

## Full Length Research Paper

## Response of cowpea genotypes to *Alectra vogelii* parasitism in Kenya

J. Karanja\*, S. N. Ngululu, J Wambua and M. Gatheru

Kenya Agricultural Research Institute (KARI) – Katumani, P.O Box 340-90100, Machakos, Kenya.

Accepted 24 October, 2013

Cowpea is popular in Eastern Kenya where it is attractive to farmers because of its high economic value and the belief that it does not require many external inputs. Farmers are however discouraged to grow the crop in this region due to massive attack by a parasitic weed *Alectra vogelii* (Benth). Yield losses due to *A. vogelii* have been estimated to range from 50 to 100% in Mbeere, Kitui and Makueni districts. No single method however is available to farmers in these regions in control of the parasitic weed. Combining several control methods, as in the management of *Striga spp* in Western Kenya should be a sustainable option. Field studies were conducted in 2010 and 2011 at Kenya Agricultural Research Institute (KARI), Kiboko farm to determine the response of 143 cowpea genotypes to *Alectra* infestation. The aim for the study was to identify resistant genotypes that could be used in breeding programme. Significant differences were observed amongst cowpea genotypes in days to first *Alectra* emergence, number of *Alectra* shoots emerged at 6, 8, 10 and 12 week after planting and grain yield. Cowpea genotypes Kir/Nya-005 and Mbe/Mach-022 showed complete resistance to *Alectra* while Ken-Kunde, M66 and K80 (all commercial varieties) supported the highest number of *Alectra* shoots. Grain yield loss in the three susceptible varieties was 80, 79 and 50% respectively. On the other hand, Sia/Cia-004, Mbe/Mach-014 and Kib-006 had high grain yields despite the high number of *Alectra* shoots present. There was a strong correlation ( $r = -0.57$ ) between grain yield and number of *Alectra* shoots emerged at 12 weeks after planting. A significant negative ( $r = -0.37$ ) correlation was also obtained between pod number per plant and number of emerged *Alectra* shoots at 12 weeks after planting. This negative correlation proves the high accumulation dry matter in the cowpea roots at the expense of the pods thus decreasing grain yield. This information showed that there is sufficient genetic variability in the cowpea genotypes studied, which can be exploited in breeding improved cowpea varieties for resistance to *A. vogelii* in Kenya. A great progress towards developing improved cowpea variety that meets farmer's preferences with durable resistance to *A. vogelii* can be achieved if the genes from the resistant and tolerant local cowpea cultivars identified in this study could be introgressed into the adapted susceptible improved varieties. This will increase the potential impact of adoption of resistant cowpea varieties in the zones.

**Key words:** Cowpea, *Alectra vogelii*, Resistance/tolerance and grain yield.

### INTRODUCTION

Cowpea (*Vigna unguiculata* L. (Walp.)) is an herbaceous warm-season annual crop that is similar in appearance to

common bean except that leaves are generally darker green, shinier, and less pubescent. Early maturing cowpea

cowpea varieties provide the first food from the current harvest sooner than any other crop (in as few as 55 days after planting), thereby shortening the “hunger period” that often occurs just prior to harvest of the current season’s crop in farming communities in the developing world. The relatively high protein content (22%) of cowpea makes it an important supplement to the diet of many African people (Bressani, 1995) who consume cereals, roots, and tuber high in carbohydrate and low in protein. Being a fast growing crop, cowpea curbs erosion by covering the ground, fixes atmospheric nitrogen, and its decaying residues contribute to soil fertility (Carsky et al., 2002; Tarawali et al., 2002; Sanginga et al., 2003).

Cowpea is the second most important grain legume in Kenya after common beans. The area under cowpea is estimated at 1800 hectares excluding the area under the crop in home gardens (Kimiti et al., 2009). About 85% of the total area under the cowpea is in arid and semi-arid lands (ASALs) of Eastern province and 15% in the Coast, Western, and Central provinces (Kimiti et al., 2009). Despite its importance in the dry regions of Eastern Kenya, its potential, growth and yield are constrained by several abiotic and biotic factors. Among them include low soil fertility, inadequate farm inputs, noxious weeds, pest and diseases and lack of seeds during planting times. This has decreased in the yield potential of 1500 to 239 kg/ha (Kimiti et al., 2009). A parasitic weed *Alectra vogelii* (Benth) an obligate root-parasitic flowering plant of the family *Scrophulariaceae* is one of the major concerns in lowering cowpea yields. In 1929, one report estimated a 20% loss in yield for cowpea crops in Embu district Eastern Kenya (Bagnall-Oakley et al., 1991).

