



ASSESSING THE PERFORMANCE OF COWPEA (*Vigna unguiculata* [L.] Walp.) VARIETIES IN *Striga* INFESTED FIELDS IN THE SEMI-ARID REGION OF NIGERIA

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ABSTRACT

A field trial was conducted in two locations, at the Teaching and Research farm of the Faculty of Agriculture, University of Maiduguri, Maiduguri (11°50'N, 13°10'E) and Federal Ministry of Agriculture and Technology Transfer Station at Gashua (12°56'N, 11°30'E) which are situated in the semi-arid region of Nigeria. The trials were conducted during the 2004 rainy season in order to assess the response of cowpea varieties to *Striga gesnerioides* infestation. The experiment consisted of 12 cowpea varieties as treatments viz: IT97K-568-18, IT98K-692, IT97K-819-118, IT97K-205-8, IT00K-1060, IT97K-499-35, IT97K-497-2, IT98K-205-10, IT97K-499-38, B-301, Borno brown and Dan'arbain. These treatments were laid in randomised complete block design (RCBD) and replicated 4 times. The data collected include, *Striga* shoot count, days to 50% flowering, number of pods/plant, number of seeds per pod and grain yield of cowpea. Results show that varieties IT97K-568-18 and IT00-1060 were tolerant to *Striga gesnerioides* as they supported significant higher *Striga* population and still produced significantly high grain yield. Variety IT97K-819-118 was found to be resistant to *Striga* as it supported low *Striga* shoots and gave significantly high yield as well. The rest of the cowpea varieties gave low yields. The local variety Dan'arbain was also considered tolerant as it supported significant high *Striga* population and gave high grain yields that were comparable to the maximum. Both the tolerant varieties, IT97K-568-18 and IT00-1060 produced significantly higher number of pods/plant and number of seeds/pod and resulted in significantly higher grain yields which were comparable to the resistant variety, IT97K-819-118 in both locations and the combined mean. Cowpea grain yield was negatively correlated with days to 50% flowering but positively correlated with *Striga* infestation at 8, 10 and 12 WAS. Variety IT97K-819-118 was found to combine the ability to resist *Striga* infestation with the production of higher grain yield comparable to the maximum. It could be recommended to farmers in the semi-arid zone of Nigeria. The tolerant varieties should be improved upon through further breeding to be able to resist *Striga*, while maintaining their potential for higher yields.

Key words: *Striga gesnerioides*, cowpea varieties, resistance, tolerance, Nigeria.

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INTRODUCTION

Cowpea (*Vigna unguiculata* [L.] Walp.) is a food legume of significant economic importance worldwide. It is grown in North and South America, Africa, Europe and Asia primarily in the semi-arid and humid tropical regions lying between 35°N and 30°S of the equator (Timko, 2002). World cowpea production was estimated at 31.3 million metric tonnes and 75% of the production is from Africa (FAO, 2000). The principal cowpea producing countries are Nigeria, Niger, Senegal, Ghana, Mali and Burkina Faso. Among these countries, Nigeria is the largest cowpea producer in West Africa with a production figure of 2.1 million metric tonnes in 1990 and 641,000 metric tonnes in 1999 (FAO, 2000).

Cowpea is one of the most important sources of plant protein especially to the majority of the population of West Africa. With about 25% protein in its grains, 62% soluble carbohydrates and small amounts of other nutrients (Brader, 2002 and Ricardo, 1985), cowpea is an important source of qualitative nourishment to the urban and rural poor who cannot afford meat and milk products (Brader, 2002). It is estimated that cowpea supplies 40 percent of the daily protein requirements of most of the people in Nigeria (Muleba *et al.*, 1997). Furthermore, Cowpea haulms contain about 15% protein and constitute a valuable source of fodder (IITA, 2001).

