Original Research Article

Agronomic Performance of Improved Cowpea Varieties under Natural Infestation with *Alectra vogelii* (Benth.) in the Northern Guinea Savannah of Nigeria

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Abstract

Field trials were conducted over three years at Samaru in the northern Guinea savannah ecological zone of Nigeria to evaluate the performance of 20 improved cowpea varieties under conditions of natural infestation by a parasitic weed, *Alectra vogelii* (Benth.). Grain yield ranged from 695 to 2043 kg ha⁻¹. The best yielding varieties were IT95K-1072-57 and IT97K-499-35. These varieties also hosted very low number of *Alectra* shoots, suggesting that they are resistant to it. In addition to high grain yield, both varieties produced high fodder yield, making them to be dual purpose varieties. They are therefore ideal for the semi-arid zone where livestock production is an integral part of the farming system and *Alectra* is a major constraint to the attainment of high cowpea yield. *Alectra* did not emerge on two of the varieties (IT95K-1090-12 and IT97K-818-35), indicating that they are highly resistant to the weed, but these varieties were among the poorest yielders. They may, however, be good sources of *Alectra* resistance in cowpea breeding programmes. Four varieties, IT95K-1380, IT93K-273-2-1, IT95K-222-5 and IT93K-573-5 supported high number of *Alectra* shoots and were therefore highly susceptible to its parasitism.

Key words: *Vigna unguiculata*; yellow witchweed; parasitic weeds; grain and fodder yields; yield components.

INTRODUCTION

Cowpea (*Vigna unguiculata* [L.] Walp) is the most important food legume and a major component of the cropping system of the dry savannas of West and Central Africa. Its grains which are rich in protein (23-25%) provide inexpensive source of protein for the people of this region. Cowpea also serves as a source of livestock feed, cash and soil ameliorant and thus contributes to food security, income generation and maintenance of the environment for a large number of resource-poor farmers.

Estimated worldwide production of cowpea grain in 2007 was 5.4 million tonnes from 11.3 million hectares out of which Nigeria produced 3.15 million tonnes of grain from about 4.5 million hectares, representing 58.3% of the world production (FAOSTAT, 2009). Nigeria, which is the highest world producer also, has the highest level of consumption and the domestic supply of cowpea far outstrips the demand leading to a deficit which is largely met by importation from neighbouring countries (Coulibaly and Lowenberg-DeBoer, 2002).

Even though FAO database estimated average cowpea grain production in Nigeria as 700 kg ha⁻¹ (FAOSTAT, 2009), actual yield on farmers' fields in northern Nigeria, where the bulk of the production takes place, ranged from 0 to 132 kg ha⁻¹ (van Ek et al., 1997). The low cowpea yield has been attributed to numerous abiotic and biotic constraints of

which the two parasitic weeds, *Striga gesnerioides* (Wild.) Vatke and *Alectra vogelii* (Benth.) are among the major ones. *Alectra* is more prevalent in the northern Guinea and southern part of Sudan savannah whereas *Striga* is more widespread in Sudan savannah and Sahelian zones (Singh et al., 1993). Total yield loss is not uncommon in fields heavily infested by these parasites when susceptible cowpea varieties are planted (Emechebe et al., 1983).

Grain yield reduction caused by *Alectra* infestation has been attributed to reduced root nodulation, shoot-root ratio and leaf area (Alonge et al., 2001a). Other research showed that *Alectra* infestation caused delayed onset of flowering and reduced number of flowers (Mugabe, 1983) as well as reduced number of pods per plant, individual seed weight and grain total soluble carbohydrate (Alonge et al., 2001b). Fields infested by *Alectra* are difficult to clean up due to a large production of viable seeds (over 50,000 per plant) which can remain dormant in the soil for several years (Singh and Emechebe, 1997). Moreover, up to 75% of the crop damage is done before the emergence of the parasite from the ground, making the control of the parasite more difficult (Singh, 2002), particularly for resource-poor farmers who could not afford the high cost of external inputs. Thus, the most economical and environmentally friendly way of controlling this parasitic weed would be through host-plant resistance.

The traditional cowpea varieties, which are still widely grown in northern Nigeria and virtually all the popular improved varieties, are susceptible to both *Striga* and *Alectra*. However, over the years concerted efforts have been made to develop improved cowpea varieties with combined resistance to the two parasitic weeds (Singh, 2002; Singh et al., 2006). The objective of this study was to evaluate the performance of some of the improved cowpea varieties for grain yield and their reaction to natural field infection by *Alectra* at a location in the northern Guinea savannah of Nigeria where this parasite is prevalent.

