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Response of Cowpea (*Vigna unguiculata* L.) Genotypes to Wicth Weed (*Alectra vogelii* Benth) Infection

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Abstract

A greenhouse pot experiment was conducted at the University of Zimbabwe to screen six cowpea varieties for resistance to *Alectra vogelii* infection. Emergence of *A. vogelii* was first detected 55 days after crop emergence. *A. vogelii* emergence was not significantly ($P > 0.05$) influenced by cowpea genotype. No differences ($P > 0.05$) in cowpea parameters that were measured were observed among the cowpea genotypes. However, *A. vogelii* infection significantly ($P < 0.05$) reduced cowpea shoot biomass and pod number by 57 % and 98 %, respectively. Infected cowpeas failed to produce any pods at all with the exception of cowpea cultivar C/83/4/6 and C/85/6/4. A similar trend of results was observed with grain yield. Root biomass was not significantly influenced by *A. vogelii* infection. *A. vogelii* infected cowpeas had significantly ($P < 0.05$) higher root /shoot ratio compared to uninfected plants. Based on results on *A. vogelii* emergence and cowpea parameters collected in this study, it can be concluded that all the cowpea genotypes evaluated are susceptible to *A. vogelii* infection. However, it can also be concluded that the two pre-released varieties C/83/4/6 and C/85/6/4 are moderately susceptible because they were able to produce grain and should therefore be further evaluated under field conditions.

Keywords: *Alectra vogelii*, Cowpea, resistance, Zimbabwe

Introduction

Cowpea (*Vigna unguiculata* L) is an important subsistence crop that is grown for food and also as a green manure cover crop (GMCC) to improve soil fertility in Conservation Agriculture (CA) systems in Zimbabwe and other African countries. In Zimbabwe, cowpea food includes tender green leaves (munyemba), boiled and then dried (mufushwa) as relish, green peas (mukove), boiled dry grain (mutakura) and seed paste (rupiza) (Rambakudzibga, 2000). Like other cultivated crops, cowpea production is affected by several biotic and abiotic factors which include poor nutrition, pests, diseases, weeds and nematodes. Amongst these factors, the obligate parasitic flowering plants, *Striga gesnerioides* and *Alectra vogelii* are regarded as the most common yield reducers in cowpea production. *A. vogelii* is more prevalent in East and Southern African countries while *S. gesnerioides* is mostly found in West and Central Africa (Parker and Riches, 1993).

In some areas, *A. vogelii* has been found growing simultaneously with *Striga asiatica*, an important parasitic weed of cereals (Hussien *et al.*, 2006; Kabambe *et al.*, 2008).

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Visser (1978) reported that a single plant of *A. vogelii* is capable of producing between 400 000 and 600 000 viable seeds per plant. This enormous reproductive capacity and persistence of their seeds which can be found in the soil even after 15 years makes it very difficult to manage this weed in one or two seasons using the currently available *A. vogelii* control strategies. Monoculture of susceptible cowpea varieties and other hosts of *A. vogelii* together with failure by farmers to recognise the importance of controlling *A. vogelii* before it flowers has resulted in the increase of the *A. vogelii* seed bank in the smallholder sector in Zimbabwe. Yield losses of 80 % have been reported in Botswana (Karanja *et al.,* 2011), up to 50 % in Tanzania (Mbwaga, 2000), 41-69 % (Lagoke *et al.,* 1993) and total crop loss in Kenya (Babnall-Oakley *et al.,* 1991).

Apart from cowpea, A vogelii has also been identified as a major growth and yield reducing parasite in other crops like bambara, soyabeans, pigeon peas, common beans and groundnuts (Rambakudzibga, 2000).

Currently the recommended *A. vogelii* preventive control methods have not been very effective and have therefore not been widely adopted. These include, rouging emerged *A. vogelii* plants before they flower, and burning them in a pit, as well as avoiding contamination of grain at harvesting especially where farmer do not use certified cowpea seed as planting material (Kabambe *et al.,* 2002). Cultural control methods for *A. vogelii* control include the use of trap crops and catch crops. Catch crops are host plants that are grown to stimulate germination of parasitic weeds but they are destroyed before flowering of the parasite and harvesting of the crop.

