Effect of *Striga gesnerioides* on Cowpea (*Vigna unguiculata* L.Walp) Yield Components

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Abstract

Background: The parasitic plant *Striga gesnerioides* (Willd) Vatke is becoming a threat to cowpea production in the three northern regions of Ghana (Derived Savanna, Southern Guinea Savanna and Northern Guinea Savanna). The objective of this study was to determine the extent of yield loss due to *Striga* in F3 progenies and their parental lines. A total of twelve cowpea genotypes were evaluated to ascertain the level of damage by *S. gesnerioides*. **Results:** The results indicated varietal differences with respect to *Striga* susceptibility in the genotypes studied. The susceptible varieties (Asomdwee and Hewale) showed an array of emerged *Striga* shoots. The F3 progenies (s52, s37, s147, s272) also exhibited the same trend. The resistance genotypes (IT99K-573-1-1 and GH3684), however, were totally devoid of *Striga* shoots. Similarly, some of the F3 progenies (r246, r286, r282 and r69) were completely without *Striga* shoot. *Striga* height was higher on susceptible genotypes than those that are moderately resistance. The results obtained from this study revealed a percentage reduction in pods per plant range between 45.12 and 49.53 %; grain yield reduction ranged between 78.22 and 87.17% on susceptible genotypes which indicated that *Striga* had greater influence on yield. Fodder yield was also significantly reduced between 70.59 and 73.03% in susceptible genotypes. There was a strong negative correlation ($r = -0.724$) between grain yield and days to *Striga* emergence. A significant negative correlation ($r = -0.762$) was also found between *Striga* shoot per plant and grain yield. **Conclusion:** *Striga* infestation reduced pods per plant to 49%, grain yield loss to 87% and fodder yield loss to 73%. This study has revealed potential F3 genotypes resistant to *S. gesnerioides* under pot experiment. The implication is that if susceptible genotypes are grown the farmer stand the chance of loosen everything to the parasite.

Background

Cowpea (*Vigna unguiculata* (L.) Walp) is considered the most essential leguminous grain in the dry Savannas of tropical Africa. Cowpea, also known as southern peas, is cultivated in a range of agro-ecologies and cropping systems in the tropics. It originated from the semi-arid areas of West Africa, it contribute to human nutrition and generate income for farmers and food vendors [1]. The low grain yield (0.025 - 0.3 Mg/ha) [2, 3] observed in farmers' fields are due to a myriad of factors. Notable among include: abiotic factors such as poor soil fertility, drought, and high temperature. In Ghana, total areas under cowpea cultivation were over 160,000 hectares which produced an estimated amount of 142,000 tonnes in 2011 [4]. An average yield of cowpea in Ghana is about 1.25 metric tonnes per hectare was observed in farmers' field [4]. Cowpea is additionally susceptible to a wide range of bacterial, fungal, viral diseases and insect pest. However, biotic limitation such as *S. gesnerioides* cause a restriction to cowpea production in the three regions of northern Ghana [5].

Parasitic weed *S. gesnerioides* (Willd) Vatke is an obligate root-parasitic flowering plant that influence the growth of cowpea and other legumes [6]. The genus *Striga* is a member of Scrophulariaceae which contains about 50 species [7]. Most members from the Scrophulariaceae are holoparasitic (without chlorophyll and absolutely reliant on the host for natural carbon, water and nitrogen), some are hemiparasitic (with chlorophyll) [8]. The geographical distribution of *S. gesnerioides* comprise West and Southern Africa, India, Asia, Europe and USA [9]. However, in West Africa *S. gesnerioides* is reported to occur in Burkina Faso, Niger, Nigeria, Benin, Togo, Ghana, Mali and Cameroon with one race designated to each country [10]. Studies have shown that *Striga* infestation is severe in Ghana; and affect cereals and legumes [11, 12, 13, 14].

