, Kano
IT98K-216-44	N/A	S	Bred at IITA, Kano
IT98K-1092-1	IT93K-596 x TVU 12349	R	Bred at IITA, Kano
IT98K-409-5	IT93K-2046 x TVU 12349	R	Bred at IITA, Kano
IT98K-409-4	IT93K-2046 x TVU 12349	R	Bred at IITA, Kano
IT81D-994	[(TVu1190 x TVu76) x TVU2027] x TVU 625	S	Bred at IITA, Kano
IT98K-1093-4	IT93K-596 x TVu12349	S	Bred at IITA, Kano
IT98D-1399	Single plant selection from Danila	S	Bred at IITA, Kano
IT94K-440-3	IT90K-59 x IT86D-717	S	Bred at IITA, Kano
IT93K-573-2-1	(IT90K-59 x IT88D-867-11) x IT86D-715	R	Bred at IITA, Kano
IT98K-615-6-1	N/A	R	Bred at IITA, Kano
IT97K-819-118	IT90K-59-2 x IT88D 876-11	S	Bred at IITA, Kano
IT98K-503-1	IT86D-715 x IT92K-284-2	R	Bred at IITA, Kano
IT03K-338-1	IT87D-941-1 x IT95K-1088-4	R	Bred at IITA, Kano
IT84S-2246-4	IT82D-716 x IT81D-1020	S	Bred at IITA, Kano
IT98K-415-1	IT89KD-288 X TVu12349	S	Bred at IITA, Kano
IT99K-494-6	IT86D-716 x IT93K-2046-1	R	Bred at IITA, Kano
IT00K-1263	(IT93K-673-1 x TVu 15549) x TVu 15549	R	Bred at IITA, Kano
IT97K-499-35	IT93K-596-12 x IT93K-2046-1	R	Bred at IITA, Kano
IT98K-205-10	IT93K-596-9-12 x IT93k-2046-1	R	Bred at IITA, Kano
TVU 7778	53C91-2 Tanzania	S	Selection from Tanzania
B301	Landrace from Botswana	R	Landrace from Botswana
IT97K-1042-3	IT90K-284-2 x Achishiru-2	S	Bred at IITA, Kano
IT00K-1217	IT93K-596-9-12 x IT93K-2046-1	R	Bred at IITA, Kano
IT97K-205-8	IT93K-596-9-12 x IT93K-2046-1	R	Bred at IITA, Kano
IT93K-452-1	IT86D-782 x IT90K-76	S	Bred at IITA, Kano
Borno Brown	Commercial cultivar in Borno	S	Local cultivar in Borno

Source, IITA, Kano; R= resistant; S= susceptible; N/A= not available.

(ANOVA) using the PROC GLM in SAS using a RANDOM statement with the Test options (SAS Institute, 2001). Year was treated as a random effect while cowpea genotypes were treated as fixed effects. Pearson's cross correlation coefficient was used to compute correlation between characters measured using PROC CORR of SAS (SAS Institute, 2001).

The pods were threshed, winnowed and the grain yield weight measured. After harvesting the pods, the leaves and stem were combined, sun-dried and weighed to estimate fodder yield.

Data analysis

Cultivars were classified as resistant, moderately resistant, or tolerant using the scale described by Singh et al. (1997):

1. Resistant = 100% plants resistant; no *Striga* emergence on plot and no *Striga* symptom observed on plant.
2. Susceptible = 5 to several *Striga*/plant emerged per plot and plants show severe *Striga* symptom.
3. Moderately resistant; few *Striga* emergence (2-3) per plot but no *Striga* symptom observed.
4. Tolerant: Several *Striga* emergences but no significant yield reduction .

RESULTS

There were significant variations in the susceptibility of cowpea lines to *Striga* and *Alectra* infestation. The year × variety interaction was evident only for pods/plant while the year effect was significant for all the traits except for grain yield and pods/plant (Table 2). The results showed that three of the 30 cowpea lines (B301, IT00K-338-1, and IT93K-573-2-1) were consistently free of *S. gesnerioides* and *A. vogelii* infestation in both years. IT98K-1092-1 and IT97K-205-8 were completely free of *Striga* but supported some emerged *Alectra* shoots (Table 3). Less *Striga*/*Alectra* shoot emergence, however, was observed on some of the cowpea lines

Table 2. Mean squares from the combined analysis of variance of 30 cowpea lines evaluated under *Striga* and *Alectra* naturally infested condition in the northern Guinea savanna in 2005 and 2006.