Cowpea production is hampered by the attack of the obligate parasitic weeds especially *Striga gesnerioides* and *Alectra vogelli* (Benth.) of the families Orobanchaceae and Scrophulariaceae, respectively. *Striga gesnerioides* is a very serious parasitic weed of cowpea and causes considerable yield reduction in more than 29 sub-Saharan African Countries (Emechebe *et al.*, 1991). It is wide spread in the savanna and arid zones of Nigeria infesting about 37.1% of cowpea field in Yobe state, Nigeria (Gworgwor *et al.*, 2000). Furthermore, Gworgwor *et al.* (2001) reported that *S. gesnerioides* infested 81% of cowpea fields studied in the savannas of the North-east Nigeria. The attack by this weed species is more severe in countries like Nigeria, Niger, Burkina Faso and Mali, where yield losses associated with the species can be up to 100% and the damage depends primarily on the number of *Striga* plants attacking and the level of resistance in the cowpea variety (Emechebe, 1981). Lagoke *et al.* (1995) reported that between 10 and 100% loss in crop yield have been attributed to *Striga* and related parasitic weeds in cereal and legume crops alike. It has been estimated that *Striga* and its closely related genus, *Alectra* depend completely on the host at early growth stage for water, minerals and sugar (Okonkwo, 1996). Generally, *Striga* species not only cause lower biomass accumulation in hosts compared to uninfected plants, but also commonly influence the allocation of biomass between tissues leading to a greater root: shoot ratio in hosts compared to uninfected control plants (Graves, 1995; Alonge and Lagoke, 2001). Graves *et al.* (1992) estimated that about 7% of the carbon transferred from host to parasite is used in parasite respiration. Farmers in 30 communities in the southern part of Borno state of North-east Nigeria where cowpea is also predominantly grown rated *Striga* infestation as a leading priority constraint together with low soil fertility during a livelihood analysis (Tarawali and Kureh, 2004).

It has been generally accepted that good control of *Striga* in West and Central Africa is obtained by growing a range of resistant varieties and/or combining a range of individual components technologies into an integrated programme (Tarawali and Kureh, 2004). At present, host plant resistance is considered the most feasible control method for *Striga* and *Alectra* in cowpea at the subsistence farmer's level particularly in semi-arid regions (Aggarwal, 1991 and 1995; Emechebe *et al.*, 1991; Lane and Bailey, 1992; Atokple, 1993; Singh *et al.*, 1995). The development of *Striga* resistant varieties by the International Institute of Tropical Agriculture, Ibadan, Nigeria from local varieties has provided the opportunity to test these varieties in the semi-arid region and identify the one that is not only resistant to *Striga gesnerioides*, but will give good growth and higher grain yield of cowpea.

The objective of the experiment was to assess the effect of *Striga gesnerioides* on the growth and yield of some cowpea varieties in the semi-arid zone of North-eastern Nigeria.

MATERIALS AND METHODS

A field trial was conducted during the rainy season (July-October) in 2004, at the Teaching and Research Farm of the Faculty of Agriculture, University of Maiduguri, Maiduguri (11°50'N; 13°10'E) and Federal Ministry of Agriculture and Technology Transfer Station, Gashua (12°56'N; 11°03'E). Both locations are situated in the Semi-arid zone of Nigeria and have a history of *S. gesnerioides* infestation (Gworgwor *et al.*, 1989). The total rainfall in the experimental sites in 2004 was 545 mm in Maiduguri and 267.8mm in Gashua.

The experiment consisted of twelve treatments which included ten improved varieties of cowpea viz: IT98K-692, IT97K-568-18, IT97K-819-118, IT98K-205-8, IT00K-1060, IT97K499-35, IT97K-497-2, IT98K-205-10, IT97K-499-38, B301, and two local varieties, *Borno brown* and *Dan'arbain*. The treatments were laid out in randomised complete block design (RCBD) and replicated 4 times.

After the experimental sites were cleared and harrowed, the fields were levelled, demarcated into 4 blocks (replications) and each block was subdivided into 12 plots and assigned the treatments. The plot size was 3 m x 5 m. The distance between the plots and replications were 0.5 m and 1 m, respectively. Single superphosphate (SSP) at the rate of 40 kg P₂O₅/ha was applied before sowing and incorporated into the soil with a hand rake immediately after demarcation of the plots in both locations. Three seeds of cowpea were sown after the rain by hand drilling at 75 cm x 20 cm on 16th and 24th of July, 2004 at Maiduguri and Gashua, respectively. Thinning of cowpea was done at 2 weeks after sowing (WAS) to 2 plants/stand. Insect pests were controlled with Karate (*Cyhalothrin*) insecticide at the rate of 2.5 kg a.i./ha at 6, 8 and 10 WAS with CP- knapsack sprayer fitted with a cone nozzle at a pressure of 1.2 g/m².

Harvesting was done manually by hand-picking matured pods that have turned brown in each plot. All treatments except *Borno brown* were harvested twice on 17th September and 18th October in both locations. *Borno brown* was later harvested on 15th and 20th November at Maiduguri and Gashua, respectively. Each plot was harvested separately, bagged, labelled and threshed using pestle and mortar. Data collected included days of 50% flowering, *Striga* shoot count, number of pods/plant, number of seeds/pod and cowpea grain yield. The data collected were subjected to analysis of variance (ANOVA). All data that were significant were subjected to Duncan's Multiple Range Test (DMRT) for mean separation at 5% level of probability.