The parasitic weed *S. gesnerioides* also referred to as witch weeds in some localities and a destructive parasites as far as cowpea production is concern. The seeds of the parasites can remain dormant in the soil until a suitable host is planted. The *Striga* seeds are microscopic in size measuring 0.20mm to 0.35mm long, weighing 4 to 7µg [15]. Because of the miniature size of the seeds, they are effectively scattered by wind, water and animal. Under farming situations, the seeds can pollute harvested products. However, the major means of dispersal is through machinery, tools and clothing [9]. Each *Striga* plant can produce up to 90,000 seeds [16]. Moreover, adaptation and inactive nature of *S. gesnerioides* permit the seeds to remain dormant in the soil for quite a long time. This underground seed stock under suitable environmental conditions germinate and infest suitable growing hosts present in that field [10]. *S. gesnerioides* thrives in areas with low precipitation and poor soil fertility conditions as found in the arid and semi-arid regions. This implies that areas with water stress and low soil fertility will continue to experience *Striga* invasion.

Cowpea yield loss associated with *S. gesnerioides* have been reported to range between 83 and 100% [10]. Often, *S. gesnerioides* population of over 10/plant on a genotype can result in 100% yield loss [17]. This implies that as population keep increasing and pressure on available land continuous, and soil fertility reduces, *Striga* will multiply at a faster rate. *Striga* harm happens at different parts of cowpea plants [18] influencing the physiological and biological processes of the crop. Decreased leaf area and photosynthesis, inadequate flowering and podding with reduced seed enlargement have been reported [18].

Different control measures, including cultural practices, chemical and biological controls, and host plant resistant have been suggested [15]. Nevertheless, no single strategy seem to be fully adequate in the control of this parasite. The most effective way to control the

parasites is the use of host plant resistance, which is economically affordable to resource-poor farmers. The objective of this study therefore was to evaluate the impact of *Striga* on the off-springs of selected cowpea genotypes and also quantify the extent of damage *Striga* may have on yield components.

Materials And Methods

Experimental Site

The experiment was conducted in the screen house at CSIR-Savanna Agricultural Research Institute at Manga-Bawku in pots during 2015 and repeated in 2016 growing seasons. The study area lies latitude 11°02'60.00" N and longitude 0°13'60.00" E. and with 229 meters elevation above the sea level. It shares boundaries with Burkina Faso to the north, Republic of Togo to the east. The topography is slightly undulating with heights of 120-150 metres above sea level. Soils are generally of the savanna ochrosol type which are shallow and low in fertility. Soils in the area are mostly sandy loam, clay loam to silty loam. The area is characterized by one rainy season from May to June or September to October. There is a pronounced long dry season from November to mid-February and characterized by cold, dry dusty harmattan winds. The annual rainfall of the area is between 800-850mm and average temperatures is 32⁰c – 37⁰c. The vegetation of the area is Sahel Savanna woodland type characterized by short scattered drought resistance trees and grasses.

Experimental material and details

The two resistant varieties used were IT99K-573-1-1 and GH3684. IT99K-573-1-1 was obtained from International Institute of Tropical Agriculture, Nigeria, Ibadan while GH3684 was obtained from CSIR-Plant Genetic Research Institute, Ghana, Bunso. Two susceptible varieties (Asomdwee and Hewale) were obtained from CSIR-Crops Research Institute, Ghana, Fumesua. Direct crosses were made between the resistant genotypes and the susceptible varieties to obtain two (2) sets of F₁ progenies (IT99K-573-1-1 x Hewale and GH3684 x Asomdwee). The F₁ progenies were selfed to obtain F₂ seeds and further selfed to obtain F₃ seeds. In all eight (8) F₃ progenies and four (4) parental lines were selected for the experiment. The treatments were inoculation of pots with *Striga* seeds and no inoculation (non-infested) as control. The experimental design was Complete Randomized Design with four replications. Seeds of *Striga* were obtained from farmers' fields in the Sudan Savanna zone. The soil was sterilized using steam sterilization method to eliminate any *Striga* seeds in the soil before inoculation. Plastic pots of 23cm diameter and depth of 20cm were filled with sterile sandy soil and *Striga* seeds of 5g inoculated into each pot. Three seeds of cowpea were subsequently planted per pot and thinning was done two weeks after emergence leaving two plants per pot. The pots were kept moist by watering as and when necessary. Pre-flowering insects were controlled using Karate at the rate of 15g per hectare and against post flowering insects with 400g Cymethoate per hectare applied to control aphids, thrips, pod sucking bugs and *Maruca*.