Catch crops are effective in reducing the seed bank but have not been effective as a viable control option to subsistence farmers who consider it as a wasteful strategy. Catch cropping has also proven to be ineffective because small *A. vogelii* infestations are capable of causing significant yield reduction since catch cropping is not able to deplete all the seed reserves in the soil within a short period of time (one or two seasons). On the other hand, trap crops are non-host crops that are able to stimulate *A. vogelii* emergence but cannot support the attachment and growth of the parasite on the host. Important trap crops for *A. vogelii* management include cereals like, maize (*Zea mays* L.), Sorghum (*Sorghum bicolor* [L.] Moench), pearl millet (*Pennisetum glaucum* [L.] R. Br), cotton (*Gossypium hirsutum* L.), sunflower (*Helianthus annus* L.), dolichos beans (*Lablab purpureus*) and guar bean (*Gymopsis tetragonoloba* [L.] Taub) (Kabambe, 2013). The control of *A. vogelii* using herbicide seed dressing reported by Berner *et al.* (1993) and Lagoke *et al.* (1994) has remained theoretical because the target farmers who are mostly resource poor farmers have not shown interest in investing in the use of chemical control.

The use of resistant varieties in the control of parasitic weeds, mainly *S. asiatica* and *S. hermonthica* has been extensive, but work on *A. vogelii* resistance remains scarce. A resisant variety has the ability to prevent emergence and attachment of a parasite to a host, whereas tolerant varieties are parasitized to the same extend as susceptible ones but suffer less damage (Mabasa, 2003). Growing resistant genotypes will not only protect the current crop from infection but will also reduce the *A. vogelii* seed bank, thus minimising infection levels in succeeding crops.

In West Africa, *A. vogelii* resistant cowpea cultivars have been developed (Rubiales *et al.,* 2006). In Ethiopia, the first *A. vogelii* incidence was reported in groundnuts, but had no effect on the cowpea variety that was grown. This suggests that the cowpea variety that was grown could be resistant to the parasitic weed or the *A. vogelii* strain that was observed was a less virulent strain (Hussien *et al.,* 2006). Variability for *A. vogelii* resistance has been widely reported (Riches, 2001) and it is recommended that routine screening against the parasite is conducted so that choices of varieties to farmers may include *A. vogelii* resistance.

Seed Company (Seedco) and the Department of Research and Specialist Services (DR&SS) in Zimbabwe have developed a series of breeding lines that are claimed to firm against the negative effects of harsh environmental conditions such as drought, pests and diseases. Therefore there could be merit in evaluating some of these cowpea varieties for tolerance to *A. vogelii* because it has been reported that genes that confer tolerance to drought are also involved in resistance to parasitic weeds mainly due to the fact that parasitic weeds behave like diseases (Taylor *et al.*, 1996).

This study determined the impact of *A. vogelii* on the growth of six Zimbabwean stress tolerant cowpea cultivars, CBC1, CBC2, CBC3 (from DR&-SS Crop Breeding Institute), IT18 (from Seed co.), C/83/4/6 and C/85/6/4 (DR&SS pre-released varieties). In this experiment it was hypothesised that some of the cowpeas genotypes that are grown in Zimbabwe are resistant to *A. vogelii*.

Materials and methods

Study Site and experimental design

A glasshouse pot experiment was conducted at the Crop Science Department, University of Zimbabwe (17.78 ^{0}S, 31.05 ^{0}E, and 1523 meters above sea level) in Harare in the summer rainy season of 2012 / 2013 using sandy soil.

The experiment was designed as a Randomised Complete Block Design (RCBD) with three replications. Blocking was done according to the position of the pot rows from the window. Four commercial cowpea genotypes (varieties) were used as treatments in this experiment, namely; CBC 1, CBC 2, CBC 3, IT-18 and two pre-released varieties, namely; C/83/4/6 and C/85/6/4. *A. vogelii* seeds that were used were taken from a seed stock collected in 2012 at Weed Research Team, Henderson Research Station in Mazoe, Zimbabwe.

Experimental procedure

Pots (diameter 20 cm, height 25 cm) were filled with sandy soil of equal volume. Five grammes of Compound D (8 % N; 14 % P_2O_5; 7 % K_2O) per pot (equivalent to 250 kg per hectare) were applied to the cowpeas at planting. Half of the pots were infested with *A. vogelii* seeds and the other half (control) were not infested because each cowpea genotype had a control. In infested pots, the top 5 cm of soil was thoroughly mixed with 0.04 g of *A. vogelii* seed.

Three seeds of cowpea were planted in each pot. Thinning was done a week after crop emergence (WACE) to one plant per pot. The pots were hand weeded regularly to remove other weeds. Pots were initially irrigated to field capacity using a watering can fitted with a fine rose.

Thereafter pots were irrigated every other day to the same level until cowpea was harvested at physiological maturity. *A. vogelii* seeds were not preconditioned prior to infestation in the pots. Time taken to *A. vogelii* emergence and flowering, as well as the number of *A. vogelii* plants per cowpea plant were recorded every two days after emergence of the first *A. vogelii* plant. Number of days to flowering, total plant dry weight, number of pods per plant, weight of pods and grain yield of cowpea plants were recorded at physiological maturity.

