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Pre–emergence and post–emergence herbicide control of the parasitic plant *Alectra vogelii* in cowpea

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SUMMARY
Several pre and post–emergence herbicides were evaluated for the control of *Alectra vogelii*. Twenty five (25) herbicide treatments were compared with a weedy check in a randomized complete block design using cowpea variety SAMPEA–7. In the two years (2003 & 2004), pre–emergence herbicide application of the mixtures containing pree (metazachlor + antidote) followed by imazaquin at 0.18kg a.i/ha resulted in significantly lower number of infected plants. In 2003, pendimethalin plus imazaquin at 0.87+0.15 and 1.09 + 0.19 kg a.i/ha and pendimethalin plus imazethaphyr at 1.58+0.12kg a.i/ha, followed by imazaquin at 0.18kg a.i/ha, resulted in lower number of cowpea plants infected by *Alectra* compared with the weedy check. The studies demonstrate that farmers can achieve significant reduction in cowpea plant infection by *Alectra vogelii* when pre-emergence herbicide mixtures containing pree (metazachlor + antidote) are applied, followed by post-emergence application of imazaquin at 0.18kg a.i/ha or pendimehalin plus imazaquin at 0.87 + 0.15 and 1.09 + 0.19 kg a.i/ha followed by imazaquin at 0.18kg a.i/ha are used.

1 INTRODUCTION

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

Alectra and related parasitic weeds including *Striga* are presently among the most important biological constraints to food production in Africa. Although the impact of crop attack by *Alectra* is less severe than that of *Striga*, total yield loss is not uncommon when susceptible varieties are planted in fields that are heavily infested by these parasites (Emechebe *et al*., 1983). Serious crop yield losses caused by *Alectra* have been reported in legumes including cowpea, groundnuts, bambara, broad and velvet beans and grams (Riches, 1987; Lagoke *et al*., 1988). Several cultivated lands have been abandoned due to high infestations of the noxious weeds (Lagoke *et al*., 1988). Fields infested by these parasitic weeds are difficult to clean, because of the large amounts of seeds produced and the dormancy mechanisms, which make them survive in the soil for many years (Emechebe *et al*., 1983).

The use of chemical to control witchweed can be divided into two general categories, namely pre-emergence and post-emergence (Dogget, 1953; Ayensu *et al*., 1984). Pre-emergence herbicides capable of controlling these parasitic plants include the dinitroanilines (DNA's) and Diphenyl ethers (Eplee *et al*., 1991). Among the DNA's, trifluralin, benefin and pendimethalin have been found to be effective. 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.*, 1993a, b). These chemicals are applied to *Striga* foliage at about the time of flowering at the rate of 0.5 – 1.0 kg a.i/ha.

Although pre- and post-emergence herbicides are effective in preventing *Striga* seed production, these treatments do not prevent the irreversible damage inflicted between the time of parasite attachment and emergence. A noble approach now under investigation is the use of systematic herbicides to control *Striga* at incipient attachment (Eplee *et al*., 1991). Metolachlor and Pendimethalin are two pre-emergence herbicides that were recently observed in field trials to provide sufficient suppression of *Striga* attachment (Eplee *et al*., 1991). Pendimethalin, applied pre-emergence to the surface at 1.7kg a.i/ha, gave a 100% reduction to early *Striga* emergence.

Control measures proposed for *Striga* are also generally applicable for *Alectra* control. The most effective method of control for the weed is through host-plant resistance/tolerance. Although roguing, and application of fertilizers and herbicides have given little and inconsistent promise, they can supplement the use of resistant/tolerant varieties. This trial was carried out to evaluate several pre- and post-emergence herbicides for potential use to control *Alectra vogelii*.