The plant-soil mass was removed from each pot, submerged in a basin of water, and tenderly agitated to loosen soil mass. The roots were washed thoroughly free of soil and examined for attachment of *S. gesnerioides* and tubercles. Those plants that had attachment, (healthy development and emergence of *Striga*) were considered susceptible and plants that appeared free from infection, (without any *Striga* attached to the roots) were regarded as resistant genotypes. The *Striga* plants were washed and dried in a well-ventilated covered area in the screen house for five days; after which the samples were weighed.

Data collection and analysis

Data were collected on week after planting with emergence of *Striga* (WAP) and days to 50% flowering. *Striga* height (cm) was measured on 15 randomly selected plants as the distance from the soil surface to the tip of the shoot and the number of branches were counted. The *Striga* height was measured two weeks after emergence and it was subsequently measured weekly for five (5) weeks. The cowpea plants matured eight (8) weeks after planting.

The cowpea grain yield, number of pods per plant were counted on both infested and non-infested pots. Pod and seed weights were also determined. After the pods were separated, the leaves and stem were oven dried for 48 hour at 180° C to estimate fodder yield.

All field data recorded were subjected to analysis of variance (ANOVA) using GenStat Version 12. Means were compared using Least Significant Difference (LSD) at 5% level of probability. Pearson's correlation coefficient was used to compute correlation between emerged *Striga*, number of pods per plant, grain, fodder yields and other components.

The results obtained on these variables from *Striga* infested cowpea plants were compared with that from non-infested cowpea plants, as shown below.

[The formula could not be inserted here. It can be found in the supplemental files]

Results And Discussion

Decline in Cowpea Characters

The analysis of variance revealed significant differences among the genotypes ($P < 0.05$) (Table 1). *Striga* infestation significantly reduced the yields of all the susceptible genotypes. The effect of *Striga* emergence and level of invasion affected most of the traits measured (Table 1). Mean days to *Striga* emergence ranged from 35 to 48 days. The results showed that two susceptible varieties (Asomdwee and Hewale) and four of the F_3 progenies (s52, s37, s147 and s272) showed *Striga* susceptibility traits with yellowing of leaves, chlorosis, necrotic and stunted growth. The two resistant genotypes (IT99K-573-1-1 and GH3684) and four F_3 progenies (r246, r286, r282, r69) were absolutely devoid of *Striga* shoots emphasizing that these lines were resistant. Godwa et al. [19], pointed out that the response to *Striga* varied among genotypes signifying that differences exist in the ability of these plants to identify the pest and to trigger defence response mechanisms. Botanga and Timko [7], reported that inconsistency appeared to be the result of the collapse of the parasite to establish appropriate vascular connection with the host. This means that the linkage between the host and parasite must be strong for proper establishment. But if the connection fail the parasite stand the chance of been deprived of food and eventually die. In actual sense, the resistant genotypes were unsuccessful host for the parasites. This implied that resistant parasite has a defence mechanisms that fight against the parasite. The resistant genotypes have fairly good growth and development, where less assimilates are channelled to the parasite as reported by Hibbered et al. [20], and Alonge et al. [21]. This indicated that the nutrients and water were readily available for the host rather than the parasite. According to Hibbered et al. [20], final biomass accumulation by cowpea infested with *S. gesnerioides* was appreciably lesser than that of uninfected plants.

In terms of *Striga* shoots per plant the susceptible genotypes had on average 27 (emerged seedlings) while F_3 progenies had *Striga* shoots ranging from 2 to 15 per plant, indicating that some of the F_3 progenies were moderately resistant. This is not surprising because a cross between susceptible and resistant genotypes would yield an array of progenies with dominant and recessive traits. *Striga* height was significantly ($P > 0.05$) different among genotypes (Table 1). *Striga* height was higher on genotypes that had higher number of *Striga* compared to those that had fewer *Striga* emergence. Hence the productive efficiency of the genotype was very much reduced. It is reported that a vascular connection is established when *Striga* infest its host, allowing the weed to imbibe water and nutrients that are essential for its growth and development [15].