Data analysis

Analysis of variance for the measured parameters was done using Genstat version 14 at $P < 0.05$. Data were checked to see if it was normally distributed before Analysis of Variance was done. In most cases the data had to be transformed using square root transformation $\sqrt{(x+1)}$ to make it normally distributed. Mean separation was done using the Least Significant Difference (LSD) and standard error calculations were done using Minitab 16.

Results

Alectra vogelii emergence

The emergence of *A. vogelii* was first noticed 55 days after planting (DAP). Figures 1 and 2 show that *A. vogelii* emergence was not significantly ($P > 0.05$) influenced by cowpea genotypes at 55 and 75 DAP.

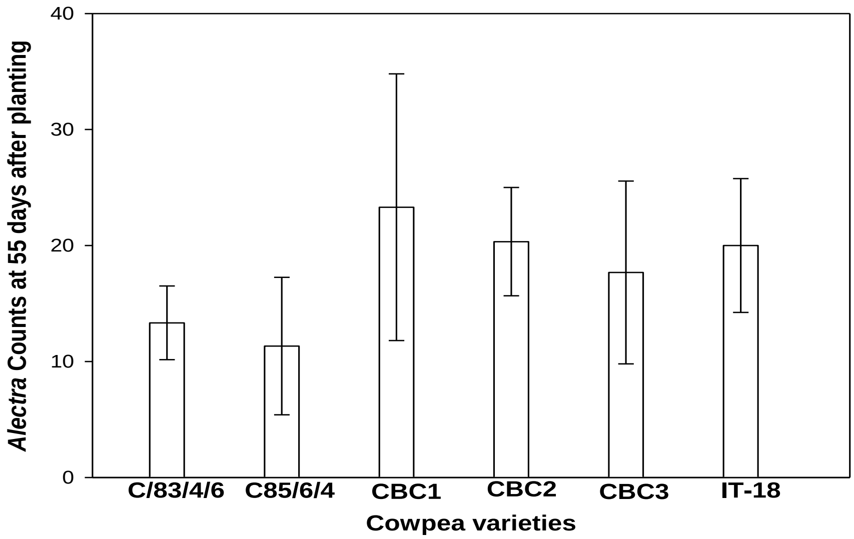

Fig. 1. Effect of cowpea genotypes on *Alectra vogelii* emergence at 55 days after planting (DAP).

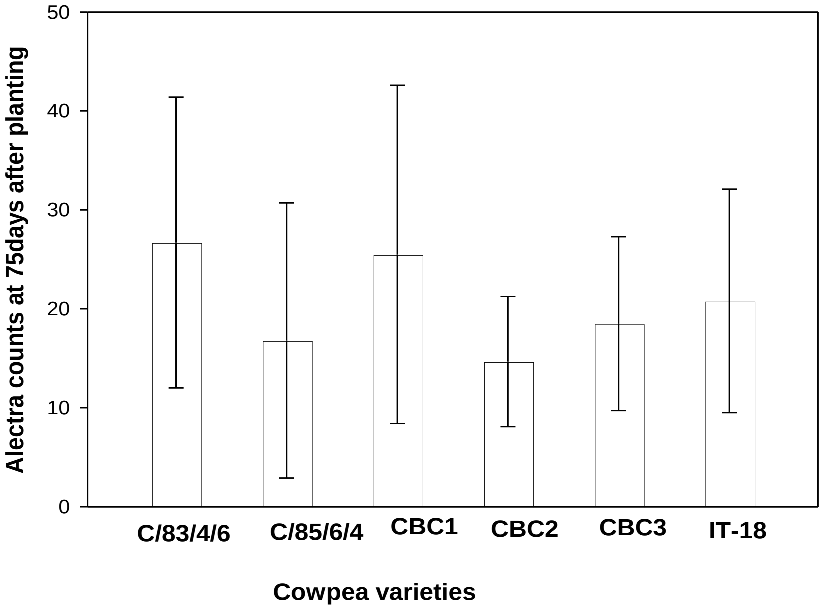

Fig. 2. Effect of cowpea genotypes on *Alectra vogelii* emergence at 75 days after plantng (DAP).

Days to cowpea flowering

The cowpea genotype x *A. vogelii* infestation interaction, the cowpea genotype and *A. vogelii* effects were not significant (P > 0.05) on flowering. Flowering of cowpea genotypes was observed between 58 and 66 days from planting.

Cowpea parameters

There was no significant interaction between cowpea genotype and *A. vogelii* infestation (P > 0.05) on cowpea shoot biomass, pod number, pod weight, grain biomass, root biomass and root to shoot ratio.