RESULTS AND DISCUSSION

Effect of cowpea varieties on *Striga* count

Table 1 shows that varietal response to *Striga gesnerioides* significantly affected the number of *Striga* shoot count per plot at 8, 10 and 12 WERE. Variety IT97K-568-18 supported significantly the highest population of *Striga* than the other varieties in both locations and their combined means at 8 WAS. Variety IT00K-1060 supported moderate population of *Striga gesnerioides* in both locations and combined means which was comparable to *Borno brown* in Maiduguri and the combined means and *Dan'arbain* in both locations and combined means at 8 WAS. Varieties IT98K-692, IT97K-499-35, IT97K-499-38, and B-301 supported no *Striga* population at 8 WAS. At 10 WAS, the results showed that variety IT97K-568-18 supported the highest *Striga* population in both years and the combined means which was comparable to the two land races, *Borno brown* and *Dan'arbain* in Maiduguri and improved variety IT00-1060 in Gashua. Improved varieties IT98K-692, IT97K499-35, B-301 supported no *Striga* population. This level of *Striga* infestation was comparable with the rest of the varietal treatments. Similarly, at 12 WAS, improved varieties, IT98K-692, IT97K-499-35 and B-301 consistently maintained no *Striga* infestation in both locations and their combined means. This was comparable to other varieties except improved varieties IT97K-568-18, IT00K-1060 in both locations and combined means, and the local varieties *Borno brown* in Maiduguri and *Dan'arbain* in Maiduguri and the combined means, which supported significantly the highest number of *Striga* population. Generally, the *Striga* population in Maiduguri was higher than that in Gashua at 8, 10 and 12 WAS (Table 1).

Though improved varieties IT98K-568-18 and IT00K-1060 consistently supported significantly higher *Striga* population especially at 12 WAS, they resulted in significantly higher yields (Table 4) compared to the rest of the treatments. This suggests that these varieties are tolerant to *Striga* damage. This is similar to the finding of Dugje *et al.* (2010) who reported that improved varieties IT89KD-288 and T89KD-391 produced significantly high grain yield though it supported moderate populations of *Striga gesnerioides*. The two local varieties, *Borno brown* and *Dan'arbain* also promoted significantly high *Striga* counts especially in Maiduguri. While *Borno brown* could be considered as a susceptible variety as a result of the low grain yield, variety *Dan'arbain* could be considered as a tolerant variety since it produced grain yield comparable to the maximum. The higher *Striga* population supported by both local varieties in Maiduguri compared to Gashua could be as a result of the reactions of cowpea varieties to different strains of *Striga* found across West Africa (Singh, 2002). Varieties IT98K-692, IT97K-499-35, B-301, IT97K-819-118, IT98K-205-8, IT97K-497-2, IT98K-205-10 and IT97K-499-38 supported significantly low or no *Striga* population. This suggests that these varieties are resistant to *Striga*

gesnerioides. The resistance of IT97K-499-35 to *Striga gesnerioides* was confirmed by Singh *et al.* (2006), who reported the resistance of this variety to *Striga gesnerioides* in Kano State, North Western Nigeria and by Kamara *et al.* (2008) who reported its resistance to *Striga gesnerioides* in the Savannas of Nigeria. The higher population of *Striga gesnerioides* in Maiduguri compared to Gashua could be as a result of earlier sowing of cowpea in the former location compared to the latter.

Table 1: Effect of cowpea varieties on *Striga gesnerioides* shoot count at 8, 10 and 12 WAS at Maiduguri and Gashua locations, 2004