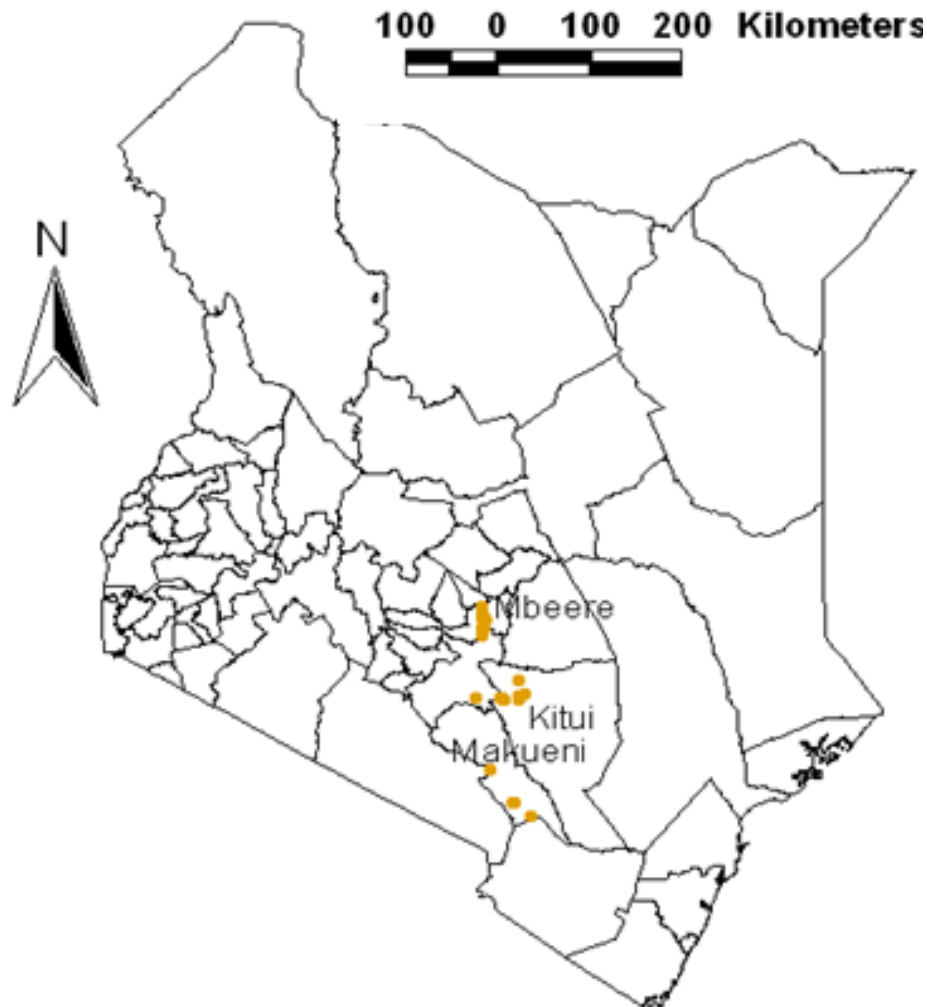
*A. vogelii* has also been observed in Bambara (*vigna subterranean* (L) Verdc.), soyabean (*Glycine max* (L) Merr.), mung bean (*Vigna radiate* (L.) Wilczek.), ground nut (*Arachi hyogaea* L.) and common bean (*Phaseolus vulgaris* L.) (Botha, 1948; Visser, 1978; Salako, 1984; Riches, 1989; Riches et al., 1992; Lagoke et al., 1993). Although *A. vogelii* is autotrophic, its photosynthetic rate is half that of host leaf on per gram dry mass basis (Gouws et al., 1980). It is said that it is not able to fix carbon at a daily rate in excess of its diurnal requirements (Harpe et al., 1981). This means *A. vogelii* depends on the host photosynthate as it induces the formation of lateral roots of the host plant (Doerr et al., 1977), also for water and nutrients. Information on cowpea yield losses resulting from *A. vogelii* infection is very scarce, but ranges from 41% (Lagoke et al., 1993) and 80 – 100% in Botswana (Riches, 1989) in a highly susceptible cultivar Black-eye. In Tanzania yield losses of up to 50% have been reported (Mbwaga et al., 2000). Yield losses of up to 15% have been reported in groundnut in Nigeria (Salako, 1984), while in South Africa 30 – 50% reductions

in yield of bambara were reported (Beck, 1987). The negative effect of the weed in reducing the vegetative and grain yield of cowpea has been well researched (Botha, 1948; Visser et al., 1977, 1990; Okonkwo and Raghavan, 1982; Rambakudzibga et al., 2002). Reports show that yield reduction is mediated through the delayed onset of flowering, reduced number of flowers and pods, and reduced mass of pods and grain (Mugabe, 1983).

From a recent survey of the level of *A. vogelii* infestation on farmers’ field, Karanja et al. (2010) observed that more than 80% of the fields grown to cowpea in Mbeere district of Eastern Kenya were infested with *A. vogelii* leading to serious crop losses. The threat of *A. vogelii* to the crop is increasing with farmers reporting up to 100% yield loss under severe infestation in these regions (Karanja et al., 2010). It is expected that the rapid spread of this parasitic weed and the enormous yield reduction caused would constitute a severe threat to cowpea production in the region.