MATERIALS AND METHODS

Field trials were conducted during the 2000-2002 wet seasons at the Institute for Agricultural Research experimental farm at Samaru (11°11'N 07°38'E, 686 m above sea level), Nigeria on a well-drained leached ferruginous tropical sandy loam. Samaru is in the northern Guinea savannah with a mean annual rainfall of 1011 mm concentrated almost entirely in the five months of May to September. The physico-chemical analysis of the top soil (0-15 cm depth) of the experimental site as determined by standard procedures showed that the soil was loam with the following properties: pH (0.001 CaCl₂), 5.5; Org C, 1.28 g kg⁻¹; Total N, 0.11 g kg⁻¹; available P (Bray 1-P), 8.75 mg kg⁻¹; and exchangeable cations (cmol₊ kg⁻¹) of Mg²⁺, 0.32; Ca²⁺, 0.98; and K⁺, 0.14.

Twenty newly-developed cowpea varieties were used. Seeds of 19 of the varieties were supplied by the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria and one by the Obafemi Awolowo University, Ile-Ife, Nigeria. The trials were planted on 5, 7 and 6 August in 2000, 2001 and 2002, respectively. Individual plots were 3.0 m × 4.0 m, made up of four ridges 4 m long and spaced 75 cm apart. Three seeds were planted at intra-row spacing of 25 cm and then thinned to two plants /stand at two weeks after planting (WAP) to give a final plant population of 106,666 plants ha⁻¹. The experimental design was randomised complete block with four replications. All plots received a basal dressing of 16 kg P ha⁻¹ as single super phosphate (18% P₂O₅). Immediately after planting the pre-emergence herbicide Igran combi (metolachlor + terbutryne) was applied at the rate of 2.0 kg a.i. ha⁻¹ to control weeds. Supplementary hoe weeding was done at 6 WAP. Insect pests (thrips (*Megalurothrips sjostedti* Tryb.), pod borers (*Maruca vitrata* Fab.) and pod and seed suckers (*Clavigralla tomentosicollis* Stal.) and diseases (*Sphaceloma* scab, brown blotch (*Colletotrichum capsici* Syd.) were controlled by four applications of a mixture of the insecticide, Uppercott (30 g L⁻¹ cypermethrin + 250 g L⁻¹ dimethoate) at 1.0 L ha⁻¹ and fungicide, benomyl at

0.6 kg ha⁻¹ at fortnightly intervals using a Knapsack sprayer, beginning from floral bud formation stage.

The number of emerged *Alectra* in the two centre rows of each plot (6.0 m²) was counted at 9 WAP. Days to 50% flowering and maturity were recorded. The grain yield was determined at maturity from the entire length of two centre rows (6.0 m²) of each plot. Dry fodder yield was also determined from the two centre rows in 2002. Four plants were sampled from each plot at maturity for the estimation of yield components. Data were subjected to analysis of variance. Where the F-ratio was found to be significant, treatment means were separated using Duncan multiple range test (DMRT) at 5% level of probability. Correlation coefficient analysis was carried out on some of the parameters to determine the association between them.

RESULTS

The amount of rainfall received during the crop's growth period is presented in Table 1. The highest precipitation was received in 2001 but this was concentrated in the two months of August and September. In contrast, the least precipitation received in 2000 was relatively evenly distributed between August and October. The effects of year, variety and year × variety interaction were significant for all variables in the combined analysis, with the exception of the number of seeds/pod and 100-grain weight where year × variety was not significant (Table 2).

Table 1: Rainfall data recorded at Samaru, Nigeria during the crop's growth in 2000-2002.