Table 1. Mean Days to *Striga* emergence, *Striga* shoot/plant, *Striga* height and *Striga* biomass of twelve Cowpea Genotypes

Reduction in harvestable yields

The study revealed a reduction in cowpea character traits (pods per plant, grain yield and fodder yield) measured on susceptible genotype. Significant differences were observed among the genotypes for number of pods per plant, grain yield (kg/ha) and fodder yield (kg/ha) (Table 2). The susceptible genotypes recorded fewer pods per plant compared with the resistant or F_3 progenies. The percentage yield reduction for the number of pods per plant for the susceptible varieties range from 45.12 to 49.53%, while F_3 progenies that were also susceptible had a yield loss ranging from 16.17 to 38.84%. The result revealed that the progenies, though susceptible had moderate susceptibility compare to the parental lines. This implies that the parasite activities on the roots reduced the efficiency of the cowpea plants. For this reason the affected plants were less able to produce adequate dry matter per pod. Press [22], pointed out that affected plants produce lower biomass due to parasite-host competition for water and carbon. The affected plants have hindered development, with reduced leaves, (leaf size) poor flowering and no pod formation. The grain yield also demonstrate a reduction in the susceptible genotype with its yield ranging between 100 and 212kg/ha, while resistant genotype had yield between 1.045 and 1.062Mt/ha and F_3 progenies moderately resistant ranged from 316 to 1050kg/ha. Yield losses were statistically significant among the susceptible, resistant and F_3 progenies (Table 2).

The grain yield loss from susceptible varieties ranged from 78.22 to 87.17%. This implies that if a farmer cultivates the susceptible variety the chances are that yield losses would be 87% to the parasite. Also under severe situations the farmer loses the entire farm to parasite infestation. Alonge et al. [21], pointed out that on susceptible cowpea, *Striga* infestation induced grain yield losses by 78.9 to 86.2%.

Fodder yield also showed significant reduction among the genotypes. The susceptible varieties suffered fodder yield loss of between 70.59 and 73.03%; indicating there will be shortage of cowpea haulm during dry seasons. Reduction in the haulm thus will lead to scarcity of fodder for animals. Hence, farmers who engage in fodder production may also experience lower income.

The pod length, 100- seed weight and number of seeds per pod had significant differences among the genotypes (Table 3). The susceptible genotypes had reduced pod length ranging from 7.40 to 8.40cm while resistant genotypes had 13 to 14cm and F₃ progenies had 10 to 13cm. *Striga* effect resulted in the reduction of pod length (ranging between 31.88 and 37.17%), 100-seed weight between 31.39 and 36.30% and number of seeds per pod between 32.29 and 37.15%. In this study, those that upheld higher number of *Striga* additionally recorded lower number of pod per plant. This suggests that the photosynthetic capacity of the cowpea plant was reduced [23]. The *Striga* had influence on the physiology and growth of cowpea thereby making it stunted in growth. The decrease in grain yield could also be due to the reduction in root nodulation and root growth and competition between the host and parasite. Therefore, *Striga* drastically reduced a number of yield components.

Table 2. Mean Pods per plant, Grain yield and Fodder yield of Cowpea response to Infection by *S. gesnerioides*

Table 3. Mean Pod length, 100 Seed weight and Number of seeds per pod of twelve Cowpea Genotypes

There were significant differences among the genotypes for days to flowering, days to maturity and plant height (Table 4). Flowering and maturity were delayed in the susceptible genotypes compared with the non-infested. The plant height also showed similar trend. The susceptible genotypes showed stunted growth with poor flowering or no flowering. The delay in flowering drastically reduce the number of pods which eventually reduce the number of seeds per cowpea plant. Under severe infestation some plants failed to make any significant investment in flowering and died as a result of parasitism.

Table 4. Mean Days to Flowering, Days to Maturity and Plant Height of twelve Cowpea Genotypes

The T-test comparison of infected and non-infected showed significant differences among the various parameters measured on cowpea plant (Table 5). The results of the T-value showed significant difference for grain yield, fodder yield, number of pods/plant and number of seeds/pod between infected and non-infected cowpea genotypes. In contract non-significant difference of pod length and 100 seed weight were recorded between infected and non-infected genotypes. Nevertheless, the means of the non-infected genotypes for pod length and 100 seed weight were higher than the infected genotypes.