Treatment	Number of <i>Striga</i> per plot								
	8 WAS ¹			10 WAS			12 WAS		
	Maiduguri	Gashua	Combined ²	Maiduguri	Gashua	Combined	Maiduguri	Gashua	Combined
IT97K-568-18	19.8(4.6) ^{3a}	16.3(4.2) ^a	16.8(4.2) ^a	38.5(6.3) ^a	32.8(5.8) ^a	35.6(6.0) ^a	42.1(6.6) ^a	48(7.0) ^a	59.1(7.8) ^a
IT98K-692	0(1.0) ^{c4}	0(1.0) ^c	0(1.0) ^c	0(1.0) ^b	0(1.0) ^c	0(1.0) ^c	0(1.0) ^{b4}	0(1.0) ^c	0(1.0) ^d
IT97K-819-118	0.3(1.1) ^c	0(1.0) ^c	0(1.0) ^c	1.8(1.7) ^b	0(1.0) ^c	0.9(1.4) ^c	6.8(2.8) ^b	0(1.0) ^c	2.9(2.0) ^d
IT98K-205-8	1.8(1.7) ^{bc}	0.8(1.3) ^c	1.3(1.5) ^c	3(2.0) ^b	1.3(1.5) ^c	2.1(1.8) ^c	4(2.2) ^b	1.3(1.5) ^c	2.6(1.9) ^d
IT00K-1060	9(3.2) ^b	4.8(2.4) ^b	6.9(2.8) ^b	21.8(4.8) ^b	16.5(4.2) ^{ab}	19.1(4.5) ^b	36.8(6.1) ^a	30.8(5/6) ^{ab}	33.8(5.9) ^a
IT97K-499-35	0(1.0) ^c	0(1.0) ^c	0(1.0) ^c	0(1.0) ^b	0(1.0) ^c	0(1.0) ^c	0(1.0) ^b	0(1.0) ^c	0(1.0) ^d
IT97K-NMK497-2	0(1.0) ^c	0(1.0) ^c	0(1.0) ^c	0.8(1.3) ^b	0(1.0) ^c	0.4(1.2) ^c	1(1.4) ^b	0(1.0) ^c	0.5(1.2) ^d
IT98K-205-10	0.8(1.2) ^c	0.5(1.2) ^c	0.6(1.3) ^c	3.3(1.9) ^b	1.3(1.5) ^c	2.3(1.8) ^c	5.5(2.5) ^b	1.8(1.7) ^c	3.4(2.1) ^{cd}
IT97K-499-38	0(1.0) ^c	0.8(1.3) ^c	0.4(1.2) ^c	0(1.0) ^b	0.8(1.3) ^c	0.4(1.2) ^c	1(1.4) ^b	0.8(1.3) ^c	0.9(1.4) ^d
B-301	0(1.0) ^c	0(1.0) ^c	0(1.0) ^c	0(1.0) ^b	0(1.0) ^c	0(1.0) ^c	0(1.0) ^b	0(1.0) ^c	0(1.0) ^d
<i>Borno brown</i>	8(3.0) ^b	0.8(1.3) ^c	4.4(2.3) ^{bc}	21(4.7) ^{ab}	1.5(1.6) ^c	10.8(3.4) ^{bc}	32.8(5.8) ^a	6.3(2.7) ^c	19.5(4.5) ^b
<i>Dan'arbain</i>	4.8(2.4) ^{bc}	3.3(2.1) ^b	4(2.2)	19.3(4.5) ^{ab}	13.3(3.8) ^b	16.3(4.2) ^b	29.8(5.5) ^a	21.3(4.7) ^b	25.5(5.1) ^a
SE(±)	0.50	0.30	0.40	0.90	0.50	0.50	1.00	0.60	0.70

¹Weeks after sowing

²Mean of the combined analysis of Maiduguri and Gashua data

³Figures in parenthesis are $\sqrt{x+1}$ transformed prior to the analysis of variance

⁴Figures followed by the same letter(s) in the same column are not significantly different from each other at 5% level of probability according to Duncan's Multiple Range Test (DMRT).

Effect of cowpea varieties on growth development and yield of cowpea

The effect of the different cowpea varieties on number of days to 50% flowering (Table 2) shows that cowpea varieties significantly affected days to 50% flowering. Improved variety IT98K---205—8 significantly attained 50% flowering earlier than the rest of the treatments in both locations and the combined means except variety IT97K-499-38 in both locations and the combined means. The land races, *Borno brown* and *Dan'arbain* significantly attained 50% flowering later than the other varieties in both locations and the combined means. The local variety *Borno brown* significantly attained 50% flowering on a later date probably because it was vulnerable to the high population of *Striga* it supported which could have competed with it for growth resource which delayed flowering. Graves *et al.* (1992) reported that the implication of xylem connection between host root and parasite is that there is competition for water between *Striga* shoot and that of the host. The rest of the varieties attained 50% flowering earlier than the local varieties of *Borno brown* as a result of their ability to tolerate *Striga* infestation and its negative effects on the performance of the cowpea crop. The difference in the number of days to 50% flowering among the varieties could be due to genetic or varietal differences. Generally, the varieties of cowpea attained flowering earlier in Maiduguri than Gashua. This could be as a result of earlier sowing and higher rainfall in Maiduguri compared to Gashua location.