Source	df	Grain yield	Emerged *Striga* count/plot	Emerged *Alectra* count/plot	*Striga* height	Seed wt	Pods/ plant	Fodder yield
Rep	2	556006***	8.97	47.73**	52.38	1.65	27.38***	893321
Variety	29	438728***	47.27***	53.67***	190.12***	70.13***	12.82***	5825789***
Rep x variety	58	56319	5.37	4.93	793438	1.42	8.07***	793438
Year	1	1219121	126.88***	75.70**	17846078***	16.08**	0.15	17846078***
Variety x year	29	98328	6.76	4.84	984641	1.12	0.16**	984641

** and ***, Significant at 5 and 1% level of probability, respectively.

such as IT99K-573-1-1, IT00K-1217, IT99K-494-6, and IT98K-503-1 and the range was 0.15 to 3.67parasites/plot. Nine cultivars (Borno brown, IT84S-2246-4, IT93K-452-1, IT94K-440-3, IT97K-1042-3, IT98D-1399, IT98K-1093-4, TVU-7778, and TVX-3236) were susceptible to infestation by both *Striga* and *Alectra* (Table 3) as shown by the higher number of parasites/plot (23.00 to 160.50). These cowpea lines also suffered significant reductions in grain yield of about 34%, compared with the resistant lines (Table 3). Yield losses were significantly high for the cowpea lines that supported large number of the parasites compared with those cowpea lines that were free or supported fewer parasites. Some of the cowpea lines such as B301, IT00K-1217, IT97K-205-8, IT97K-499-35, and IT99K-573-1-1 that were either completely free or supported fewer emerged *Striga*/*Alectra* plants produced significantly higher grain yield (981 to 1550 kg/ha) than the susceptible cowpea lines (601 - 992 kg/ha) . The *Striga* emergence in the susceptible cowpea cultivar (Borno Brown) compared with the resistant cowpea lines was very high. Borno Brown and TVX-3236 recorded the highest number of *Striga* emergence, which resulted in low yields (Table 3). Borno Brown and TVX-3236 produced grain yields of about 642 and 601 kg/ha respectively, under Striga infested plot compared to the potential yields of 1100 and 1300 kg/ha under Striga free plot.

Significantly taller *Striga* plants were observed on the lines that supported higher numbers compared with those that had fewer emerged *Striga* shoots (Figure 1). Borno Brown, IT84S-2246-4, TVU-7778, and TVX-3236 recorded the taller *Striga* and also had lower grain yields. *Alectra* height was not measured in this experiment. The lines that supported large number of parasites recorded fewer pods/plant than the resistant lines and those that supported fewer parasites (Table 3). Lines IT98K-409-4, IT98K-1092-1, and IT98K-409-5 recorded significantly higher fodder yields than the other cowpea lines. Number of pods/plant, seed weight, and fodder weight were positively and significantly correlated with grain yield (Table 4). On the other hand, number of emerged *Striga* shoots/plot was negatively and highly significantly correlated with grain yield (-0.518***, $P<0.05$) and pods/plant (-0.176*). *Alectra* shoot count was negatively correlated with grain yield (-0.494***). Similarly, *Striga* height was negatively and significantly correlated with grain yield and pods/plant (Table 4). Generally, the yields recorded in the present experiment in both years were higher than those recorded under farmers' condition. This was due to fertilizer application and the even distribution of rain. High rainfall and temperatures were observed in 2005 compared to 2006 (Figure 2 and Table 5).