Despite the scourge of *Alectra* on cowpea, relatively less work has been done on its control in Kenya. Several control measures, including hand weeding, chemical control, biological control, trap crops and host plant resistance have been suggested (Boukar, 2004; Riches, 1993). Of all these methods, host plant resistance appears the most effective, economical and environmentally friendly method in controlling the *Alectra* and affordable to farmers (Rubiales et al., 2006; Mainjeni, 1999; Riches, 1989). While a number of improved, high yielding *striga/Alectra* resistant cowpea genotypes have been developed and are fast becoming popular with farmers in Nigeria, Bukinafaso, Malawi, Tanzania and South Africa (Singh et al., 2002; Kabambe et al., 2008), the same cannot be said for Kenya.

Cowpea as a crop of resource-poor households been affected by *A. vogelii*, it imposes an additional stress with which farmers, who have little capacity for investment in crop production, have to cope in an environment characterized by marginal rainfall for cropping and declining soil fertility. Cowpea has traditionally been grown in multiple cropping systems in which low populations of landraces are planted in mixtures with cereals. An increase in the importance of *A. vogelii* in the last 20 years in Kenya has often been associated with a change to sole cropping of introduced, potentially higher yielding susceptible cultivars, an increase in the area and frequency of cultivation (Farms’ own communication, Mbeere district). Based on the foregoing, it is clear that there is need to screen for *Alectra* resistance among existing local cowpea cultivars or varieties. This would aid in identifying *A. vogelii* resistant genotypes that can be exploited in breeding improved cowpea varieties for resistance to *A. vogelii* in Kenya. A great progress towards developing improved cowpea



**Figure 1.** Map showing areas with high incidences of *Alectra vogelii* weed and point of cowpea local germplasm collection points in Eastern Kenya.

variety that meets farmer's preferences with durable resistance to *A. vogelii* can be achieved if the genes from the farmer's local cultivars are introgressed into the adapted susceptible improved varieties in the area. This would increase the potential impact of adoption of resistant cowpea varieties in the zones. The objectives of the studies in this paper were to collect and screen collected accessions of cowpea for their resistance/tolerance/susceptibility to *A. vogelii* in Kenya.

#### MATERIALS AND METHODS

Pot and field evaluations were conducted at the research farm of Kenya Agricultural Research Institute, Kiboko sub-centre (11° 11'N; 7° 38'E; 686 m above sea level). The pot screening was conducted in 2009 while field trials were conducted in 2010 and 2011 under irrigation. A total of 143 cowpea genotypes were collected from

Mbeere, Kitui, Makueni and Makindu (Figure 1). The 143 cowpea genotypes and two commercial checks were planted in pots. The experiment was arranged in a randomized complete block design with three replications. *Alectra* inoculum stock was obtained by thoroughly mixing 30 g of *Alectra* seeds with 500 g of sieved sand. About 10 g of *A. vogelii* from the stock (about 7,000 *Alectra vogelii* seeds) were mixed with 1.8 kg of top soil (4-10 cm) and transferred into 2 kg polythene pot. Four seeds were sown in each pot and thinned to two plants two weeks after planting. The pots were watered everyday and maintained free from any other weed other than *A. vogelii* in the course of the research through hand weeding. Observation was made on days to cowpea flowering, days to *A. vogelii* first emergence, number of emerged *Alectra* shoot at 6, 8, 10 and 12 weeks after planting (WAP) and grain yield. Analysis of variance (ANOVA) was performed on all data with the general linear model (GLM) procedure of SAS (version 8.0; SAS Institute, Cary, NC). The GLM procedure of SAS uses the method of least squares to fit data to a general linear model. The accessions were rated as resistant/tolerance and susceptible depending on number of *Alectra* plant/s emerged and grain yield.

Twenty eight cowpea accessions were selected from the pot results for further screening. The 28 cowpea genotypes and two commercial checks; M66 and K80 were further evaluated to re-validate their reaction to *A. vogelii* in 2010 at Kiboko research farm. The soils of the area are broadly classified as alfisols. The soil of the experimental site was loam with pH of 6.7. The trials were conducted under irrigation in a field that had previously been observed to be heavily infested with *A. vogelii*. The land was ploughed with disc harrow in order to get a fine tilth. Cowpea cultivars were arranged in a randomized complete block design with 3 replicates. Each plot consisted of four rows 5m long. Two seeds were sown at intra-row spacing of 0.20 m between hills and 0.75 m between rows. About 10 g of *A. vogelii* inoculum from the stock (as explained above) were added to each planting hill and thoroughly mixed before sowing to add the pool of *Alectra* seeds in the soil. The trials were always surrounded with three rows of *Alectra* susceptible check (M66). All the weeds other than *A. vogelii* were controlled through hand weeding. Cyper-methrin and dimethoate were applied with a knapsack sprayer fortnightly at the rate of 1.01/ha 4 WAP until harvest to control insect pests.

