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Mechanism of reaction of cowpea varieties to *Alectra vogelii* (Benth) and its control

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ABSTRACT

Objective: To study the mechanism of reaction of cowpea varieties to *Alectra vogelii* and how this impacts on the control of the parasitic plant.

Methodology and results: In the first trial eighteen cowpea varieties were evaluated for resistance/tolerance to *A. vogelii* in a randomized complete design. The second trial was made up of 25 herbicide treatments compared to hoe – weeding at 3 and 6 weeks after sowing (WAS) and untreated check using cowpea variety SAMPEA – 7. The third trial was laid out in a split – plot design, with three cowpea varieties (B301, TN93 – 80 and VITA – 3) with three levels of N and P in the main and sub–plot treatments, respectively. The results showed that variety B301 and the derivatives of its crosses with IT84S – 2246 – 4 (IT90K – 59 and IT90K – 76) did not support *Alectra* emergence, while SAMPEA – 7 and TVX3236 supported high infestation with consequent high susceptibility to the parasite. Pre – emergence herbicide application of a mixture containing pree (metazachlor + antidote) followed by imazaquin at 0.18kg a.i/ha resulted in significantly lower number of plants infected by the parasite. Highest level of N (60kg N/ha) significantly reduced the number of plants infected by the parasite at harvest while grain yield increased with P levels.

Conclusion and application of findings: This investigation showed that variety B301 and the derivative of its crosses with IT84S – 2246 – 4 (IT90k – 59 and IT90k – 76) did not support the emergence of *Alectra*, and thus exhibits resistance. Cowpea variety VITA – 3 has potential to tolerate *Alectra*, while higher dose of N (≥60kg/ha) is detrimental to cowpea grain yield. Farmers can reduce cowpea infection by *Alectra* when pre–emergence herbicide mixtures containing pree (metazachlor + antidote) are applied followed by post–emergence application of imazaquin at 0.18kg a.i/ha.

Key words: *Alectra vogelii*, cowpea, exudates, fertilizers, herbicides, parasitism

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INTRODUCTION

Alectra vogelii (Benth) is a hemiparasite of the family Scrophulariaceae that parasites a wide range of legumes in the West, East and South Africa (Bagnall-Oakeley *et al*., 1991). Aggarwal (1985) and Emechebe *et al*. (1991) observed that *Alectra* appears to be more destructive in the Northern Guinea and Sudan agroecologies, largely because of marginal nutrient status of the soils and unreliable rainfall.

Alectra and related parasitic weeds including *Striga* are presently among the most important biological constraints to food production in Africa. Although attack by *Alectra* is less severe than that of *Striga*, total yield loss is not uncommon in fields heavily infested by these parasites when susceptible varieties are planted (Emechebe *et al*., 1983). Serious crop yield losses caused by *Alectra* have been reported in legumes including cowpea, broad and velvet beans, groundnuts, bambara groundnut and grams (Riches, 1987; Lagoke *et al*., 1988). Several cultivated lands have been abandoned due to high infestations of the noxious parasitic weeds (Lagoke *et al*., 1988). Fields infested by these parasitic weeds are difficult to clean, because of the large amount of seeds produced and the dormancy mechanisms that enable them to stay in the soil for several years (Emechebe *et al*., 1983). It is apparent that no single method can adequately control them and therefore a number of integrated methods are required for effective control.

Alectra has a similar life – cycle to that of *Striga* sp. Seed germination occurs in response to the root exudates of potential host and a hemi–parasitic phase after emergence follows the holo–parasitic development of the plant on the host roots (Botha, 1984). Control measures proposed for *Striga* sp. are therefore also generally applicable to *Alectra*. The most plausible method of control for the weed is through host–plant resistance/tolerance. The other methods including hand pulling, fertilizers and herbicides have not resulted in consistent success, and can only supplement the use of resistant/tolerant varieties. Although there has been no reported work on the effect of nitrogen fertilizer on incidence of cowpea infection by *Alectra*, there are reports on the effect of nitrogen on infection of cowpea by *Striga gesnerioides*. Application of nitrogen fertilizer up to 60kg N/ha reduced the incidence of cowpea attack by *S. generioides* without necessarily affecting grain yield (Adu *et al*., 1989).