DISCUSSION

The significant mean squares observed for the two parasites (*Striga* and *Alectra*) on the cowpea lines and the differences in their reactions to the parasites indicate differential response of the cowpea lines to the parasites. A few of the cowpea lines were consistently free of *Striga*/*Alectra* infestation and were referred to as resistant while some were free of *Striga* but supported some *Alectra* shoots. These observed differential responses to *Striga*/*Alectra* indicate that the genes controlling these parasites are non-allelic and independent of one another. A similar result was reported by Atokple et al. (1995), who reported that the cultivar IT97K-499-35 is resistant to races 1, 2, and 3 of *Striga* in Nigeria (Singh et al., 2006), but in the present study IT97K-499-35 showed some level of infestation that revealed that it is not completely resistant to the *Striga* race present in the study area thereby confirming early observations by Kamara et al*.* (2007). This suggests the presence of other races, or variants within the population of *S. gesnerioides* present in the region. Further studies should be required to confirm this hypothesis. *Striga* race 3 is prevalent in Nigeria. Some of the cowpea lines supported many *Striga*/*Alectra* shoots per plot, but their yield remained largely unaffected. For example, IT97K-819-118 supported a large number of *Striga*/*Alectra* shoots but the yield level was > 1.3 t/ha indicating that these lines were tolerant to *Striga/Alectra.* In this study, the effect of *Striga*/*Alectra* infestation on cowpea was considered combined. *Striga* and *Alectra* infestation do not necessary occur in isolation in the savanna. When they occur together, their synergistic effects can be disastrous

Table 3. *Striga* and *Alectra* shoot count, grain yield and yield components of cowpea lines evaluated in the northern Guinea savanna of northeast Nigeria in 2005 and 2006.

Genotypes	*Striga* count/plot (6m^2)	*Alectra* count/plot (6m^2)	Grain yield (kg/ha)	100-seed weight (g)	Pods per plant	Fodder yield (kg/ha)
Completely resistant to both parasites						
B301	0.00	0.00	1143.90	5.58	12.13	833.30
IT98K-573-2-1	0.00	0.00	1360.60	16.50	7.00	2805.60
IT03K-338-1	0.00	0.00	1550.70	22.00	8.28	1834.40
Completely resistant to *Striga* but moderately resistant to *Alectra*						
IT98K-1092-1	0.00	1.67	1461.00	11.90	7.06	4305.00
IT97K-205-8	0.00	0.17	1118.20	13.68	8.33	2494.40
Moderately resistant to *Striga* and *Alectra*						
IT98K-503-1	0.17	1.50	1454.90	13.86	7.60	2638.90
IT99K-573-1-1	1.00	3.67	1319.20	16.75	7.20	2258.30
IT99K-494-6	1.17	2.00	1308.10	13.03	8.60	1097.20
IT00K-1217	1.33	1.67	1242.90	12.61	9.06	2438.90
Tolerant to *Striga* and *Alectra*						
IT97K-499-35	0.5	7.50	1460.50	14.98	7.26	2666.70
IT98K-409-4	1.67	6.33	1411.70	11.55	7.46	5013.90
IT99K-7-21-2-2	2.67	5.00	1490.80	17.62	7.20	2944.40
IT98K-409-5	4.50	4.67	1369.80	13.43	8.33	4444.40
IT98K-205-10	4.00	22.17	1176.00	14.58	7.00	1541.70
IT99K-7-16-1	8.83	16.00	1178.60	16.73	7.73	3000.00
IT98K-216-44	2.83	33.00	970.44	19.48	9.93	2083.30
IT97K-819-118	14.33	26.83	1313.40	12.88	9.66	2777.80
IT98K-615-6-1	14.67	6.50	1129.30	10.85	8.13	1127.80
IT00K-1263	15.17	4.67	1216.50	15.41	9.86	2363.90
IT93K-452-1	4.50	22.67	981.80	14.08	8.46	1244.40
Susceptible to *Striga* and *Alectra*						
Borno Brown	77.50	23.00	642.90	17.78	8.16	1833.3
TVX 3236	49.17	87.83	601.00	8.56	8.50	1916.70
IT98K-1093-4	37.17	127.67	897.7	15.33	4.80	2861.10
IT98D-1399	160.50	60.00	748.20	12.11	6.53	1319.40
IT94K-440-3	30.33	52.50	992.10	12.31	7.00	2236.10
IT84S-2246-4	28.50	67.83	727.80	10.86	7.86	1833.3
TVU 7778	53.67	96.33	762.40	7.93	8.80	1222.20
IT98K-415-1	22.33	85.17	1307.30	16.11	7.06	2236.10
IT81D-994	40.50	27.00	1301.40	15.16	6.93	3013.90
IT97K-1042-3	33.33	24.33	915.40	11.13	11.40	2027.60
Mean	20.34	27.25	(11151.82??	13.83	8.12	2347.16
LSD (P<0.05)	8.63	9.73	284.06	1.37	0.32	912.11
CV %	46.7	67.15	21.35	8.59	3.44	33.64