Month	Rainfall (mm)		
	2000	2001	2002
August	245.2	360.9	201.4
September	182.1	271.7	218.8
October	78.2	0	125.2
November	0	0	0
Total	505.5	632.8	545.4

Average grain yield ranged from 695 kg ha⁻¹ for IT97K-819-132 to 2043 kg ha⁻¹ for IT95K-1072-57 (Table 3). The 20 varieties tested can be divided into three groups based on their yield performance. The first group consists of IT95K-1072-57 and IT97K-499-35, which yielded significantly higher than the other varieties. The second group comprises the 15 varieties that produced intermediate yield (1055 to 1349 kg ha⁻¹) while the third group is made up of the three lowest yielding (< 800 kg ha⁻¹) varieties (IT97K-819-132, IT97K-818-35 and IT95K-1380). Grain yield data for individual years indicated that IT95K-1072-57 and IT97K-499-35 were the top yielding

Table 2: Mean square values showing the effect of year, cowpea variety and their interaction on some agronomic characters and severity of *Alectra* infestation on cowpea at Samaru, Nigeria

Source of variation	Days to 50% flowering	Days to maturity	Pods/ plant	Seeds/ pod	100-seed wt. (g)	Grain yield (kg ha ⁻¹)	Emerged <i>Alectra</i>
Year	155.40***	359.95***	1701.91***	39.92***	7.82*	2166545.02***	9718.20***
Variety	18.67***	97.13***	61.65**	10.60***	47.84***	1150656.45***	2617.09***
Year x Variety	3.99***	34.74***	46.46*	3.19	2.20	220418.57***	1578.48***
Error	1.90	9.74	31.79	4.41	2.05	110387.19	278.77

*, **, *** indicate significance at the 0.05, 0.01 and 0.001 probability levels, respectively

varieties in each year (rank of 1 or 2) while IT95K-1380 and IT97K-819-132 consistently had the lowest yields (data not presented). On the other hand, the ranking of most of the other varieties varied widely between years, resulting in significant year × variety interaction.

Days to flowering and maturity varied from 44.0 to 50.5 and 77.1 to 87.7 days from sowing, respectively (Table 3). Variety IT93K-452-1 was the earliest to flower and mature. The late flowering and maturing varieties include IT97K-568-19, IT97K-820-18, LDP10-OBLI and IT-90K-277-2. With regards to yield components, number of pods/plant ranged from 10.2 to 19.9 for IT97K-819-132 and IT93K-273-2-1, respectively (Table 3). Variety IT97K-819-132 also produced the lowest number of

seeds/pod while IT95K-1072-57 had the highest. Average 100-grain weight ranged from 10.8 g for IT93K-273-2-1 to 18.7 g for IT95K-1072-57. Thus, IT95K-1072-57 had the highest number of seeds/pod and 100-grain weight.

Alectra shoot did not emerge on two of the varieties, IT95K-1090-12 and IT97K-818-35 but these varieties were among the poorest yielders (Table 3). Four of the varieties (IT97K-820-18, IT97K-499-35, IT97K-819-132 and IT95K-1072-57), out of which two were the highest yielding varieties, had very low number (< 1.0) of emerged *Alectra* making them resistant. The other varieties could be considered susceptible to *Alectra* but IT95K-1380, IT93K-273-2-1, IT95K-222-5 and IT93K-573-5 in that order were most susceptible.

Table 3: Grain yield and some agronomic characters of improved cowpea varieties evaluated at Samaru, Nigeria (2000-2002 combined data)