2 MATERIALS AND METHODS

The trials were conducted during the 2003 and 2004 wet seasons in Samaru (11° 11'N, 7° 38'E) in the Northern Guinea Savannah of Nigeria. Twenty five (25) herbicide treatments were compared with a weedy check in a randomised complete block design with three (3) replications using cowpea variety SAMPEA – 7. The pre-emergence herbicide treatments were applied one day after sowing in the two years. The herbicides were applied with a Knapsack (CP_3) sprayer in a spray volume of 250 l/ha using a deflector nozzle at a pressure of 2.1 kg/cm^2. The gross and net plot sizes in the two years were 12 and 6m^2, respectively. Two seeds per hole of cowpea dressed with Benlate were planted on 75cm wide ridges at an intra-row spacing of 30cm. Fungal and insect pests were controlled by the use of Benlate and Dithane M45; and Cypermethrine and Dimethoate, respectively.

Observations made included number of plants infected and *Alectra* shoot count per unit area, days to first *Alectra* emergence, crop damage score, weight of pods and grain yield of cowpea. The data collected were subjected to analysis of variance. Treatment means were compared using Duncan Multiple Range Test (Duncan, 1955). Coefficient of correlation between cowpea grain yield and various parameters under *Alectra* infestation were also determined.

3 RESULTS AND DISCUSSION

Generally, in the repeated trial, all pre-emergence herbicide mixtures containing pree (metazachlor + antidote) as well as pendimethalin plus imazaquin at 0.87 + 0.15 kg a.i/ha and 1.09 + 0.19 kg a.i/ha; Pendimethalin plus imazethapyr at 1.58 + 0.12 kg a.i/ha all followed by imazaquin at 0.18 kg a.i/ha resulted in low number of plants infected and *Alectra* shoot count (Tables 1 and 2). Lagoke (personal communication) reported that pendimethalin plus imazaquin at 1.09 + 0.19 kg a.i/ha followed by one supplementary hoe-weeding (SHW) at 6 weeks after sowing (WAS) resulted in lower *Alectra* shoot count and number of plants infected with consequent increase in cowpea grain yield. In the control of *Orobanche crenata*, Garcia *et al*. (1992) reported effective control of the parasitic weed with imazaquin at 0.80 kg a.i/ha. However, early sowing coupled with 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.

In a study to develop cowpea seed treatment for control of both *Striga gesnerioides* and *Alectra vogelii*, a five minute seed soak in solutions of 3.6 - 7.2 imazaquin/ml reduced parasite attachment by 90% in comparison to untreated controls (Berner *et al*, 1993). The mechanism of control appears to be post-attachment mortality of the parasites with no reduction in parasite seed germination (Berner *et al*., 1993).

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Table 1: The effect of herbicide on number of plants infected, Alectra emergence and Alectra shoot count at Samaru, 2003 wet season.