on cowpea production and productivity. The effect of *Striga* and *Alectra* damage on grain yield reduction was more pronounced on susceptible lines than on the moderately resistant or tolerant lines. Among these cultivars, the local adapted local variety Borno Brown widely grown in the area and other improved cowpea lines such as TVX-3236, IT84S-2246-4, IT93K-452-1, IT97K-1042-3, IT98D-1399, IT98K-1093-4, and TVU-

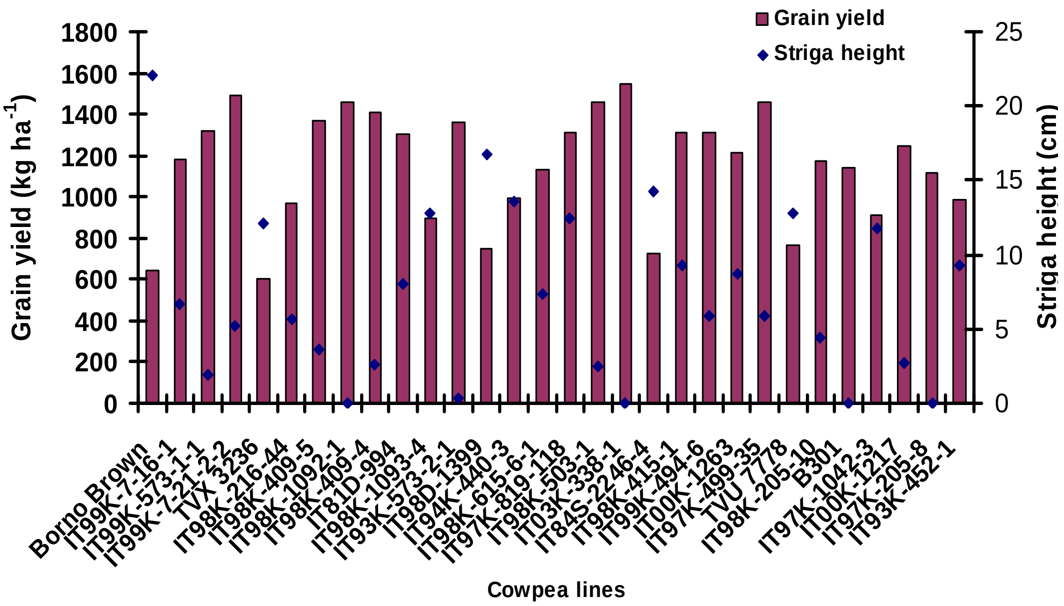

Figure 1. Effect of striga height on cowpea grain yield reduction.

Table 4. Correlation coefficients of *Striga* and *Alectra* shoot count on yield and yield components of cowpea lines.

	Yield/ha	100 seed weight	Pod/plant	Emerged *Striga*	Emerged *Alectra*
Yield/ha					
100 seed weight	0.2576 ns				
Pod/plant	0.0240 ns	-0.219**			
Emerged *Striga*	-0.518***	-0.1215 ns	-0.1765*		
Emerged *Alectra*	-0.4944***	-0.169ns	-0.1635*	0.3441***	
Striga height	-0.5301***	0.0733ns	-0.1635*	0.4595***	0.3951***

*,**, ***, significant at 0.10, 0.05 and 0.01 levels of probability, respectively; ns, not significant.