Table 5. T-test Comparison of Yield Components of Infected and Non-infected Cowpea Varieties

The correlation coefficients among most of the parameters were negative and highly significant (Table 6). There were significant correlations found among percentage yield reduction and percentage reduction in various yield components. There was a strong negative correlation ($r = -0.625$) between number of pods per plant and days to *Striga* emergence.

The number of pods per plant, 100 seed weight, grains and fodder yields were highly negatively correlated with number of emerged *Striga* shoot indicating that as the number of emerge *Striga* shoot increases the other components keep decreasing. Moreover, the drastic reduction of these parameters may be due to inadequate nitrogen and nutrient absorption for vegetative growth. The results further revealed that *Striga* was solely responsible for overall yield reduction in the various components. The result showed that the early emergence of *Striga* attached to the host root drastically affects the physiological and morphological growth of the host plant thereby reducing its efficiency to produce. According to Singh and Emebeche [24], the extent of yield reduction depends upon the time and level of infection.

Table 6. Correlation Coefficients between Parameters measured and its Components caused by *S. gesnerioides*

Conclusion

The study has revealed significant impact on *Striga gesnerioides* infestation on cowpea yield and yield components. Breeding of *Striga* resistant varieties for farmers could be the only solution for improving farmers' livelihoods. This gives a clue to famers on the need to cultivate *Striga* resistant cowpea varieties. The study had revealed some F₃ genotypes that are resistant to *Striga gesnerioides* under artificial infestation in pot. These genotypes had high genotypic variation for resistance to the *Striga* strains and therefore such genotypes provide opportunity for genetic improvement through selection.

Declarations

Ethics approval and consent to participate 'Not applicable'

Consent for publication 'Not applicable'

Availability of data and material 'Not applicable'

Competing interests 'Not applicable'

Funding 'Not applicable'

Authors Contributions

The corresponding author RA was the main supervisor reviewed the write-up for technical content; SA reviewed literature and also helped with data analysis; JYA search literature, experimental design and data analysis; FK helped in the field establishment and data collection and RP helped with data entry and analysis.

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Tables

Table 1. Mean Days to *Striga* emergence, *Striga* shoot/plant, *Striga* height and *Striga* biomass of twelve Cowpea Genotypes

Genotype	Days to <i>Striga</i> emergence	<i>Striga</i> shoots/plant	<i>Striga</i> height (cm)	<i>Striga</i> biomass (g)
Asomdwee	42.75a	27.75a	12.50a	7.57a
Hewale	42.25a	27.00a	11.00a	7.60a
GH3684	0.00b	0.00b	0.00b	0.00b
IT99K-573-1-1	0.00b	0.00b	0.00b	0.00b
F ₃ (s52)	35.25a	15.50a	13.25a	5.65a
F ₃ (s37)	35.25a	15.25a	13.75a	0.92a
F ₃ (r246)	0.00b	0.00b	0.00b	0.00b
F ₃ (r286)	0.00b	0.00b	0.00b	0.00b
F ₃ (s147)	41.50a	2.50a	7.75a	1.93a
F ₃ (s272)	47.75a	11.50a	11.25a	4.83a
F ₃ (r282)	0.00b	0.00b	0.00b	0.00b
F ₃ (r69)	0.00b	0.00b	0.00b	0.00b
Mean	20.7	8.29	5.79	2.38
CV(%)	10.27	8.566	3.224	1.164
LSD	25.7	30.1	15.6	34.0

Means followed by the same letter in each column are not significantly different (P> 0.05).