At 8 and 10 WAP, the numbers of emerged *Alectra* shoots were recorded to assess the host support for growth in the two central rows of each plot (3.75m<sup>2</sup>). All the plots were harvested at maturity and grain yield was measured as the weight of threshed grain from a plot.

In 2011, three cowpea genotypes; Kir/Nya-005, Mbe/Mach-022 and Mkn/Wot-003 identified to support zero *Alectra* emergence in 2010 were further evaluated alongside three widely grown cowpea genotypes; M66, K80 and Ken-Kunde to assess their yield potential under artificial, natural *Alectra* infestation, and *Alectra*-free condition. The trials were arranged in a randomized complete block design and in three replications. Annual weeds, except *Alectra* were controlled by hoe-weeding at 2 and 5 WAP and hand pulling during the last two weeding to avoid tampering with the un-emerged *Alectra* shoots.

Data on the number of days to first *Alectra* emergence and number of emerged *Alectra* shoots were collected from the two middle rows of each plot at 6, 8, 10, and 12 WAP from the artificial and natural *Alectra* infested treatment, while number of days to cowpea flowering, number of seeds for 10 randomly selected pods and grain yield at physiological crop maturity were collected from the three treatment. Analysis of variance (ANOVA) was performed on all data with the general linear model (GLM) procedure of SAS (version 8.0; SAS Institute, Cary, NC). The GLM procedure of SAS uses the method of least squares to fit data to a general linear model. Duncan Multiple Range (DMR) Tests were performed to compare treatment means at the 5% level.

## RESULTS

### Cowpea germplasm collection

Cowpea germplasm were collected late in the season, 2009 from farmers in Mbeere, Kitui, Yatta, Machakos, Makueni and Makindu districts of Eastern Kenya (Figure 1). Other than Machakos district, *A. vogelii* incidences were found to have severely affected cowpea production in Mbeere, Kitui, Yatta and Makueni districts. A total of 143 cowpea landraces were collected and were found almost all of them to have mixed seed colours ranging from white to black, with cream and red colours dominating. Also they were of different seed sizes from small to large, but large was dominating. The collections were sor-

sorted according to seed colour and screened against *A. vogelii* resistance. From farmers' views, mixed seed colour was not a problem as the majority grow the crop for green vegetables and home consumption and local markets. However, those found to grow the crop for other markets reported said that traders prefer uniform seed colour.

In both pot and field trials, *Alectra* shoots emerged on susceptible cowpea genotypes 44 days after planting (Table 2). However, the genotypes varied significantly in their support for *Alectra* shoots in the year. High number of *Alectra* shoots was observed at 10 and 12 WAP during the screening period. Genotypes Kir/Nya-005, Mbe/Mach-022 and Mkn/Wot-003 exhibited zero support for *Alectra* shoots, both in pot and field screenings. Under pot experiment, 81% of the collected cowpea genotypes supported *A. vogelii* emergence while 19% showed resistance for the parasitic weed (data not shown). After pre-screening the selected cowpea genotypes from the pot experiment were planted at Kiboko field to confirm their resistance against two checks (M66 and K80), Kir/Nya-005, Mbe/Mach-022 and Mkn/Wot-003 confirmed their resistance (Table 1). From Table 1, Kir/Nya-005, Mbe/Mach-022 and Mkn/Wot-003 supported no *Alectra* emergence while Mbe/Mach-004, Gac/Kar-003, Sia/Wit-004 and Ki-006 recorded the highest *Alectra* shoots at 10 WAP compared to M66 and K80. At 10 WAP, the number of emerged *Alectra* shoots ranged from 0 to 127 per 7.5 m<sup>2</sup> under artificial infestation.

In addition, *Alectra* infestation significantly reduced grain yield of Gac/Nge-003, Mkn/Kai-001 and Wot/Kil-002 recording 123, 125 and 200 kg/ha. However, Sia/Wit-001, Mbe/Mach-004 and Kib-021 recorded the highest yields despite the high number of *Alectra* shoots present (Table 1).

In 2011, there was significant differences in the number of emerged *Alectra* shoot per plot in both artificial and natural infestation. The results showed that Mbe/Mach-022, Mkn/Wot-003 and Kir/Nya-005 completely supported zero *Alectra* weed emergence. However, *Alectra* first emergence coincided with 50% days to host flowering in susceptible genotypes (Table 2). There was no significant difference on 50% days to cowpea flowering and number of seeds per pod under *Alectra* infestation and *Alectra* free condition. *Alectra* infestation significantly reduced grain yield of the susceptible cowpea genotypes (Table 3). Yield losses were statistically highly significant with Ken-Kunde and M66 recording 80 and 79%, respectively. Resistant genotype Kir/Nya-005 was the most stable recording insignificant reduction of 6.5% (Figure 1).

Mkn/Wot-003 which recorded zero number of emerged *Alectra* shoots recorded grain yields reduction of 63.5% (Table 3 and Figure 2).