The use of chemicals to control witchweed can be divided into two general categories, i.e. pre–emergence and post-emergence (Ayensu *et al*., 1984). Pre–emergence herbicides that are capable of controlling these parasitic plants include the dinitroanilines (DAN's) and Dipheny/ethers (Eplee *et al*., 1991). These herbicides act as barriers to prevent *Striga* emergence. Post–emergence herbicides most commonly used to stop the reproduction of *Striga* are the salt formulations of 2, 4–D (Choudhari *et al*., 1980; Lagoke *et al*., 1993). These chemicals are applied to *Striga* foliage at about the time of flowering at the rate of 0.5 – 1.0 kga.i/ha.

The purpose of this study was to evaluate the effects of interactions between cowpea varieties, herbicides, fertilizers and *Alectra vogelii*.

MATERIALS AND METHODS

Study site: Three field trials were conducted at Samaru (11°11'N, 7°36'E) in the Northern Guinea Savannah of Nigeria. The site was naturally uniformly and heavily infested with *A. vogelii*. In the first trial, 18 cowpea varieties were evaluated for resistance/tolerance to *Alectra* in a randomized complete block design with three replications. The gross and net plot sizes were 9 m^2 and 4.5 m^2, respectively. In the second trial, 25 herbicide treatments were compared with hoe-weeding at 3 and 6 weeks after sowing (WAS) and untreated check in a randomized complete block design using cowpea variety SAMPEA – 7. The gross and net plot sizes were 12 m^2 and 6 m^2, respectively. The third trial was laid out in a split-plot design with three replications. Three cowpea varieties B 301 (resistant), TN 93-80 (tolerant) and VITA 3 (susceptible) and 3 levels each of nitrogen and phosphorus fertilizers constituted the main plot and sub-plot treatments, respectively. The sub-plot treatments consisted of combinations of 3 levels of nitrogen, i.e 0, 30 and 60kg N/ha, and phosphorus at 0,45 and 90Kg P_20_5/ha, all applied at planting.

In the three (3) trials, two seeds per hole of cowpea dressed with Benlate were planted on 75cm wide ridges at an intra-row spacing of 30cm. Fungal and insects attacks were controlled with Benlate and Cymbush COEC, respectively. Observations made included number of days to *Alectra* emergence, number of plants infected and *Alectra* shoot count and cowpea grain yield. Treatment means were compared using Duncan Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

In the first trial, variety B301 and the derivatives of crosses with IT84S-2264-4 (IT90K-59 and IT90K-76) did not support the emergence of *Alectra* (Table 1). Line B301, a local variety, which was initially identified for resistance to *A. vogelii* in Botswana has since been observed to exhibit combined resistance to various strains of *Alectra* and *Striga* in Africa including Nigeria (Riches, 1987; Emechebe & Singh, 1989). However, Emechebe and Singh (1989) have reported that the other two sources of resistance to *Striga gesnerioides* (SUVITA-2 and IT82D-849) are susceptible to *Alectra*. Resistance to *Striga* in the genotype B301 has been reported to be controlled by one dominant gene, while that of *Alectra* is controlled by two dominant genes (Singh & Emechebe, 1990[a], 1990[b]). This then indicates that there are differences in mechanisms of resistance and the genes controlling resistance to these parasitic weeds in different varieties.

Table 1: Reaction and yield of cowpea varieties under *Alectra vogelii* infestation at Samaru, 2005.