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Table 2: Effect of cowpea varieties on the number of days to 50% flowering at Maiduguri and Gashua locations, 2004

Treatment	Days to 50% flowering		
	Maiduguri	Gashua	Combined ¹
IT97K-568-18	45.0 ^{cd2}	48.0 ^{bc}	46.5 ^{cd}
IT98K-692	45.3 ^{cd}	48.5 ^{bc}	46.9 ^c
IT97K-819-118	45.8 ^c	49.3 ^b	47.4 ^c
IT98K-205-8	40.5 ^f	46.0 ^c	43.3 ^e
IT00K-1060	45.0 ^{cd}	48.3 ^{bc}	46.6 ^{cd}
IT97K-499-35	43.5 ^{de}	47.5 ^{bc}	45.5 ^d
IT97K-NMK497-2	41.8 ^{ef}	47.0 ^{bc}	44.1 ^{de}
IT98K-205-10	42.8 ^e	46.5 ^c	45.0 ^d
IT97K-499-38	42.0 ^{ef}	47.0 ^{bc}	44.4 ^{de}
B-301	45.5 ^c	46.5 ^{bc}	47.3 ^c
<i>Borno brown</i>	84.5 ^a	78.3 ^a	81.4 ^a
<i>Dan' arbain</i>	50.5 ^b	49.0 ^b	50.8 ^b
SE(±)	0.80	0.70	0.50

¹Mean of combined analysis of Maiduguri and Gashua data.

²Figures followed by the same letter(s) in the same column are not significantly different from each other at 5% level of probability according to Duncan's Multiple Range Test (DMRT).

The number of cowpea pods/plant and numbers of seeds per cowpea pod were significantly differed among the cowpea varieties in both locations and the combined mean (Table 3). In Maiduguri location, IT00K-1060 produced significantly the highest number of pods per plant which was comparable to IT97K-568-18, IT97K-499-35 and the local varieties of *Borno brown* and *Dan'arbain*. The rest of the varietal treatments produced significantly low number of pods. In Gashua, IT97K-568-18 produced significantly the highest number of pods per plant which was comparable to IT00K-1060 and the local varieties only (Table 3). The improved varieties IT00K-1060 and IT97K-568-18 produced significantly highest number of pods in Maiduguri and Gashua, respectively, despite supporting significantly high *Striga* population. In the combined means the same trend was observed. This could be as a result of their abilities to tolerate *Striga* coupled perhaps with their genetic potential which promoted good growth.

For the number of seed/pod, in Maiduguri, B-301 produced significantly the highest number of seeds per pod but it was comparable to IT97K-568-18, IT98K-692, IT98K-205-8, IT00K-1060, IT97K-499-38 and the local varieties *Borno brown* and *Dan'arbain*. The rest of the varieties produced significantly lower number of seeds per pods (Table 3). Similar trend was observed in Gashua and the combined means with B-301 producing the highest number of seeds per pod, but was also comparable to other varieties except IT97K-819-118, IT97K-497-2 and *Borno brown* and *Dan'arbain* which produced significantly lower number of seeds per pod (Table 3). The improved variety IT00K-1060 produced significantly higher number of seeds per pod in Maiduguri and Gashua and the combined means probably due to the ability of this variety to better tolerate *Striga* infestation and damage. Improved variety IT97K-499-35 produced significantly higher number of seeds per pod in Gashua but significantly lower number of seeds/pod in Maiduguri, while the land races produced significantly higher number of seeds in Gashua. This is in line with the report of Singh (2002) that cowpea varieties react differently to different *Striga* strains found across West Africa (Table 3).

Cowpea grain yield was significantly affected among the cowpea varieties in both locations and the combined means (Table 4). Improved variety IT97K-568-18 produced significantly the highest yield in Maiduguri which was comparable only to IT00K-1060 and IT97K-819-118, while *Borno brown* produced significantly the lowest yield. However in Gashua location, improved variety IT97K-819-118 produced significantly the highest cowpea yield which was comparable to IT00K-1060, IT98K-692, IT97K-568-18 and the local variety *Dan'arbain*. The rest of the varieties produced significantly lower grain yield. Similar result was observed for combined means as IT97K-568-18 produced the highest grain yield which was comparable with IT00K-1060, IT97K-819-118 and the local variety *Dan'arbain* (Table 4). The rest of the treatments gave significantly low yield while *Borno brown* gave significantly the lowest grain yield. Generally, Maiduguri location produced higher grain yield than Gashua location (Table 4).