Table 2. Mean Pods per plant, Grain yield and Fodder yield of Cowpea response to Infection by *S. gesnerioides*

Genotypes	Pods/plant		Loss (%)	Grain yield (kg/ha)			Fodder yield (kg/ha)		
	Infested	Not Infested		Infested	Not Infested	Loss (%)	Infested	Not Infested	Loss (%)
Asomdwee	3.25d	6.00a	45.12a	212.5c	979b	78.22a	254.2c	892b	70.59a
Hewale	2.25d	4.75a	49.53a	100.0c	913b	87.17a	275.0c	1488a	73.03a
GH3684	5.50b	5.25a	4.17b	1045.8a	1258a	16.13c	1470.8a	1483a	27.58b
IT99K-573-1-1	6.25b	6.50a	16.91b	1062.5a	1017a	5.32c	1041.7b	1183a	32.93b
F ₃ (s52)	4.25cd	6.60a	29.60a	425.0c	925b	48.83b	458.3c	900a	69.04a
F ₃ (s37)	6.75a	7.00a	16.17b	966.7a	1104a	11.53c	1208b	1521a	45.95a
F ₃ (r246)	7.50a	6.00a	18.75b	1050.0a	1004b	9.41c	1841.7a	1733a	17.10b
F ₃ (r286)	7.00a	6.25a	26.34ab	1016.7a	1058a	1.08c	1091.7b	1008b	43.17b
F ₃ (s147)	5.50b	6.75a	29.11a	870.8bc	1113a	20.88c	787.5bc	1029ab	23.4b
F ₃ (s272)	4.25cd	7.25a	38.84 a	316.7c	879b	62.99ab	475.0c	1008b	44.41ab
F ₃ (r282)	6.00b	6.50a	13.84b	950.0a	1021a	13.99c	1137.5b	1404a	26.74b
F ₃ (r69)	6.75a	7.00a	3.57b	1016.7a	1021a	10.60c	1094.7b	1250a	35.94b
Mean	5.44	6.31		753	1024		928	1242	
CV(%)	15.7	20.9		17.4	17.1		44.9	36.9	
LSD	1.227	1.899		187.9	251.7		599.1	659.8	

Means followed by the same letter in each column are not significant different (P>0.05) using LSD

Table 3. Mean Pod length, 100 Seed weight and Number of seeds per pod of twelve Cowpea Genotypes

Genotypes	Pod Length (cm)			100 Seed Weight (g)			Number of seeds/pod		
	Infested	Not infested	Loss (%)	Infested	Not infested	Loss (%)	Infested	Not infested	Loss (%)
Asomdwee	8.40d	12.40b	31.88a	9.38d	14.40a	31.39a	6.50b	10.00a	32.29a
Hewale	7.40d	11.90b	37.17a	6.97e	11.10b	36.30a	5.50c	8.75b	37.15a
GH3684	13.9a	15.47a	7.78b	11.80c	13.22a	9.69b	11.00a	12.00a	20.17a
IT99K-573-1-1	14.87a	13.27a	5.29b	15.15a	14.92a	4.10b	8.00b	7.75b	18.68a
F ₃ (s52)	10.35c	10.80b	0.71b	9.72d	11.20b	10.84b	8.50b	10.75a	18.37a
F ₃ (s37)	11.60b	11.05b	7.33b	11.05cd	13.22ab	16.22ab	9.25ab	10.25a	7.53b
F ₃ (r246)	12.50b	11.22b	5.29b	11.67c	10.92b	8.71b	9.25ab	9.75ab	3.61b
F ₃ (r286)	11.07c	12.72b	11.55ab	12.25bc	11.65b	5.58b	10.50a	11.75a	13.05ab
F ₃ (s147)	11.30bc	12.20b	5.71b	12.20c	12.17b	6.20b	8.00b	9.75ab	16.92a
F ₃ (s272)	10.75c	11.27b	3.01b	9.22de	12.50b	26.17a	6.25bc	8.50b	25.16a
F ₃ (r282)	13.05b	13.15a	0.64b	14.62a	15.52a	19.95a	6.25bc	7.7b	17.71a
F ₃ (r69)	13.85ab	13.05a	7.87b	14.82a	15.82a	4.82b	7.50b	7.25b	7.29b
Mean	11.59	12.38		11.57	13.06		8.04	9.52	
CV(%)	11.1	14.7		12.9	16.0		20.0	19.6	
LSD	1.850	2.616		2.146	3.003		2.319	2.686	

Means followed by the same letter in each column are not significantly different (P>0.05) using LSD