Variety	Grain yield (kg ha ⁻¹)	Pods/ plant	Seeds/pod	100-grain wt. (g)	Days to 50% flowering	Days to maturity	Number of <i>Alectra</i> shoots	Dry fodder yield (kg ha ⁻¹) [*]
IT97K-499-35	1793a	15.6ab	10.1a-c	15.6d-f	47.4c-e	81.0d-g	0.3d	2667bc
IT95K-1072-57	2043a	15.5a-c	11.2a	18.7a	47.9cd	82.5c-f	0.9d	3166ab
IT93K-273-2-1	1119b	19.9a	9.8a-c	10.8h	47.2c-e	83.0b-e	46.7a	1750de
IT95K-222-5	1222b	14.9a-c	9.0bc	17.2bc	47.7c-e	79.6f-i	28.4b	1666de
IT95K-1090-12	1097b	15.3a-c	10.7ab	15.1ef	46.6de	77.7hi	0d	1541de
IT95K-2011-11	1263b	13.7bc	9.0bc	16.7cd	46.5e	81.2d-g	9.4cd	1625de
IT95K-1380	768c	16.6ab	9.3a-c	11.5h	46.9de	80.4e-h	47.7a	1750de
IT93K-452-1	1289b	18.4ab	9.1bc	15.1ef	44.0f	77.1i	11.0cd	1458e
IT95K-181-9	1149b	18.7ab	9.4a-c	13.5g	47.5c-e	81.7d-g	18.4bc	1791de
IT97K-568-19	1166b	19.2ab	9.5a-c	14.9ef	50.5a	85.2a-c	4.5cd	2083c-e
IT95K-222-3	1180b	14.9a-c	10.6ab	18.1ab	47.6c-e	79.5g-i	8.2cd	1833de
IT97K-820-18	1210b	15.9ab	8.8bc	16.8cd	47.0c-e	85.3a-c	0.2d	1708de
IT89KD-391	1048b	15.9ab	8.7bc	16.8cd	47.5c-e	81.7d-g	3.1cd	2041c-e
IT93K-573-5	1203b	16.5ab	8.8bc	16.8cd	46.7de	82.7c-e	27.6b	3457a
IT95K-238-3	1091b	13.7bc	9.0bc	15.8d-f	47.2c-e	79.6f-i	10.4cd	1750de
IT93KZ-8-21-23-3	1055b	16.0ab	9.1bc	13.1g	46.7de	83.7b-d	4.5cd	1916de
IT97K-818-35	753c	14.6a-c	8.4cd	16.1c-e	48.2bc	77.6hi	0d	1583de
LDP10-OBL1	1349b	18.8ab	10.1a-c	15.8d-f	46.8de	87.7a	12.7cd	1875de
IT97K-819-132	695c	10.2c	6.9d	14.7f	46.7de	81.4d-g	0.6d	1833de
IT90K-277-2	1080b	14.8a-c	9.7a-c	15.6d-f	49.3b	85.6ab	3.2cd	2291bc
Mean	1179	16.0	9.4	15.4	47.3	81.7	11.9	1989
SEM	95.9	1.63	0.61	0.41	0.40	0.90	4.82	222.6

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using DMRT

^{*}Values for 2002

Mean value of dry fodder yield recorded in 2002 was 1989 kg ha⁻¹ with a range of 1458 kg ha⁻¹ for IT93K-452-1 and 3457 kg ha⁻¹ for IT93K-573-5 (Table 3). Other varieties that produced more than 2.0 tonnes of fodder per hectare include IT95K-1072-57, IT97K-499-35, IT90K-277-2, IT97K-568-19 and IT89KD-391.

A comparison of the years showed that average grain yield was higher in 2000 than the succeeding two years that were at par (Table 4). Higher number of pods/plant was recorded in 2000 compared with the succeeding two years whereas reverse was the case for number of seeds/pod. Mean 100-grain weight was lower in 2002 compared with 2001. The plants flowered earlier in 2000 compared with 2002, which in turn was earlier than 2001. However, the crop matured earlier in 2002 than the preceding two years. The lowest number of emerged *Alectra* was recorded in 2000 and the highest in 2001.

Table 4: Effect of year on the agronomic performance of improved cowpea varieties at Samaru, Nigeria.

Character	2000	2001	2002	Mean	SEM
Grain yield (kg ha ⁻¹)	1362a	1130b	1044b	1179	37.15
Pods/plant	21.3a	13.8b	12.8b	16.0	0.63
Seeds/pod	8.5b	9.8a	9.7a	9.4	0.23
100-grain wt. (g)	15.52b	15.7a	15.1b	15.4	0.16
Days to 50% flowering	46.1c	48.8a	46.9b	47.3	0.15
Days to maturity	84.0a	81.2b	79.9c	81.7	0.35
Number of <i>Alectra</i> shoots	2.6c	24.0a	9.1b	11.9	1.87

Means followed by the same letter in a row are not significantly different at 5% level of probability using DMRT.

The combined data indicated a significant negative correlation between grain yield and the number of emerged *Alectra* while the relationship between grain yield and the yield components was significantly positive (Table 5). The number of emerged *Alectra* was also significantly negatively correlated with the number of pods per plant and 100-seed weight in the combined analysis.