## DISCUSSION

For seed size, large seeded types were more preferred

**Table 1.** Responses of cowpea genotype to *Alectra vogelii* parasitism at Kiboko, Kenya, 2010

| Code           | Collection points |                         |                          | Cowpea days  | Number Emerged | <i>Alectra</i> shoots | Grain yield |
|----------------|-------------------|-------------------------|--------------------------|--------------|----------------|-----------------------|-------------|
|                | Local name        | Latitude (S)            | Longitude (E)            | to Flowering | 8 WAP          | 10 WAP                | (kg/ha)     |
| Gac/Nge-003    | -                 | -                       | -                        | 49d          | 85.5           | 91                    | 123b        |
| Mkn/Kai-001    | -                 | -                       | -                        | 52bdc        | 55             | 68                    | 125b        |
| Wot/Kil-002    | Ndamba            | 038 <sup>0</sup> 07.23' | 02 <sup>0</sup> 42.052'  | 73.3a        | 11             | 16                    | 200b        |
| Kib-016        | C                 | 037 <sup>0</sup> 43.14' | 02 <sup>0</sup> 12.946'  | 69.3ba       | 74.5           | 127                   | 437.5b      |
| Mbe/Kir-016    | Ndamba            | 00 <sup>0</sup> 41.686' | 037 <sup>0</sup> 40.846' | 61.7bdac     | 13             | 14.5                  | 512.5b      |
| Sia/Cia-004    | A                 | 00 <sup>0</sup> 35.721' | 037 <sup>0</sup> 36.554' | 70.7ba       | 89.5           | 37                    | 587.5b      |
| Mbe/Kir-020    | Nangwe            | 00 <sup>0</sup> 45.146' | 037 <sup>0</sup> 38.693' | 69bac        | 121.5          | 93.5                  | 825b        |
| Mbe/Mach-022   | Kang'ao           | 037 <sup>0</sup> 58.37' | 02 <sup>0</sup> 33.853'  | 63.7ba       | 0              | 0                     | 825b        |
| Mbe/Mach-012   | Kamurugu          | 00 <sup>0</sup> 45.038' | 037 <sup>0</sup> 38.674' | 49.3d        | 16             | 22                    | 1075b       |
| Kir/Nya-013    | Kinyuru           | 00 <sup>0</sup> 40.418' | 037 <sup>0</sup> 38.389' | 60.7bdac     | 4.5            | 6.5                   | 1100b       |
| K80            | Check 1           | -                       | -                        | 61bdac       | 77             | 97.5                  | 1387.5b     |
| Mbe/Kir-016-2  | KVU               | 00 <sup>0</sup> 45.118' | 037 <sup>0</sup> 38.632' | 68.3ba       | 7.5            | 11                    | 1550b       |
| M66            | Check 2           | -                       | -                        | 67ba         | 76.5           | 109                   | 1662.5b     |
| Mbe/Kir-003-2  | Ndune             | 00 <sup>0</sup> 41.777' | 037 <sup>0</sup> 40.917' | 62.7bac      | 17.5           | 63                    | 2137.5b     |
| Mbe/Mach-014   | Ndamba            | 00 <sup>0</sup> 45.038' | 037 <sup>0</sup> 38.674' | 58.3bdc      | 6              | 10.5                  | 2337.5b     |
| Kib-010        | B                 | 037 <sup>0</sup> 43.16' | 02 <sup>0</sup> 12.940'  | 68.7ba       | 3.5            | 4.5                   | 2550b       |
| Kir/Nya-005    | Ndamba            | 00 <sup>0</sup> 40.808' | 037 <sup>0</sup> 38.305' | 68ba         | 10.5           | 13                    | 2812.5b     |
| Kib-018        | -                 | -                       | -                        | 66.3bac      | 50             | 7.5                   | 3212.5b     |
| Kib-006        | Ndamba            | 037 <sup>0</sup> 57.21' | 02 <sup>0</sup> 34.344'  | 68ba         | 14             | 23                    | 367.5b      |
| Mkn/Wot-003    | A                 | 037 <sup>0</sup> 43.16' | 02 <sup>0</sup> 12.939'  | 60.7bdac     | 0              | 0                     | 3887.5ba    |
| Kir/Nya-004    | Muthiriri         | 00 <sup>0</sup> 40.808' | 37 <sup>0</sup> 38.305'  | 66.3bac      | 8              | 24                    | 3925ba      |
| Kir/Nya-010    | Ndamba            | 00 <sup>0</sup> 40.722' | 037 <sup>0</sup> 38.022' | 65.3bac      | 0              | 0                     | 4012.5ba    |
| Gac/Kar-003    | Ndamba            | 00 <sup>0</sup> 35.562' | 037 <sup>0</sup> 31.342' | 64.7bac      | 81.5           | 116                   | 4400ba      |
| Kir/Nya-016    | Gikuu             | 00 <sup>0</sup> 40.418' | 37 <sup>0</sup> 38.389'  | 59.3bdac     | 77             | 87                    | 4512.5ba    |
| Mbe/Mach-007   | Ndamba            | 00 <sup>0</sup> 47.051' | 37 <sup>0</sup> 39.878'  | 65.3bac      | 27             | 69                    | 4812.5ba    |
| Sia/Wit-004    | Ndamba            | 00 <sup>0</sup> 35.605' | 37 <sup>0</sup> 38.440'  | 69ba         | 99.5           | 124                   | 4837.5ba    |
| Sia/Cia-005    | B                 | 00 <sup>0</sup> 35.721' | 037 <sup>0</sup> 36.554' | 61.7bdac     | 19             | 37                    | 5812.5ba    |
| Kib-021        | -                 | -                       | -                        | 65.3bac      | 12.5           | 17.5                  | 6237.5ba    |
| Mbe/Mach-004   | Ndamba            | 00 <sup>0</sup> 46.916' | 37 <sup>0</sup> 39.548'  | 66bac        | 81             | 110                   | 6362.5ba    |
| Sia/Wit-001    | Kamurugu          | 00 <sup>0</sup> 35.631' | 37 <sup>0</sup> 38.549'  | 61.3bdac     | 69             | 91.5                  | 10512.5ba   |
| Mean           |                   |                         |                          | 63.7         | 40.3           | 50.4                  | 2875        |
| L.s.d (P<0.05) |                   |                         |                          | 11.93        | 66.1           | 57.2                  | 5796.2      |
| Cv%            |                   |                         |                          | 11.5         | 87.3           | 54.6                  | 15037.5     |