Pre-emergence	**Rate Kg a.i/ha**	**Post-emergence**	**Number of Plants Infected with Alectra/6m² 9 WAS¹**	**Alectra count/6m ²**	**Number of days to Alectra emergence**	**Crop damage² Score at 9 WAS**
Pree+mazethapyr	1.0+0.05	SHW	6.7^{d-h}	34.3^{a-e}	58^{abc}	2.3^{def}
Pree+mazethapyr	1.0+0.05	Imazaquin at 0.18	6.3^{e-h}	22.7^{a-e}	54^{b-f}	3.3$_{a-f}$
Pree+mazethapyr	-	1.0+0.05 at 3WAS	6.7^{e-h}	17.0^{cde}	55^{a-e}	3.7^{a-e}
Pree+mazethapyr	1.0+0.075	SHW	4.0^{gh}	15.0^{cde}	59^{ab}	2.3^{def}
Pree+mazethapyr	1.0+0.075	Imazaquin at 0.18	3.7^{gh}	5.3^{e}	59^{ab}	2.3^{def}
Pree+mazethapyr	-	1.0+0.18at 3WAS	5.0^{fgh}	9.0^{de}	57^{a-d}	3.0^{b-f}
Pree+Imazaquin	1.0+0.18	SHW	7.3^{d-h}	17.3^{b-e}	55^{a-e}	2.7^{e-f}
Pree+Imazaquin	1.0+0.18	Imazaquin at 0.18	3.7^{gh}	13.7^{cde}	58^{abc}	3.3^{a-f}
Pree+Imazaquin	-	1.0+0.36 at 3WAS	9.0^{b-h}	22.0^{a-e}	58^{abc}	4.9^{a-d}
Pree+Imazaquin	1.0+0.36	SHW	8.0^{c-h}	25.3^{a-e}	59^{ab}	3.7^{a-e}
Pree+Imazaquin	1.0+0.36	Imazaquin at 0.18	1.3^{h}	3.3^{e}	60^{c}	2.0^{ef}
Pree+Imazaquin	-	1.0+0.36 at 3WAS	15.3^{a-d}	48.7^{abc}	56^{a-d}	3.7^{a-e}
Pendimethalin+Imazaquin	0.87+0.15	SHW	15.7^{abc}	51.0^{ab}	51^{efg}	3.7^{a-e}
Pendimethalin+Imazaquin	0.87+0.15	Imazaquin at 0.18	8.3+c-h	21.0^{a-e}	49^{fg}	3.7^{a-e}
Pendimethalin+Imazaquin	-	0.87+0.15 at 3WAS	13.7^{a-e}	39.3^{a-e}	53^{c-g}	3.3^{a-f}
Pendimethalin+Imazaquin	1.09+0.19	SHW	11.3^{a-g}	40.0^{a-d}	51^{efg}	3.3^{a-f}
Pendimethalin+Imazaquin	1.09+0.19	Imazaquin at 0.18	5.3^{f-h}	17.3^{b-e}	56^{a-d}	1.7^{f}
Pendimethalin+Imazaquin	-	1.09+0.19 at 3WAS	17.0^{ab}	40.3^{a-d}	50^{efg}	4.0^{a-d}
Pendimethalin+Imazeth.	1.27+.096	SHW	12.3^{a-f}	26.0^{a-e}	52^{d-g}	4.0^{a-d}
Pendimethalin+Imazeth.	1.27+.096	Imazaquin at 0.18	14.3^{a-e}	33.3^{a-e}	49^{fg}	4.0^{a-d}
Pendimethalin+Imazeth.	-	1.27+0.96 at 3WAS	15.3^{a-d}	42.3^{a-e}	49^{fg}	5.0^{a}
Pendimethalin+Imazeth.	1.58+0.12	SHW	14.3^{a-e}	52.3^{a}	51^{efg}	4.3^{abc}
Pendimethalin+Imazeth.	1.58+0.12	Imazaquin at 0.18	8.3^{c-h}	25.3^{a-e}	54^{b-f}	3.3^{a-f}
Pendimethalin+Imazeth.	-	1.58+0.12 at 3WAS	15.7^{abc}	43.0^{abc}	51^{efg}	4.3^{abc}
Mektolachlor+Metob.	2.5	0.87+0.15 at 3WAS	10.3^{a-g}	21.0^{a-e}	55^{a-e}	3.3^{a-f}
Hoe weeded 3&6 WAS			17.0^{ab}	41.0^{a-d}	52^{d-g}	4.7^{ab}
Unweeded check			18.0^{a}	43.3^{abc}	48^{g}	5.0^{a}
S.E. ±			2.52	9.93	1.72	0.55

WAS= Weeks after sowing; Crop damage score scale (1-5), where 1 = normal crop plant growth, no chlorosis, no blotching, no leaf scorching and 5 = total leaf scorching or/and obviously stunted or dead plants. Imazeth. = Imazethapyr; Metob. = Metobromuron; Means followed by the same letter(s) are not significantly different at 5% level of probability according to the Duncan's Multiple Range Test.

The highest pod weight and consequently cowpea grain yield were obtained with pendimethalin plus imazaquin at 1.09 + 0.19 kg a.i/ha followed by SHW and pendimethalin plus imazethapyr at 1.58 + 0.12 kg a.i/ha followed by SHW in 2003 and 2004, respectively (Tables 3 and 4). The yields of pree and imazaquin treatments were generally lower than those of pendimethalin containing mixtures, although the former had fewer plants infected and less *Alectra* shoot count. This could be attributed to phytotoxicity on cowpea stand establishment (Berner *et al.*, 1993).