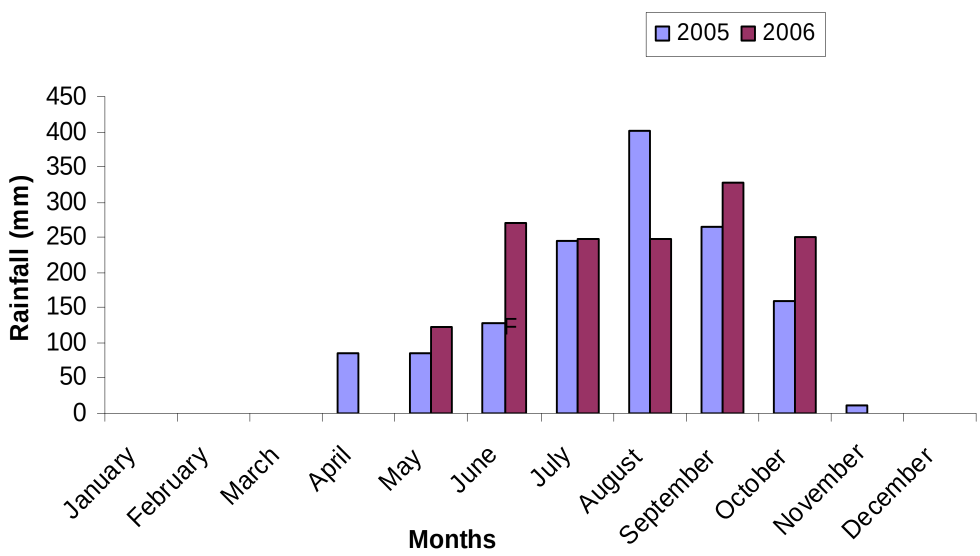

Figure 2. Mean monthly rainfall in 2005 and 2006 in Tilla.

Table 5. Average minimum and maximum temperature in Tilla in 2005 and 2006.

Month	Tilla in 2005		Tilla in 2006	
	Min	Max	Min	Max
January	28.77	30.00	20.23	35.03
February	29.17	29.00	20.32	38.07
March	29.13	32.58	23.19	36.05
April	28.00	39.94	23.23	39.42
May	26.00	41.81	21.06	37.13
June	27.53	34.63	20.50	36.37
July	27.81	33.45	20.68	34.23
August	27.61	41.00	20.32	33.00
September	27.47	41.00	19.97	33.40
October	27.52	42.00	20.61	35.81
November	32.53	38.80	20.13	33.57
December	29.00	34.58	20.16	38.06

7778 supported significantly high numbers of emerged *Striga*/*Alectra* shoots. These cultivars also experienced severe yield losses and gave grain yields that were significantly lower than those of the resistant or the tolerant cultivars, thus, suggesting that they are susceptible to *Striga/Alectra*. In contrast, the moderately resistant or tolerant cultivars gave higher yields comparably to those of the resistant lines. The observed large loss in grain yield and large number of emerged *Striga*/*Alectra* shoots recorded in the susceptible cowpea line (Borno Brown) was an indicator of the severe parasite pressure on the genotype. This result corroborates the findings of Kamara et al. (2007) and Omoigui et al. (2007), who reported that Borno Brown was highly susceptible to *Striga* with the yield loss from 30 to 100 %. The continuous cultivation of the local variety, Borno Brown, will have serious food security implications since cowpea is an important food crop in this dry savanna ecology. The wide range of responses shown by the cowpea lines to infestation by both *Striga* and *Alectra* indicates that the potential exists for improving cowpea varieties for resistance in the savanna. Resistance to *Striga* does not necessary translate to higher yield by a particular variety. This is clearly demonstrated by such cultivars such as B301 and IT97K-205-8 which recorded zero emerged *Striga* but recorded a yield lower than some of the tolerant varieties. Such lines have inherent low yield potential but can be used in breeding programme to improve local adapted cultivars for resistance to *Striga/Alectra.* On the other hand, in spite of the relatively higher numbers of *Striga*/*Alectra* shoots supported by IT81D-994, IT97K-818-118, and IT98K-415-1 in both years, grain yield did not significantly differ from that of the resistant cultivars. This suggests that these cultivars are tolerant to the parasites. Generally, the yield obtained in this study was higher than what is observed in farmers' condition. The fertilizer applied helped to boost the yield of the cowpea cultivars despite the severe attack of the parasites.