Means followed by the same letter (s) in a column are not significantly different at 5% level of probability using Duncan multiple range test.

at the local markets than the small seed. These are good guidelines that are to be considered when breeding for *Alectra* resistance to select what the farmers and market like. This study showed significant differences exist amongst cowpea genotypes in their performance under *Alectra* infestation. These differences occurred in the number of emerged *Alectra* shoots and grain yield. Lower cowpea grain yield with number of emerged *Alectra* shoot, shows that *Alectra* infestation reduced grain yield for cowpea genotypes susceptible to *Alectra*. This is well signified by Ken-Kunde which is the highest yielder under un-infested conditions but lowest under *Alectra* infested

conditions. Ken-Kunde, M66 and K80 which had high grain yield reduction (over 50%) could be regarded as being susceptible. The symptoms displayed these susceptible cultivars were that of stunted growth, chlorosis and premature defoliation as earlier reported by Magani (1994). Longe et al. (2002) observed that resultant chlorosis could be due to chlorophyll degradation which result to reduction in photosynthetic site hence, yield reduction. A combination of high yield, growth potentials and no support for *Alectra* shoots by Kir/Nya-005, and Mbe/Mach-022 cultivars make them suitable candidates for use to improve the genetic base of existing cultivars. The

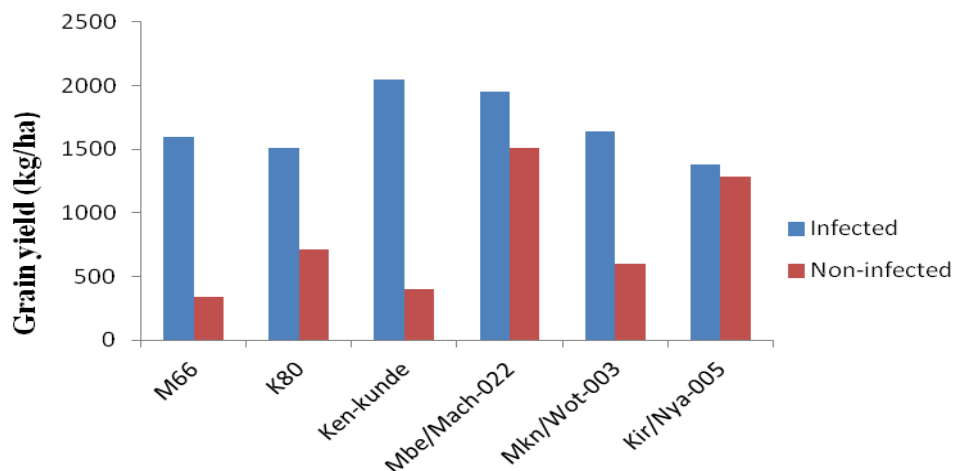
**Table 2.** Days to *Alectra* first emergence, emerged *Alectra* shoots at 6, 8, 10 and 12 weeks after planting of cowpea genotypes under artificial and natural field infestation of *Alectra vogelii* at Kiboko, 2011.