Similarly, with *Striga* Eplee *et al*. (1991) reported that among dinitroanilines, pendimethalin has been found to act as barrier to *Striga* emergence. Pendimethalin, applied pre-emergence to the surface at 1.7 kg a.i/ha, gave a 100% reduction in early *Striga* emergence. The mode of action of this herbicide in preventing early season *Striga* attachment is not yet known. In 2004, hoe-weeded control produced grain yields that was comparable to the maximum obtained in the trial with pendimethalin + imazethapyr at 1.58 + 0.12 kg a.i/ha followed by SHW.

Table 2: The effect of herbicide on number of plants infected, Alectra and shoot count and number of days to first Alectra emergence at Samaru, 2004 wet season.

Pre-emergence	Rate Kg a.i/ha	Post-emergence	Number of Plants Infected with Alectra/$6m^2$ 9 WAS[1]	Alectra count/$6m^2$ 9 WAS[1]	Number of days to Alectra emergence	Crop damage[2] Score at 9 WAS
Pree+mazethapyr	1.0+0.05	SHW	6.7^{bc}	29.3^{cde}	47^{b-f}	2.0
Pree+mazethapyr	1.0+0.05	Imazaquin at 0.18	5.0^{bcd}	11.7^{de}	49^{b-f}	1.7
Pree+mazethapyr	-	1.0+0.05 at 3WAS	87.7^{abc}	42.7^{a-e}	50^{b-e}	1.7
Pree+mazethapyr	1.0+0.075	SHW	10.0^{abc}	51.4^{a-e}	48^{b-f}	1.7
Pree+mazethapyr	1.0+0.075	Imazaquin at 0.18	5.3^{bcd}	21.3^{de}	53^{bc}	1.3
Pree+mazethapyr	-	1.0+0.18at 3WAS	6.4^{bcd}	25.3^{de}	52^{bcd}	1.7
Pree+Imazaquin	1.0+0.18	SHW	7.7^{abc}	25.3^{de}	44^{c-f}	1.7
Pree+Imazaquin	1.0+0.18	Imazaquin at 0.18	7.0^{abc}	58.7^{a-e}	44^{c-f}	2.0
Pree+Imazaquin	-	1.0+0.36 at 3WAS	5.7^{bcd}	28.7^{cde}	52=bcd	1.7
Pree+Imazaquin	1.0+0.36	SHW	5.3^{bcd}	15.7^{de}	56^{b}	1.7
Pree+Imazaquin	1.0+0.36	Imazaquin at 0.18	1.0^{d}	4.7^{e}	67^{a}	1.0
Pree+Imazaquin	-	1.0+0.36 at 3WAS	5.7^{bcd}	42.3^{a-f}	50^{b-ea}	1.3
Pendimethalin+Imazaquin	0.87+0.15	SHW	11.0^{abc}	94.3^{ab}	44^{c-f}	2.0
Pendimethalin+Imazaquin	0.87+0.15	Imazaquin at 0.18	9.3^{abc}	45.0^{a-e}	41^{ef}	2.3
Pendimethalin+Imazaquin	-	0.87+0.15 at 3WAS	10.0^{abc}	59.0^{a-e}	43^{c-f}	2.0
Pendimethalin+Imazaquin	1.09+0.19	SHW	13.7^{a}	91.7^{ab}	40^{ef}	2.3
Pendimethalin+Imazaquin	1.09+0.19	Imazaquin at 0.18	11.3^{abc}	102.7^{a}	40-ef	2.3
Pendimethalin+Imazaquin	-	1.09+0.19 at 3WAS	10.3^{abc}	68.7^{a-d}	42^{def}	1.7
Pendimethalin+Imazethapyr	1.27+0.096	SHW	9.7^{abc}	77.3^{a-d}	49^{b-f}	2.3
Pendimethalin+Imazethapyr	1.27+0.096	Imazaquin at 0.18	8.0^{abc}	41.0^{a-e}	40^{ef}	2.3
Pendimethalin+Imazethapyr	-	1.27+0.96 at 3WAS	10.3^{abc}	56.7^{a-e}	49^{b-f}	4.0
Pendimethalin+Imazethapyr	1.58+0.12	SHW	11.0^{abc}	98.7^{a}	46^{c-f}	2.7
Pendimethalin+Imazethapyr	1.58+0.12	Imazaquin at 0.18	10.3^{ab}	47.0^{a-e}	44^{c-f}	1.7
Pendimethalin+Imazethapyr	-	1.58+0.12 at 3WAS	13.7^{abc}	89.3^{abc}	46^{c-f}	2.3
Mektolachlor+Metobromuron	2.5	0.87+0.15 at 3WAS	11.7^{ab}	73.3^{a-d}	39^{f}	2.0
Hoe weeded 3&6 WAS			4.7^{cd}	32.3^{b-e}	44^{c-f}	1.7
Unweeded check			6.3^{bcd}	44.7^{a-e}	45^{c-f}	1.2
S.E. ±			2.00	18.65	3.03	0.45