Table 5: Coefficient of correlation of cowpea grain yield, number of emerged *Alectra* shoots and yield components at Samaru, Nigeria

Variable	R	p-value
Grain yield vs. Pods/plant	0.280	< .0001
Grain yield vs. Seeds/pod	0.137	0.0344
Grain yield vs. 100-grain wt.	0.278	< .0001
Grain yield vs. Number of <i>Alectra</i> shoots	-0.277	< .0001
Number of <i>Alectra</i> shoots vs. Pods/plant	-0.129	0.0467
Number of <i>Alectra</i> shoots vs. Seeds/pod	0.082	0.2069
Number of <i>Alectra</i> shoots vs. 100-grain wt.	-0.267	< .0001

DISCUSSION

This three-year field study has revealed differential response of improved cowpea varieties to *Alectra* infection under natural conditions at a site in the northern Guinea savannah where this parasite is widespread. Two of the varieties, IT95K-1090-12, IT97K-818-35 consistently had no emerged *Alectra* and therefore appeared to be immune to this parasite. Singh (2002) had previously listed IT95K-1090-12 among the most promising cowpea varieties with combined resistance to *Striga* and *Alectra*. However, the present data showed that the two varieties that were highly resistant to *Alectra* were among the lowest yielders, indicating that the performance of varieties could be more affected by their inherent low yield potential rather than by *Alectra*. On the other hand the two best yielding varieties, IT95K-1072-57 and IT97K-499-35 supported very low number of *Alectra*, indicating that they are resistant to *Alectra*. Moreover, cowpea grain yield was significantly negatively correlated ($r = -0.28^{***}$, $n = 240$) with the number of *Alectra* shoots at 9 WAS, an indication that cowpea yields were depressed by *Alectra* in susceptible varieties.

The grain yield of most of the varieties, ranging between 1000 and 2000 kg ha⁻¹ was lower than a yield potential of 1500 to 2500 kg ha⁻¹ reported for *Striga/Alectra* resistant cowpea lines by Singh (2002) in a more productive environment in the Sudan savannah of Nigeria. Cowpea is a warm weather crop which thrives best in the dry savannas where temperatures range from 20 °C to 35 °C. The northern Guinea savannah where the present study was conducted is considered rather wet for the crop. Apart from insect pests and *Alectra*, the potential of cowpea in this environment is limited by diseases, especially *Sphaceloma* scab and brown blotch which are induced by the hot and humid weather (Emechebe and Lagoke, 2002). The better yield performance of cowpea in 2000 compared to the succeeding two years could therefore be attributed to lower amount of rainfall received in 2000, particularly in the month of September. The 2000 precipitation was adequate and more evenly distributed than the succeeding two years. Another contributing factor to greater yield obtained in 2000 was a higher number of pods per plant probably resulting from lower incidence of *Alectra*, which has been reported to reduce grain yield mainly by its adverse effect on the number of pods per plant than the other yield components (Alonge et al., 2001b).

The two cowpea varieties, IT95K-1072-57 and IT97K-499-35 that gave the highest grain yield also supported a low number of emerged *Alectra*, suggesting that they are resistant to *Alectra*. The grain yields of these varieties were stable over the years despite the fact that different part of the field was used in each year. In field trials conducted at two locations in northeastern Nigeria, Kamara

et al. (2008) found that IT97K-499-35 was also resistant to *Striga*. These findings therefore confirm earlier report by Singh et al. (2006) that this variety has combined resistance to *Striga* and *Alectra*. In addition to high grain yield and *Alectra* resistance, both IT95K-1072-57 and IT97K-499-35 produced high fodder yields in the present study, indicating that they are dual purpose varieties. In the Nigerian dry savannah crop and livestock farming are integrated and some cowpea varieties are planted purposely for fodder production to take care of animal feed during the dry season thus producing little or no grain while other varieties are mainly grown for grains. The dual purpose characteristic of IT95K-1072-57 and IT97K-499-35 stand them out as the most ideal varieties for this zone where livestock production is an integral part of the farming system as cowpea is a major source of nutritious fodder for livestock and protein for humans. According to Ntare (1990) an appropriate cowpea cultivar for the dry savannah would be the one that yields both grain and fodder.

Results of this study revealed that some cowpea varieties are resistant to *Alectra*. Even though the two varieties, IT95K-1090-12, IT97K-818-35 that appeared to be immune to *Alectra* have poor grain yield potential, they may be suitable candidates for use to improve the genetic base of existing cultivars and the varieties that are being developed for *Alectra* resistance. The two cowpea varieties, IT95K-1072-57 and IT97K-499-35 that combined *Alectra* resistance with high grain and fodder yield could be considered for cultivation in the northern Guinea savannah zone and other areas where *Alectra* is endemic.

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