Table 3: Effect of cowpea varieties on number of pods/ plant and number of seeds/ pod at Maiduguri and Gashua locations, 2004

Treatment	Number of pods per plant			Number of seeds per plant		
	Maiduguri	Gashua	Combined ¹	Maiduguri	Gashua	Combined
IT97K-568-18	24.5 ^{ab2}	17.5 ^a	21.0 ^a	10.3 ^{ab}	8.5 ^{ab}	9.4 ^{ab}
IT98K-692	16.3 ^b	11.4 ^b	13.9 ^{bc}	10.4 ^{ab}	8.6 ^{ab}	9.5 ^{ab}
IT97K-819-118	14.6 ^b	10.6 ^b	12.6 ^c	8.8 ^b	7.5 ^b	8.1 ^b
IT98K-205-8	14.5 ^b	10.0 ^b	12.3 ^c	9.9 ^{ab}	8.1 ^{ab}	9.0 ^b
IT00K-1060	24.7 ^a	16.8 ^{ab}	20.7 ^a	11.1 ^a	8.9 ^{ab}	10.0 ^{ab}
IT97K-499-35	14.7 ^a	10.2 ^b	12.5 ^c	9.0 ^b	8.5 ^{ab}	8.8 ^b
IT97K-NMK497-2	15.0 ^b	10.3 ^b	12.7 ^c	8.6 ^b	6.4 ^b	7.5 ^b
IT98K-205-10	14.3 ^b	10.5 ^b	12.4 ^c	9.3 ^b	8.1 ^{ab}	8.7 ^b
IT97K-499-38	13.9 ^b	9.7 ^b	11.8 ^c	9.6 ^{ab}	7.9 ^{ab}	8.8 ^b
B-301	16.6 ^b	11.8 ^b	14.2 ^{bc}	11.1 ^a	9.9 ^a	10.7 ^a
<i>Borno brown</i>	19.8 ^{ab}	16.2 ^{ab}	18.1 ^{ab}	10.0 ^{ab}	7.8 ^b	8.9 ^b
<i>Dan' arbain</i>	21.5 ^{ab}	15.8 ^{ab}	18.7 ^{ab}	9.9 ^{ab}	7.5 ^b	8.7 ^b
SE(±)	2.90	2.00	2.30	0.70	0.70	0.60

¹Mean of combined analysis of Maiduguri and Gashua data.²Figures followed by same letter(s) in the same column are not significantly different from each other at 5% level of probability according to Duncan's Multiple Range Test (DMRT).

Table 4: Effect of cowpea varieties on grain yield of cowpea at Maiduguri and Gashua locations, 2004.

Treatment	Grain yield (kg/ha)		
	Maiduguri	Gashua	Combined ¹
IT97K-568-18	1722.0 ^{a2}	527.8 ^{ab}	1125.3 ^a
IT98K-692	958.3 ^{bc}	513.8 ^{ab}	736.3 ^b
IT97K-819-118	1347.0 ^{ab}	625.3 ^a	986.3 ^{ab}
IT98K-205-8	861.0 ^{bc}	416.5 ^b	639.0 ^b
IT00K-1060	1597.3 ^{ab}	583.3 ^{ab}	1090.8 ^{ab}
IT97K-499-35	958.3 ^{bc}	430.3 ^b	694.5 ^b
IT97K-NMK497-2	805.5 ^c	416.5 ^b	611.3 ^b
IT98K-205-10	861.3 ^{bc}	430.3 ^b	646.0 ^b
IT97K-499-38	805.5 ^c	430.8 ^b	618.3 ^b
B-301	819.5 ^c	360.0 ^b	590.5 ^b
<i>Borno brown</i>	220.0 ^d	131.3 ^c	175.6 ^c
<i>Dan' arbain</i>	1277.8 ^b	472.0 ^{ab}	875.3 ^{ab}
SE(±)	189.00	72.00	117.80

¹Mean of combined analysis of Maiduguri and Gashua data.²Figures followed by the same letter(s) in the same column are not significantly different from each other at 5% level of probability according to Duncan's Multiple Range Test (DMRT).