WAS= Weeks after sowing; Means followed by the same letter(s) are not significantly different at 5% level of probability according to the Duncan's Multiple Range Test.

The negative correlation between cowpea grain yield, number of plants infected and *Alectra* shoot count confirms the high vulnerability of cowpea to *Alectra* with consequent reduction in grain yield. There was also negative correlation between *Alectra* parameters and weight of pods while grain yield was positively correlated to weight of pods (Tables 5 and 6). The results indicate that these parameters are critical determinants of cowpea grain yield and that the effect of *Alectra* on them was the main cause of yield reduction. Yield reduction of 100% due to *Striga* parasitism has been reported to occur in cowpea depending on the level of infestation (Emechebe *et al*., 1983). Similarly, Salako (1984) reported 34 – 39% loss in pod yield for individual groundnut plants due to *Alectra* infestation.

In this study, the use of pre-emergence and post-emergence herbicides was to act as both barriers to prevent *Alectra* emergence and *Alectra* seed production, respectively. Since members of Imidazolinone herbicides are characterized by high phytotoxicity while the Dinitroaniline herbicides tend to volatilise on dry soil surface, there is a need to use antidote(s) and to apply on wet soil surfaces. Considering that yields of treatments containing Pree (Metazachlor + antidote) had lower number of plants infected and *Alectra* shoot count, there is a need to investigate further and determine a more appropriate application rate that would still give acceptable cowpea yield with lower number of plants infection by the parasite.

Table 3: The effect of herbicide on weight of pods and grain yield at Samaru, 2003 wet season.

Pre-emergence	Rate Kg a.i/ha	Post-emergence	Weight of Pods (Kg/ha)	Grain Yield (Kg/ha)
Pree+mazethapyr	1.0+0.05	SHW	515^{abc}	326^{bc}
Pree+mazethapyr	1.0+0.05	Imazaquin at 0.18	395^{a-d}	298^{bc}
Pree+mazethapyr	-	1.0+0.05 at 3WAS	342^{a-d}	221^{bc}
Pree+mazethapyr	1.0+0.075	SHW	568^{ab}	402^{ab}
Pree+mazethapyr	1.0+0.075	Imazaquin at 0.18	421^{a-d}	314^{bc}
Pree+mazethapyr	-	1.0+0.18at 3WAS	293^{e-d}	194^{bc}
Pree+Imazaquin	1.0+0.18	SHW	498^{a-d}	363^{abc}
Pree+Imazaquin	1.0+0.18	Imazaquin at 0.18	413^{a-d}	391^{abc}
Pree+Imazaquin	-	1.0+0.36 at 3WAS	178^{cd}	176^{bc}
Pree+Imazaquin	1.0+0.36	SHW	155^{cd}	166^{bc}
Pree+Imazaquin	1.0+0.36	Imazaquin at 0.18	253^{a-d}	191^{bc}
Pree+Imazaquin	-	1.0+0.36 at 3WAS	325^{a-d}	244^{bc}
Pendimethalin+Imazaquin	0.87+0.15	SHW	403^{a-d}	285^{bc}
Pendimethalin+Imazaquin	0.87+0.15	Imazaquin at 0.18	431^{a-d}	315^{bc}
Pendimethalin+Imazaquin	-	0.87+0.15 at 3WAS	256^{a-d}	187^{bc}
Pendimethalin+Imazaquin	1.09+0.19	SHW	788^{a}	598^{a}
Pendimethalin+Imazaquin	1.09+0.19	Imazaquin at 0.18	256^{a-d}	183^{bc}
Pendimethalin+Imazaquin	-	1.09+0.19 at 3WAS	208^{a-d}	152^{bc}
Pendimethalin+Imazethapyr	1.27+0.096	SHW	241^{a-d}	181^{bc}
Pendimethalin+Imazethapyr	1.27+0.096	Imazaquin at 0.18	123^{d}	84^{c}
Pendimethalin+Imazethapyr	-	1.27+0.96 at 3WAS	136^{d}	95^{c}
Pendimethalin+Imazethapyr	1.58+0.12	SHW	378^{a-d}	290^{bc}
Pendimethalin+Imazethapyr	1.58+0.12	Imazaquin at 0.18	485^{a-d}	388^{abc}
Pendimethalin+Imazethapyr	-	1.58+0.12 at 3WAS	341^{a-d}	252^{bc}
Mektolachlor+Metobromuron	2.5	0.87+0.15 at 3WAS	156^{cd}	112^{c}
Hoe weeded 3&6 WAS			210^{a-d}	155^{bc}
Unweeded check			313_{a-d}	125^{bc}
S.E. ±			111.03	83.95