All the cowpea parameters that were measured were not significantly affected by cowpea genotype ($P > 0.05$). However, *A. vogelii* infestation significantly ($P < 0.05$) influenced most of the parameters, with the exception of root biomass (Table 1).

Table 1: Effect of *A. vogelii* on cowpea parameters

	Shoot biomass	Pod numbers	Pod weight	Grain	Root biomass	Root to shoot ratio
+Alectra	4.30±0.59 (2.24)	0.11±0.07 (1.05)	0.1±0.09 (1.04)	0.08±0.06 (1.03)	1.54±0.31 (1.55)	0.356±0.05 (1.160)
- Alectra	9.99±1.15 (3.24)	5.56±0.81 (2.47)	9.3±2.49 (2.87)	6.57±1.83 (2.45)	1.42±0.149 (1.54)	0.151±0.01 (1.07)
P value	<0.001	<0.001	<0.001	<0.001	0.763	<0.001
LSD	2.495	1.768	4.59	3.376	NS	1.106

Data in brackets represent $\sqrt{(x+1)}$ transformed values. NS=Not Significant

Alectra vogelii infection significantly ($P < 0.05$) reduced cowpea shoot biomass and pod number by 57 % and 98 %, respectively (Table 1).

It was observed that infected cowpeas failed to produce any pods at all with the exception of cowpea cultivar C/83/4/6 and C/85/6/4. A similar trend of results was observed with grain yield.

Root biomass was not significantly influenced by *A. vogelii* infection. Alectra infected cowpeas had significantly ($P < 0.05$) higher root to shoot ratio compared to uninfected plants.

Discussion

The six cowpea genotypes that were evaluated had the same capacity to germinate *A. vogelii* seeds as evidenced by similar emergence counts that were obtained in this study.

This suggests that these cowpea varieties do not differ in terms of strigolactone production. Some of the germination stimulants that have been identified are alectrol and sorgoleone produced by cowpea and sorghum respectively (Rambakudzibga, 2000). *A. vogelii* was first noticed at 55 DAP contrary to results by Kabambe *et al.* (2008), who reported that *A. vogelii* emerged at 75 DAP in soyabean and 109 DAP in groundnut. This would suggest that cowpea genotypes evaluated in this study are very susceptible to *A. vogelii* infection due to their ability to produce high levels of stimulants.

Alectra vogelii infection reduced shoot biomass, pod numbers, pod weight and grain yield. Only two genotypes, C/83/4/6 and C/85/6/4 managed to produce pods and grain under *A. vogelii* infection. These results concur with findings by Mugabe (1983) and Alonge *et al.* (2001) who reported that early infection delayed the onset of flowering, reduced number of flowers and resulted in a concomitant decrease in the number of pods per plant and low grain yield.

Whilst *A. vogelii* emergence in this study suggested that all the cowpea genotypes were highly susceptible, the ability of the two pre-released genotypes, C/83/4/6 and C/85/6/4 to produce pods and grain under *A. vogelii* infection could suggest that these genotypes have some degree of tolerance to this parasitic weed. Haussman *et al.* (2000) reported that the susceptibility of the host may not be explained by the number of emerged parasitic plants but probably by the host genotype. *A. vogelii* infected cowpea had significantly higher root to shoot ratios than uninfected plants. Similar findings were reported by Rambakudzibga *et al.* (2002). Attachment of *A. vogelii* plants to the roots of the host results in an increase in sink demand in the roots. This carbon transfer from the shoots to the roots due to changes in sink demands largely accounts for the reduction in shoot biomass and was reported to be responsible for the reduction in pod formation (Rambakudzibga, 2000). Similar findings were obtained in other host parasite associations involving tomato and tobacco infected with *Orobanche aegyptiaca* (Hibberd *et al.*, 1996) and sorghum infected with *S. hermonthica* (Cechin and Press, 1993). However, inconsistent results on *S. gesnerioides* on cowpea infection have been reported (Hibberd *et al.*, 1995 and Hibberd *et al.*, 1996).

Conclusion and recommendations

Based on results on *A. vogelii* emergence and cowpea parameters collected in this study, it can be concluded that all the cowpea genotypes evaluated are susceptible to *A. vogelii* infection. However, it can also be concluded that the two pre-released varieties C/83/4/6 and C/85/6/4 are moderately susceptible because they were able to produce grain and should therefore be further evaluated under field conditions. Further evaluations of the effect of *A. vogelii* infection on the physiology of C/83/4/6 and C/85/6/4 can be useful to determine the level of tolerance of these two pre-released varieties.

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