| Genotype       | Artificial             |                                     |      |      |      | Natural                |                                     |       |      |      |
|----------------|------------------------|-------------------------------------|------|------|------|------------------------|-------------------------------------|-------|------|------|
|                | Days to <i>Alectra</i> | Emerged <i>Alectra</i> shoots (WAP) |      |      |      | Days to <i>Alectra</i> | Emerged <i>Alectra</i> shoots (WAP) |       |      |      |
|                | First emergence        | 6                                   | 8    | 10   | 12   | First emergence        | 6                                   | 8     | 10   | 12   |
| M66            | 40.7                   | 2                                   | 18.3 | 65   | 70   | 43                     | 0.7                                 | 6.7   | 56   | 57   |
| K80            | 43                     | 0                                   | 5    | 32.7 | 34   | 43.6                   | 0.3                                 | 12.3  | 48   | 49.7 |
| Ken-kunde      | 42.7                   | 0.7                                 | 12.7 | 75   | 76.7 | 45.3                   | 0                                   | 7.7   | 42   | 42.3 |
| Mbe/Mach-022   | 0                      | 0                                   | 0    | 0    | 0    | 0                      | 0                                   | 0     | 0    | 0    |
| Mkn/Wot-003    | 0                      | 0                                   | 0    | 0    | 0    | 0                      | 0                                   | 0     | 0    | 0    |
| Kir/Nya-005    | 0                      | 0                                   | 0    | 0    | 0    | 0                      | 0                                   | 0     | 0    | 0    |
| Mean           | 31.2                   | 0.4                                 | 6.1  | 29.1 | 30.4 | 22                     | 0.2                                 | 4.4   | 24.3 | 24.8 |
| L.s.d (P<0.05) | 18.7                   | 1.14                                | 7.7  | 19.5 | 22.6 | 2.9                    | 1.0                                 | 13.1  | 27.6 | 27.3 |
| cv%            | 15.1                   | 57.3                                | 15.7 | 10   | 12.8 | 7.2                    | 328.6                               | 162.1 | 62.4 | 60.3 |

**Table 3.** Combined analysis of 50% Days to cowpea flowering, number of pods per plant, grain yield and percentage yield reduction of six cowpea genotypes under *Alectra vogelii* infected and un-infected condition at Kiboko, 2011.

| Genotype      | Infected                |           |                     | Un-infected             |           |                     | Yield reduction (%) |
|---------------|-------------------------|-----------|---------------------|-------------------------|-----------|---------------------|---------------------|
|               | Days to flowering (50%) | Seeds/pod | Grain yield (kg/ha) | Days to flowering (50%) | Seeds/pod | Grain yield (kg/ha) |                     |
| M66           | 50.5a                   | 13.0a     | 337.8b              | 50.0a                   | 13.3a     | 1600.0a             | 78.9                |
| K80           | 48.8ba                  | 13.6a     | 711.1b              | 51.0a                   | 14.0a     | 1511.1a             | 52.9                |
| Ken-kunde     | 48.3ba                  | 13.111a   | 400.0b              | 47.0b                   | 12.4a     | 2044.4a             | 80.4                |
| Mbe/Mach-022  | 48.3ba                  | 14.0a     | 1511.1a             | 50.0ba                  | 12.6a     | 1955.6a             | 22.7                |
| Mkn/Wot-003   | 48.11b                  | 10.5b     | 600.0b              | 50.0ba                  | 12.6a     | 1644.4a             | 63.5                |
| Kir/Nya-005   | 47.0b                   | 12.8a     | 1288.9a             | 51.3a                   | 12.6a     | 1377.8a             | 6.5                 |
| Mean          | 48.4                    | 12.9      | 808.2               | 50.06                   | 12.9      | 1688.9              | 50.8                |
| L.s.d (0.05%) | 2.2                     | 1.5       | 349.4               | 1.63                    | 1.5       | 608.6               |                     |
| cv%           | 4.5                     | 11.9      | 43.2                | 3.3                     | 11.9      | 36                  |                     |

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using Duncan Multiple Range Test.

**Figure 2.** Effect of *Alectra vogelii* on grain yield on six cowpea genotypes compared to *Alectra* free condition.

failure of *Alectra* emergence may be due to low production of germination stimulants by these two genotypes or host-plant-parasite incompatibility whereby the initiation of haustoria, and subsequent attachment and penetration are inhibited (Okonkwo and Raghavan, 1982). This confers resistance of the genotypes as earlier reported in cereals to striga resistance (Ejeta, 1993a, b). In 1983, Mugabe showed delayed onset of flowering, reduced number of flowers and pods and reduced weight of pods and seeds in cowpea due to *Alectra* infestation. This indicates that Sia/Wit-004, Sia/Cia-005, Kib-021, Mbe/Mach-004 and Sia/Wit-001 are either moderately resistance or tolerant to *A. vogelii*. This might have been achieved through low production of germination stimulant which in one of the resistance mechanism advocated by Yohanna et al., 2010. Kurech and Alabi (2003) considered tolerance as a horizontal resistance which is polygenic in contrast to vertical resistance which breaks down faster with time. Since the tolerant genotypes can produce high yield in spite of high parasitism, it implies they have to be very efficient in the production of assimilates to support the parasites and still have enough to give high yields (Musell, 1980). Several authors (Atokple et al., 1995; Kim and Adetimirin, 1997; Adetimirin et al., 2000; Kim, 2000) have indicated that the use of moderately tolerant varieties in combination with other control measures help in the depletion of *Alectra/Striga* soil seed bank.