Means followed by the same letter(s) are not significantly different at 5% level of probability according to the Duncan's Multiple Range Test.

Table 5: Correlation between Cowpea grain yield and varieties parameters under Alectra infestation as affected by different herbicide mixtures at Samaru, 2003 wet season.

	1	2	3	4	5	6	7	8	9	10	11
1	1.0										
2	-0.18	1.0									
3	-0.15	0.95**	1.0								
4	-0.22**	0.88**	0.83**	1.0							
5	-0.03	0.83**	0.55**	0.85**	1.0						
6	-0.06	0.76**	0.70**	0.87**	0.77**	1.0					
7	-0.05	0.84**	0.85**	0.85**	0.87**	0.84**	1.0				
8	0.96**	-0.13	-0.11	-0.15	-0.02	-0.02	0.11	1.0			
9	0.16	-0.66**	-0.65**	-0.64**	-0.62	-0.59**	0.58**	-0.12	1.0		
10	-0.50	0.63**	0.58**	0.62**	0.48**	-0.58**	0.48**	-0.46**	-0.58**	1.0	
11	0.51	-0.07	-0.07	-0.01	0.03	0.24*	0.18	0.55**	0.12	-0.29**	1.0

Parameters: 1 Grain yield; 2 Number of plants infected at 8 WAS; 3 Alectra count at 8 WAS; 4 Number of plants infected at 9 WAS; 5 Alectra count at 9 WAS; 6 Number of plants infected at harvest; 7 Alectra count at harvest; 8 Weight of pods; 9 Number of days to Alectra emergence; 10 Crop damage symptom score at 9 WAS; 11 Crop stand count at harvest.; *indicates significant of 5% level of probability (r = 0.22); ** Significant at 1% level of probability (r = 0.28).

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Table 4: The effect of herbicide on weight of pods and grain yield at Samaru, 2003 wet season.