Variety	Plants infested with *Alectra* at harvest (4.5m^2)	*Alectra* Shoot count at harvest (4.5m^2)	Number of Days to First *Alectra* Flowering	Number of Pods/Plot	Grain yield (kg/ha)
IT84 S-2246-4	14.67^{a}	63.3^{ab}	68^{ab}	282^{cd}	378^{bc}
KANO 1696	15.33^{a}	81.0^{a}	67^{ab}	256^{cd}	894^{ab}
ITK89KD-245-1	3.00^{cd}	8.3^{d}	74^{a}	374^{abc}	1099^{a}
TVX3236	12.33^{ab}	60.3^{abc}	68^{ab}	364^{abc}	664^{abc}
IT90K-59	0.00^{d}	0.0^{d}	-	435^{abc}	974^{a}
IT90K-76	0.00^{d}	0.0^{d}	-	541^{ab}	981^{a}
IT86D-534	11.00^{d}	1.0^{d}	82^{a}	315^{ab}	648^{abc}
IT89D-245	3.33^{cd}	11.0^{d}	50^{b}	297^{bcd}	987^{a}
IT82-849	16.33^{a}	94.0^{a}	68^{ab}	88^{d}	161^{c}
B301	0.00^{d}	0.0^{d}	-	612^{a}	860^{ab}
IT81D-985	4.67^{cd}	9.3^{d}	70^{ab}	272^{cd}	821^{ab}
IT81D-994	2.33^{cd}	3.7^{d}	81^{a}	304^{bcd}	757^{ab}
IT86D-843	8.00^{bc}	19.3^{bcd}	73^{a}	259^{cd}	650^{abc}
TN93-80	6.00^{cd}	24.3^{bcd}	70^{a}	598^{a}	1122^{a}
TN121-80	12.33^{ab}	26.0^{bcd}	68^{ab}	418^{abc}	714^{ab}
VITA 3	16.33^{a}	84.0^{a}	69^{ab}	207^{cd}	777^{ab}
SUVITA-2	7.67^{bc}	15.7^{cd}	69^{ab}	244^{bc}	643^{abc}
SAMPEA-7	114.67^{a}	75.3^{a}	66^{ab}	321^{bc}	624^{abc}
S.E (±)	1.93	15.02	6683	76.7	156.15

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

Lane and Bailey (1991) and Lane *et al.* (1991) reported that in B301, actual stimulation and germination of the *Striga* seeds and the formation of haustoria occurs but anatomical studies show that the haustorium remains in the endodermis and fail to develop any further, possibly because of antibiosis. In contrast cultivars IT89KD-24 5-1 and IT89KD-245, both of which are derivatives of B301 and local variety Kananado, still supported low emergence of *Alectra*. The varieties still produced cowpea grain yield that were comparable to the maximum. Cultivar Kano 1696 produced low pod number, but acceptable grain yield in spite of high and moderate infestation by *Alectra*. This may be compensated for in seed size, which consequently increases the grain yield of the crop. Since it is a late maturing variety, it would produce adequate photosynthetic apparatus for the production of assimilates for grain filling at the later stage of life-cycle inspite of the initial adverse effect of *Alectra* infection. Cultivar VITA-3 exhibited a high degree of tolerance, combining high yield with tolerance, and thus it could be used to improve the genetic base of the varieties being developed for *Alectra* tolerance/resistance. The currently recommended varieties SAMPEA – 7 and TVX3236 were observed to be highly susceptible to *Alectra* in this trial.

Table 2: Effect of herbicides on *Alectra vogelii* and cowpea grain yield at Samaru, 2005 wet season.