Significant differences were also observed in the growth of *Striga* on the different cowpea lines. *Striga* plants were taller on susceptible cultivars than on cultivars that supported very few or no emerged *Striga*. This implies that the susceptible cowpea lines were effective hosts of the parasite's growth. In contrast, the resistant cultivars were ineffective hosts. This result supports the observation of Lane et al. (1997) that the growth of the parasite and the subsequent parasite-induced host damage are strongly related. The data also showed that, apart from grain yield, the number of pods/plant and seed weights of the susceptible cultivars were also reduced. Studies had shown that *Striga* infested plants record lower biomass accumulation as a result of competition between the host and parasites for solutes, including carbon and water, and a lower rate of photosynthesis (Press, 1995). In the present study, cultivars that supported higher numbers of emerged *Striga*/*Alectra* also recorded lower numbers of pods/plant, seed weight and fodder yield than the *Striga* resistant cultivars. This suggests that reduced photosynthesis can result in a lower number of pods/plant. The number of pods/plant, 100-seed weight, grains and fodder yields were negatively correlated with the number of emerged *Striga* and *Alectra* shoots. This supports the observation that *Striga* and *Alectra* infestation reduced root and shoot growth in the susceptible host, and this could be attributed to competition between the host and parasites for solutes, including carbon, and lower rate of photosynthesis in the leaves of infested plants (Press, 1995). The results indicate that some of the breeding line (B301, IT00K-338-1, IT93K-573-2-1, IT98K-1092-1 and IT97K-205-8) would be useful sources of cowpea *Striga* and *Alectra* resistance genes for incorporation into high-yielding and adapted cultivars for host specific race in the region. The use of resistant cultivar integrated with other cultural practices is the only viable management option for effective control of *Striga* and *Alectra* infestation on cowpea.

Conclusion

Based on the response of the cultivars to Striga and Alectra in the region, we recommend that the cultivars such as IT98K-573-2-1, IT03K-338-1 and 1T97K-205-8 should be used in the area. These cultivars would serve as potential parental lines that can be used in any breeding programs aimed at improving cowpea cultivars for *Striga* resistance.

ACKNOWLEDGEMENTS

The authors thank Generation Challenge Program (GCP), Kirkhouse Trust, and CIDA for funding the research. We acknowledge the support of Dr. F. Massawe.

REFERENCES

Atokple IDK, Singh BB, Emechebe AM (1995). Genetics of resistance to *Striga* and *Alectra* in cowpea. J. Hered., 86: 45-49.

Bressani R (1985). Nutritive value of cowpea. In: Singh SR, Rachel KO, editors. Cowpea research, production and utilization. Chester, (UK): Wiley and sons, pp. 353-360.

Boukar O, Kong L, Singh BB, Murdock I, Ohm HW (2004). AFLP and AFLP-derived SCAR markers associated with *Striga gesnerioides* resistance in cowpea [*Vigna unguiculata* (L.) Walp.]. Crop Sci., 44: 1259-1264.

Botanga J, Timko P (2006). Phenetic relationships among different races of *Striga gesnerioides* (Willd) Vatke from West Africa. Genome, 49: 1351-1365.

Cardwell KF, Lane JA (1995). Effect of soils, cropping system and host phenotype on incidence and severity of *Striga gesnerioides* on cowpea in West Africa. Agric. Ecosyst. Environ., 53: 53-262.

Carsky RJ, Akakpo C, Singh BB, Detongnon J (2003). Cowpea yield grain from resistance to *Striga gesnerioides* parasitism in Southern Benin. Exp. Agric., 39: 327-333.

Dube MP, Oliver A (2001). Le *Striga gesnerioides* et son hôte, le niébé : interaction et méthodes de lutte. *Can J Botany*. 79 (10) 1225-1228.