Pre-emergence	Rate Kg a.i/ha	Post-emergence	Weight of Pods (Kg/ha)	Grain Yield (Kg/ha)
Pree+mazethapyr	1.0+0.05	SHW	2920^{b-e}	1420^{bc}
Pree+mazethapyr	1.0+0.05	Imazaquin at 0.18	3360^{bcd}	1420^{abc}
Pree+mazethapyr	-	1.0+0.05 at 3WAS	3040^{b-e}	1381^{bc}
Pree+mazethapyr	1.0+0.075	SHW	2960^{b-e}	1396^{bc}
Pree+mazethapyr	1.0+0.075	Imazaquin at 0.18	3080^{b-f}	1287^{bcd}
Pree+mazethapyr	-	1.0+0.18at 3WAS	3000^{b-e}	1372^{bc}
Pree+Imazaquin	1.0+0.18	SHW	2920^{b-c}	1213^{b-e}
Pree+Imazaquin	1.0+0.18	Imazaquin at 0.18	3320^{bcd}	1369^{bc}
Pree+Imazaquin	-	1.0+0.36 at 3WAS	3680^{ab}	1578^{abc}
Pree+Imazaquin	1.0+0.36	SHW	3640^{ab}	1596^{abc}
Pree+Imazaquin	1.0+0.36	Imazaquin at 0.18	2800^{b-e}	1505^{abc}
Pree+Imazaquin	-	1.0+0.36 at 3WAS	2520^{b-e}	1272^{bcd}
Pendimethalin+Imazaquin	0.87+0.15	SHW	3000^{b-e}	1422^{bc}
Pendimethalin+Imazaquin	0.87+0.15	Imazaquin at 0.18	2480^{b-e}	1329^{bc}
Pendimethalin+Imazaquin	-	0.87+0.15 at 3WAS	2120^{cde}	1114^{c-e}
Pendimethalin+Imazaquin	1.09+0.19	SHW	3360^{bcd}	1322^{bc}
Pendimethalin+Imazaquin	1.09+0.19	Imazaquin at 0.18	2200^{cde}	1227^{b-e}
Pendimethalin+Imazaquin	-	1.09+0.19 at 3WAS	1640^{e}	724de
Pendimethalin+Imazethapyr	1.27+0.096	SHW	3440^{abc}	1547^{abc}
Pendimethalin+Imazethapyr	1.27+0.096	Imazaquin at 0.18	3440^{abc}	1650^{abc}
Pendimethalin+Imazethapyr	-	1.27+0.96 at 3WAS	2640^{b-e}	1408^{bc}
Pendimethalin+Imazethapyr	1.58+0.12	SHW	4720^{a}	2032^{a}
Pendimethalin+Imazethapyr	1.58+0.12	Imazaquin at 0.18	3040^{b-e}	1627^{abc}
Pendimethalin+Imazethapyr	-	1.58+0.12 at 3WAS	1920de	1108^{c-e}
Mektolachlor+Metobromuron	2.5	0.87+0.15 at 3WAS	1760^{e}	688^{e}
Hoe weeded 3&6 WAS			2120de	1729^{ab}
Unweeded check			2040^{cde}	741de
S.E. ±			440.0	18.06

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

Table 6: Correlation between Cowpea grain yield and various parameters under Alectra infection as affected by different herbicide mixtures at Samaru, 2004 wet season.

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.0												
2	-0.11	1.0											
3	-0.12	0.89**	1.0										
4	-0.29**	0.86**	0.77**	1.0									
5	-0.22**	0.82**	0.85**	0.87**	1.0								
6	-0.25*	0.73	0.71**	0.78**	0.77**	1.0							
7	-0.13	0.67	0.66**	0.75**	0.81**	0.84**	1.0						
8	0.28	-0.66	0.62**	-0.76**	0.71**	-0.93**	0.84**	1.0					
9	0.15	-0.67	-0.66**	-0.76**	-0.80**	-0.85**	0.99**	0.03**	1.0				
10	-0.78**	0.03	0.06	-0.06	-0.04	-0.13	-0.07	-0.13	-0.08	1.0			
11	0.23	-0.66	-0.55**	-0.67**	-0.54**	-0.55**	-0.46**	-0.54**	-0.47**	-0.17	1.0		
12	0.06	0.52	-0.36**	0.56**	0.51**	0.39**	0.38	0.33**	0.37**	-0.12	-0.36**	1.0	
13	0.07	0.52	-0.36	0.56	0.51**	0.39**	0.38	0.38	0.33**	0.37**	0.12	-0.36**	1.0

Parameters: 1 Grain yield; 2 Number of plants infected at 8 WAS; 3 Alectra count at 8 WAS; 4 Number of plants infected at 9 WAS; 5 Alectra count at 9 WAS; 6 Number of plants infected at harvest; 7 Alectra count at harvest; 8 Number of plants infected at harvest; 9 Alectra count at harvest; 10 Weight of pods; 11 Number of days to Alectra emergence; 12 Crop damage symptom score at 9 WAS; 13 Crop stand count at harves; * = Significant of 5% level of probability (r = 0.22); ** = Significant of 1% level of probability (r = 0.28).

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