Treatment	Rate kga.i/ha	Post-emergence	[a]Plants infected with *Alectra*	[a]*Alectra* shoot count	Days to first *Alectra* emergence	Grain yield (kg/ha)
Pree + Imazr	1.0 + 0.05	SHW	12.3	28.7	58^{abc}	326^{bc}
Pree + Imazr	1.0 + 0.05	Imazaquine at 0.18	13.7	40.0	54^{b-f}	298^{bc}
Pree + Imazr	-	1.0 + 0.5[b] at 3 WAS	16.0	40.7	55^{a-e}	221^{bc}
Pree + Imazr	1.0 + 0.075	SHW	8.0	20.7	59^{ab}	402^{ab}
Pree + Imazr	1.0 + 0.075	Imazaquine at 0.18	6.3	17.7	59^{ab}	314^{bc}
Pree + Imazr	-	1.0 + 0.075[b]	12.7	25.7	57^{a-d}	194^{bc}
Pree + Imazr	1.0 + 0.18	SHW	15.7	32.7	55^{a-e}	363^{abc}
Pree + Imazr	1.0 + 0.18	Imazaquine at 0.18	8.3	29.3	58^{abc}	391^{abc}
Pree + Imazr	-	1.0 + 0.18[b]	15.0	38.7	58^{abc}	176^{bc}
Pree + Imazr	1.0 + 0.36	SHW	11.7	32.0	59^{ab}	166^{bc}
Pree + Imazr	1.0 + 0.36	Imazaquine at 0.18	6.0	12.0	60^{a}	191^{bc}
Pree + Imazr	-	1.0 = 0.36[b]	20.3	74.3	56^{a-d}	244^{bc}
Pend. + Imaz.	0.87 + 0.15	SHW	21.0	74.0	51^{e-g}	285^{bc}
Pend. + Imaz.	0.87 + 0.15	Imazaquine at 0.18	15.7	40.0	49^{fg}	315^{bc}
Pend. + Imaz.	-	0.87 + 0.15[b]	17.3	59.3	53^{c-g}	187^{bc}
Pend. + Imaz.	1.09 + 1.19	SHW	19.0	63.7	51^{e-g}	598^{a}
Pend. + Imaz.	1.09 + 1.19	Imazaquine at 0.18	10.0	26.3	56^{a-d}	183^{bc}
Pend. + Imaz.	-	1.09 + 0.19[b]	20.7	60.7	50^{efg}	152^{bc}
Pend. + Imaz.	1.27 + 0.096	SHW	16.0	45.0	52^{d-g}	181^{bc}
Pend. + Imaz.	1.27 + 0.096	Imazaquine at 0.18	20.3	54.3	49^{fg}	84^{c}
Pend. + Imaz.	-	1.27 + 0.096[b]	19.0	57.7	49^{fg}	95^{c}
Pend. + Imaz.	1.58 + 0.12	SHW	20.0	76.0	51^{e-g}	290^{bc}
Pend. + Imaz.	1.58 + 0.12	Imazaquine at 0.18	14.0	46.0	54^{b-f}	388^{abc}
Pend. + Imaz.	-	1.58 + 0.12 at 3 WAS	22.3	63.7	51^{e-g}	252^{bc}
Metol. + Metb.	2.5		15.3	32.0	55^{a-e}	112^{c}
Hoe weeded	At 3 & 6 WAS		20.5	74.7	52^{d-g}	155^{bc}
Unweeded			20.7	74.7	48^{g}	125^{bc}
S.E ±			2.71	13.06	1.72	83.95

[a] at harvest; [b] at 3 weeks after sowing; Pree + Imazr = Pree + Imazethapyr; Pend. + Imaz. = Pendimenthalin + Imazaquine; Imazr = Imazethapyr; Metol. + Metob = Metolachlor + Metobromuron; Means followed by the same letter (s) are not significantly different at 5% level of probability (DMRT).

In the second trial, pre-emergence application of Pree (metazachlor + antidote) + imazathapyr at 1.0 + 0.075 kg a.i/ha and pree + imazaquin at 1.0 + 0.36 kg a.i/ha each followed by imazaquin at 0.18kg a.i/ha, respectively reduced the number of plants infected as well as the *Alectra* shoot count (Table 2). Moderate control was also obtained with Pree + Imazethapyr at both rates (1.0 + 0.18 and 1.0 + 0.05 kg a.i/ha) each followed by supplementary hoe-weeding and Pree + imazaquin at 1.0 + 0.18kg a.i/ha followed by imazaquin at 0.18 kg a.i /ha.

Garcia *et al*. (1992) reported effective control of the parasitic weed with imazaquin at 0.80kg a.i/ha. However, early sowing/high yield cropping systems, which are normally subject to heavy and lasting parasite infestations, would require a combination of pre-emergence and post-emergence treatments. Results of experiments to develop a cowpea seed treatment in the laboratory and screen house to control both *Striga gesnerioides* and *Alectra vogelii*, that consisted of a five minute seed soak in solutions of imazaquin in concentrations ranging from 1.8 to 7.2mg a.i/ml reduced parasite attachment by 90% in comparison to untreated controls. The mechanism of control appears to be post-attachment mortality of the parasites with no reduction in parasite seed germination (Berner *et al.* 1993).