Dugje IY, Kamara AY, Omoigui LO (2006). Infestation of crop fields by *Striga* species in the savannas of northeast Nigeria. *Agr, Ecosyst, Environ.* 116: 251-254.

Emechebe AM, Singh BB, Leleji OI, Atokple IDK, Adu JK. (1991). Cowpea *Striga* problems and research in Nigeria. In: Kim *SK, editor.* Combating *Striga* in Africa, Proceedings of an International Workshops, 1988 August22-24; August, Ibadan, Nigeria.

Kamara AY, Chikoye D, Ekeleme F, Omoigui LO, Dugje IY (2007). Field performance of cowpea varieties under natural infestation with the parasitic weed, *Striga gesnerioides.* Intern. J. Pest Mangt., 54 (3): 189-195.

Kamara AY, Kwari JD, Ekeleme F, Omoigui LO, Abaidoo R (2008). Effect of phosphorus application and soybean cultivar on grain and dry matter yield of subsequent maize in the tropical savanna of north-eastern Nigeria. Afr. J. Biotech., 7: 2593-2599.

Kureh I, Katung PD, Orakwue FC (1999). Reaction of soybean varieties to preconditioning and concentration of seed inoculum of *Alectra vogelii* (Benth). Science Forum. J. Pure Appl. Sci., 2(1): 116-124.

Kwari JD (2005). Soil fertility status in some communities in Southern Borno. Final report to PROSAB project, Maiduguri, Nigeria.

Lane JA, Bailey JA, Butler RC, Terry PJ (1993). Resistance of cowpea (*Vigna unguiculata* (L.) Walp, to *Striga gesnerioides* (Willd) Vatke, a parasitic angiosperm. The New Phytol., 125: 405-412.

Lane JA, Moore THM, Cild DV, Cardwell KE, Singh BB, Bailey JA (1994). Virulence characteristics of a new race of the parasitic angiosperm *Striga gesnerioides* from southern Benin on cowpea. Euphytica, 72: 183-188.

Lane JA, Moor THM, Child D, Bailey J (1997). Variation in virulence of *Striga gesnerioides* on cowpea: New sources of crop resistance. In: Singh BB., Mohan R, Dasheill KE,. Jackai LEN. Editors. Advances in Cowpea research Ibadan (Nigeria): IITA-JIRCAS, pp. 225-230.

Omoigui LO, Kamara AY, Massawe FS, Ishiyaku MF, Boukar O, Alabi SO, Ekeleme F (2007). Evaluation of cowpea genotypes for their reactions to *Striga gesnerioides* in the dry savanna of northeast (what?). In: Ahmed KZ, Mohamoud A , Abdel-Hakim M, Shalabi, SI, El-Morsi.H, Ismael AM. editors. Proceedings of the 8th African Crop Science Society Conference: 2007 (El-Minia) Egypt, pp. 273-278.

Parker C (1991). Production of crops against parasitic weeds. Crop Prod., 10: 6-13.

Press MC (1995). How do the parasitic weeds *Striga* and *Orobancheae* influence host carbon relation? Aspects Appl. Biol., 42: 63-70.

SAS Institute (2001). Statistical Analysis Software (SAS) user's guide: SAS Institute Inc., Cary, NC., USA.

Singh BB, Emechebe AM (1997). Advances in research on cowpea *Striga* and *Alectra*. In: Singh BB, Mohan R, Dashiel KE, Jackai LEN editors. Advances in cowpea research. IITA-Jircas, Ibadan, Nigeria, pp. 215-224.

Singh BB (2002). Breeding cowpea varieties for resistance to *Striga gesnerioides* and *Alectra vogelii*. In: Fatokun CA et al. editors. Challenges and opportunities for enhancing sustainable cowpea production. IITA, Ibadan, Nigeria, pp. 154-166.

Singh BB, Olufajo O, Ishiyaku MF, Adeleke RA, Ajeigbe HA, Mohammed SG (2006). Registration of six improved germplasm lines of cowpea with combined resistance to *Striga gesnerioides* and *Alectra vogelii*. Crop Sci., 46: 2332-2333.