The varieties IT97K-568-18, IT00K-1060 and IT97K-819-118 consistently produced significantly the highest grain yields in both locations and the combined means. This could be due to the ability of the first two varieties to tolerate high *Striga* infestation. Therefore, both varieties can be considered to be high yielding tolerant cowpea varieties. Similarly, improved variety IT97K-819-118 produced significantly high yields due to its ability to resist *Striga* infestation by suppressing *Striga* emergence. This could have prevented competition between this variety and *Striga gesnerioides* which could have resulted in higher uptake of growth resources to achieve higher yield. Thus, this variety can be considered as high yielding resistant variety. Between the two local varieties tested, *Dan' arbain* seems more tolerant to *Striga* as it produced significantly higher yields in Gashua and the combined means, despite supporting high population of *Striga*.

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Apart from IT97K-568-18, IT00K-1060 and IT97K-819-118, the rest of the improved varieties could be considered as resistant since they supported significantly low population of *Striga*, but had significantly low yields. Resistance to *Striga* might not necessarily mean higher yield by a particular variety. This is demonstrated by varieties B-301 and IT97K-449-35 which supported no *Striga* population but had significantly low yields. Gworgwor *et al.* (1989) reported that variety B-301 KN-1, K VX30-305-3G and VITA-5 had both low *Striga* count and yield at the same time. Lagoke *et al.* (1996) also reported that B-305 produced lower yield despite non-emergence of *Striga* on the crop. Ramaiah (1986) reported that one of the limitations to breeding for *Striga* resistance/tolerance in crops, particularly sorghum has been low yield and low quality grain in resistance/tolerant varieties. The low grain yield by resistant varieties despite their support of zero *Striga* population also agrees with the conclusions of Babiker *et al.* (1987) that low grain yield obtained in KSV1007 sorghum variety despite the low *Striga* infestation under field conditions might be due to varietal difference in response to environment apart from where it was initially developed. *Borno brown* produced significantly the lowest yield in both locations and combined means. This could be due to the susceptibility of this variety to *Striga* attack and damage as it supported high *Striga* population, especially at the Maiduguri location. This result corroborate Dugje *et al.* (2010) who reported that local varieties including *Borno brown* promoted higher *Striga* population and recorded lower grain yield than the improved varieties in Northern Guinea and Sudan savanna of the country.

Table 5 shows the correlation coefficient between grain yield, days to 50% flowering number of pods/plant, number of seeds/pod, *Striga* shoot count at 8, 10 and 12 WAS, in Maiduguri. Grain yield had significant negative correlation with days to 50% flowering and significant positive correlation with number of pods/plant and *Striga* shoot count at 8, 10 and 12 WAS. Days to 50% flowering had significant positive correlation with *Striga* count at 10 and 12 WAS. Number of pods/plant had significant positive correlation with number of seeds/pod and *Striga* count 10 and 12 WAS. *Striga* count at 12 WAS had significant positive correlation with *Striga* count at 10 WAS, while *Striga* count at 10 WAS had significant positive correlation with *Striga* count at 8 WAS.

Table 5: The correlation coefficient (r) between cowpea agronomic parameters and *Striga* count at Maiduguri location, 2004

Parameter	GY	DF	NPP	NSP	SC12WAS	SC10WAS	SC8WAS
Grain yield (GY)	-						
Days to 50% Flowering (DF)	-0.52*	-					
Number of pods/plant (NPP)	0.55*	0.29	-				
Number of seed/pod (NSP)	0.21	0.16	0.63*	-			
<i>Striga</i> count at 12 WAS ¹ (SC12WAS)	0.48*	0.37*	0.92**	0.05	-		
<i>Striga</i> count at 10 WAS (SC10WAS)	0.44*	0.46*	0.94**	0.43	0.97**	-	
<i>Striga</i> count at 8 WAS (SC8WAS)	0.50*	0.27	0.86*	0.40	0.97**	0.90**	-

¹Weeks after sowing

*Significant at 5% level of probability

**Significant at 1% level of probability

Values without asterisk have no significant linear correlation

In Gashua, there was significant negative correlation between grain yield and days to 50% flowering while grain yield was positively correlated with *Striga* count at 10 and 12 WAS (Table 6). Days to 50% had significant positive correlation with number of pods/plant. The number of pods/plant had significant positive correlation with *Striga* shoot count at 8, 10 and 12 WAS. *Striga* count at 12 WAS had significant positive correlation with *Striga* count at 8 and 10 WAS while *Striga* count at 10 WAS had significant positive correlation with *Striga* count at 8 WAS.