The yields of plots treated with Pree and imazaquin were generally lower than those treated with pendimethalin containing mixture. This could be attributed to phytotoxicity on cowpea stand establishment (Berner *et al*., 1993).

In the third trial, the number of plants infected with *Alectra* was significantly higher for cultivar VITA-3 than cv. TN93-80. Irrespective of the applied nitrogen and phosphorus combinations *Alectra* did not emerge at all in cultivar B301 that exhibited high level of resistance as earlier indicated (Riches, 1987) and later confirmed (Emechebe & Singh, 1990). The highest level of nitrogen (60kg N/ha) significantly reduced *Alectra* count at harvest compared to 0 and 30Kg N/ha, in the two varieties of cowpea (VITA-3 and TN93-80).

In a similar study using sand culture Emechebe *et al*. (1991) showed that 140ppm N applied as sodium nitrate ($NaN0_3$) solution completely reduced the incidence of *S. gesneriorides* with a concomitant decrease in the number of nodules. However, Adu *et al*. (1989) reported that lower levels of N in combination with some host resistance would be appropriate to reduce *Striga* infection. The use of N in controlling *S. gesneriorides* in cowpea seems to be limited due to detrimental effect of high rates on nodulation with consequent yield reduction. Earlier works (Parker, 1984; Sharif & Parker, 1986, Raju *et al*., 1990) have shown that high N reduces stimulant production from sorghum and can delay *Striga* emergence and reduce infestation of *Striga* when compared with low N application. This might be through physiological changes in the growth rate of the cell tissues in the active stimulant producing area of the sorghum roots. It is also possible that the high N encourages rapid and vigorous cell growth and elongation, which demands a lot of stimulants to perform such functions, consequently leading to a small quantity of the stimulant being released into the soil medium. High N could also caused the reduction of radicle elongation of the few germinated *Striga* seeds as observed by Pesch and Pieterse (1982) providing an escape mechanism effect on the attachment of the *Striga* seedlings to the host.

The significant increase in weight of pods per unit area and grain yield with P application has earlier been attributed to the fact that P promotes good establishment, nodulation and yields of legumes (Whitney, 1975). Phosphorus application, however, did not have any effect on *Alectra* parameters, while the damage symptoms on crop plants was more intense at 40kg P/ha compared to 0 and 20 kg P/ha. This may be attributed to better establishment and increased number of nodules and lateral roots which could serve as haustorial attachment points for the parasite.

Based on the findings of this investigation, it is concluded that a combination of cowpea variety VITA – 3 and N and P at 60kg/ha and 95kg/ha, respectively, can be used as an effective management measure for *Alectra vogelii*. However, there is a need to investigate further and determine a more appropriate application rate of herbicide combinations that would still give acceptable cowpea yield with lower number of plants infection by the parasite considering the yields of treatments containing pree (metazachlor + antidote) that gave lower number of plants infected and *Alectra* shoot count.

Table 3: Effect of nitrogen and phosphorus on days to *Alectra* emergence, number of plants infected, *Alectra* shoot count and grain yield at Samaru, 2005 wet season.

Treatment	Days to first *Alectra* Emergence	No. of plant infected with *Alectra* at harvest (6 m^2)	*Alectra* shoot count at harvest	Grain yield (kg/ha)
Varieties (V)				
B301	-	0.00[c]	0.00	641
TN 93-80	56.70[a]	9.59[b]	28.0[b]	532
Vita – 3	55.96[b]	18.22[a]	68.0[a]	660
S.E (±)	0.35	0.55	3.93	44.2
Phosphorus (Kg P_2O_5/ha)				
0	37.52	9.63	35.4	390[b]
45	37.78	8.96	28.4	685[a]
90	37.37	9.22	32.3	759[a]
S.E (±)	0.68	0.89	4.82	45.76
Nitrogen (Kg N/ha)				
0	37.11	12.19[a]	43.1	613[a]
30	37.78	9.41[b]	33.5	694[a]
60	37.37	6.22[c]	19.5	526[b]
S.E (±)	0.68	0.89	4.82	526
Interactions				
VXP	NS	NS	NS	NS
VXN	NS	NS	NS	NS
NXP	NS	NS	NS	NS
VXPXN	NS	NS	NS	NS

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

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