Table 4. Mean Days to Flowering, Days to Maturity and Plant Height of twelve Cowpea Genotypes

Genotype	Days to Flowering		Days to Maturity		Plant Height (cm)	
	Infested	Not Infested	Infested	Not Infested	Infested	Not Infested
Asomdwee	57.50a	51.25ab	81.50a	66.25b	19.8c	31.50a
Hewale	52.00bc	45.00cd	66.25b	58.50d	18.38c	23.75c
GH3684	53.00b	52.50a	64.25 b	66.75ab	31.7a	31.12a
IT99K-573-1-1	46.75d	44.25d	63.50bc	60.00c	24.38b	27.75b
F ₃ (s52)	52.25b	47.75b	65.00b	63.75bc	23.62b	26.75bc
F ₃ (s37)	51.75c	46.50c	66.75b	62.00c	23.12b	24.12c
F ₃ (r246)	54.00b	52.25a	67.25b	69.50a	29.88ab	32.38a
F ₃ (r286)	51.50c	49.75b	64.75b	61.00c	23.50b	24.12c
F ₃ (s147)	53.75b	48.25b	60.75c	60.00c	24.50b	32.12a
F ₃ (s272)	55.25ab	47.50bc	67.00b	58.75d	16.12d	18.62d
F ₃ (r282)	48.00d	48.25b	61.00c	59.75cd	18.38c	18.88d
F ₃ (r69)	50.00cd	47.00c	62.50c	60.00 c	26.38b	23.75c
Mean	52.15	48.35	65.88	62.19	23.32	26.24
CV(%)	3.0	3.4	5.0	3.1	9.4	7.1
LSD	2.214	2.394	4.739	2.800	3.153	2.697

Means followed by the same letter in each column are not significantly different (P>0.05) using LSD

Table 5. T-test Comparison of Yield Components of Infected and Non-infected Cowpea Varieties

Parameters	Mean $\pm$ SE	Confidence Interval	T-value
Grain Yield	274.30 $\pm$ 89.03	78.34 - 470.26	2.97*
Fodder Yield	313.54 $\pm$ 106.47	81.47 - 545.86	3.08*
No of seeds/pod	1.48 $\pm$ 0.35	0.71 - 2.24	4.26*
No of pods/plant	0.94 $\pm$ 0.43	-0.01 - 1.89	2.17*
Pod length (cm)	0.79 $\pm$ 0.55	-0.43 - 2.00	1.43 ^{ns}
100 Seed weight (g)	1.57 $\pm$ 0.52	0.41 - 2.72	2.99 ^{ns}

* Significant at 0.05% levels of probability, ns= not significant

Table 6. Correlation Coefficients between Parameters measured and its Components caused by *S. gesnerioides*

	<i>Days to Striga emergence</i>	<i>Fodder yield kg/ha</i>	<i>Grain yield kg/ha</i>	<i>No. of pods/plant</i>	<i>No. of seed /pod</i>	<i>Pod Length (cm)</i>	<i>Striga height (cm)</i>	<i>Striga shoot/plant</i>	<i>100 seed weight (kg)</i>
r yield	-0.5639**								
l yield	-0.7237**	0.6483**							
f plant	-0.6257**	0.6337**	0.8428 ^{ns}						
seed	-0.336*	0.2969*	0.4687 ^{ns}	0.4537 ^{ns}					
length	-0.6402**	0.5268**	0.7425**	0.608**	0.4492**				
height	0.8729**	-0.5502**	-0.6898**	-0.5834**	-0.2871*	-0.645**			
	0.6492**	-0.5616**	-0.7619**	-0.6975**	-0.3781**	-0.712**	0.7942**		
plant seed t kg	-0.7342**	0.4263**	0.7325**	0.6593**	0.2185 ^{ns}	0.6894**	-0.7119**	-0.7209**	
ss (g)	0.749**	-0.6846**	-0.9247**	-0.7975**	-0.4749**	-0.7804**	0.7174**	0.8089**	-0.7444**

*Significant at 5% level of probability, **Significant at 1% level of probability, ns=not significant

Figures

Figure 1

Height of Striga and host plants across five weeks after planting

Supplementary Files

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- [Formula.JPG](#)