In the combined analysis, grain yield had significant negative correlation with days to 50% flowering while it had significant positive correlation with *Striga* shoot count at 8, 10 and 12 WAS (Table 7). Number of pods/plants was significantly positively correlated with number of seeds/pod and *Striga* count at 8, 10 and 12 WAS. *Striga* shoot count at 8 WAS had significant positive correlation with *Striga* shoot count at 10 and 12 WAS, while *Striga* shoot count at 10 WAS had significant positive correlation with *Striga* shoot count at 12 WAS.

Table 6: The correlation coefficient (r) between cowpea agronomic parameters and *Striga* count at Gashua location, 2004.

Parameter	GY	DF	NPP	NSP	SC12WAS	SC10WAS	SC8WAS
Grain yield (GY)	-						
Days to 50% Flowering (DF)	-0.73*	-					
Number of pods/plant (NPP)	-0.04	0.43*	-				
Number of seed/pod (NSP)	0.05	-0.16	0.16	-			
<i>Striga</i> count at 12 WAS ¹ (SC12WAS)	0.34*	-0.09	0.10**	0.15	-		
<i>Striga</i> count at 10 WAS (SC10WAS)	0.31*	-0.02	0.85**	0.16	0.99**	-	
<i>Striga</i> count at 8 WAS (SC8WAS)	0.28*	-0.07	0.70*	0.15	0.97*	0.93**	-

¹Weeks after sowing

*Significant at 5% level of probability

**Significant at 1% level of probability

Values without asterisk have no significant linear correlation

Table 7: The correlation coefficient (r) between cowpea agronomic parameters and *Striga* count in the combined means at Maiduguri and Gashua locations, 2004.

Parameter	GY	DF	NPP	NSP	SC12WAS	SC10WAS	SC8WAS
Grain yield (GY)	-						
Days to 50% Flowering (DF)	0.27	-					
Number of pods/plant (NPP)	0.20	0.32*	-				
Number of seed/pod (NSP)	0.38*	0.58*	0.28	-			
<i>Striga</i> count at 12 WAS ¹ (SC12WAS)	0.41*	0.68*	0.28	0.93**	-		
<i>Striga</i> count at 10 WAS (SC10WAS)	0.38*	0.69*	0.26	0.92**	0.99**	-	
<i>Striga</i> count at 8 WAS (SC8WAS)	-0.48*	0.27	0.00	0.23	0.21	0.24	-

¹Weeks after sowing

*Significant at 5% level of probability

**Significant at 1% level of probability

Values without asterisk have no significant linear correlation

Grain yield was negatively correlated with days to 50% flowering in both locations and their combined means. This was probably due to the genetic differences among the variety which probably allowed the early flowering varieties to utilize more growth resources which resulted in better growth and yield. However, grain yield and number of pods/plant was significantly positively correlated with *Striga* count at 8, 10 and 12 WAS in both locations and the combined means probably as a result of the ability of some of the varieties IT97K-568-18 and IT00K-1060 to tolerate significant high *Striga* infestation and yet resulted in better growth and significantly high yield. In both locations and the combined means *Striga* population at 8 WAS correlated positively with *Striga* population at 10 and 12 WAS. This is probably due to release of more exudates/stimulants from the root of cowpea which stimulated more *Striga* seeds leading to higher infestation. In Maiduguri location, grain yield was positively correlated with number of seeds/plant and number of pods/plant. This show the yield components which contribute to high yield of cowpea.

CONCLUSIONS AND RECOMMENDATION

From this study, it can be concluded that improved varieties IT97K-568-18 and IT00-6010 are *Striga* tolerant varieties since they could give significantly high cowpea grain yield despite supporting high *Striga* population. This is further corroborated by the significant positive correlation between grain yield and *Striga* infestation at 8 10 and 12 WAS. Although variety IT97K-819-118 gave comparable grain yield as the above two varieties, it is considered a resistant variety since it supported significantly low population of *Striga*. The local variety, *Borno brown*, was found to be susceptible to *Striga* infestation as it supported high population of *Striga* leading to significantly low yield. The other tested varieties though resistant as they supported zero to significantly low *Striga* population, they produced significantly low yields. The other local variety *Dan'arbain* was found to be tolerant to high *Striga* infestation as it gave

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significantly higher yield comparable to the maximum. It is suggested that this variety can be crossed with any of the low yielding resistant varieties to produce a high yielding resistant varieties.

The variety IT97K-819-118 is recommended to farmers in the semi-arid region of Nigeria for its ability to resist *Striga gesnerioides* infestation and realise high grain yield of cowpea.

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