The decrease in the yield of varieties Mnk/Wot-003 (variety that was hardly found with any attached *Alectra*) by *Alectra* could have been partly due to the reduction in its root growth and root nodulation by the *Alectra*. This could result in inadequacy of nitrogen and nutrient absorption for adequate shoot growth and thereby reduced yield production (Dart and Mercer, 1965). It is also likely that, the seeds of *Alectra* contain certain toxins which leaked into the soil and hindered Mkn/Wot-003 root growth, but this may require further investigation as also suggested by Omoigui et al., 2007. In addition to the export of nutrients, water and metabolites from host to the parasite, *Alectra* prevents nodulation (Kurech and Alabi 2003).

## Conclusion

These results could be used as a preliminary basis for choosing cowpea genotypes in encouraging farmers to grow and assembling management packages for *A. vogelii* to ensure reduced risk to farmers. Compared to Ken-Kunde, M66 and K80, it was interesting to note that the Kir/Nya-005 and Mbe/Mach-022 had zero emergences *Alectra* recorded throughout the evaluation period hence suggesting a possible absolute resistance. This information would be valuable for breeding effort to develop or select *Alectra* resistant cowpea varieties. However, there is need to evaluate the genotypes with

farmers.

## ACKNOWLEDGEMENT

This publication is part of the output from a project funded by the European Union through Kenya Arid and Semi-arid lands program in Kenya Agricultural Research Institute (KARI) to whom we are very grateful.

## REFERENCES

- Adetimirin VO, Kim SK, Aken'ova ME (2000). Expression of mature plant resistance to *striga hermonthica* in maize. *Euphytica*, 34:1-10.
- Atokple IDK, Singh BB, Emechebe AM (1995). Genetics of resistance to *striga* and *Alectra* in cowpea. *J. Heredit.* 86:45-59.
- Bagnall-Oakley H, Gibberd V, Nyongesa TE (1991). The incidence and control of *A. vogelii*, in Embu district, Kenya. In: Ransom, J. K., Musselman, L. J., Worsham, A. D., Parker, C. (Eds.), *Proceedings of the 5<sup>th</sup> International Symposium on Parasitic Weeds, CIMMYT, Nairobi, Kenya*.
- Beck BDW (1987). The effect of *Alectra vogelii* Benth. On the yield of njigo beans (*Vigna subterranean* (L.) Verdc.). In: Chr. Weber H, Forstreuter W (Eds). *Parasitic Flowering Plants*. Phillips University, Marburg, Gemarny. pp.79-82.
- Botha PJ (1948). The parasitism of *Alectra vogelii* with special reference to the germination of its seeds. *J. South Afri. Bot.* 16:49-72.
- Boukar O, Kong L, Singh BB, Murdock I, Ohm HW (2004). AFLP and AFLP-derived SCAR markers associated with striga gesnerioides resistance in Cowpea {*Vigna unguiculata* (L.) Walp.}. *Crop Science* 44:1259-1264.
- Bressani R (1985). Nutritive value of cowpea. In cowpea research, production, and utilization. Singh, S. R and Rachel, K. O (Eds.), Wiley and sons, Chester, Uk. pp. 353-360.
- Carsky RJ, Vanlauwe B, Lyasse O (2002). Cowpea rotation as a resource management technology for cereal-based systems in the savannas of West Africa. In: Fatokun, C. A., Tarawali, S. A., Singh, B. B., Kormawa, P. M., Tamo, M. (eds.). *Challenges and Opportunities for Enhancing Sustainable Cowpea Production*. International Institute of Tropical Agriculture, Ibadan, Nigeria, pp.252-266.
- Dart PJ, Mercer FV (1965). The effect of growth temperature, level of ammonium nitrate, and light intensity on the growth and nodulation of cowpea (*Vigna sinensis* End]. ex Hassk.). *Aust. J. Agricul. Res.* 16:321-345.
- Doerr I, Visser JH, Albers F (1977). On the parasitism of *Alectra vogelii* (Benth.). (Scrophulariaceae) II. Origin of lateral roots in the contact area of the haustorium.
- Ejeta G, Butler LG (1993a). Host plant resistance to striga. In: *International crop science 1*. Crop Science Society of America., Madson, WI, USA. pp.561-569.
- Ejeta G, Butler LG (1993b). Host plant interactions throughout the striga life cycle, and their contributions to striga resistance. *Afr. Crop Sci. J.* 1(2):75-80.
- Gouws J, Visser JH & Grobbelaar NZ (1980) Some aspects of the bidirectional translocation of C-14 labeled metabolites between *Alectra vogelii* (Benth) and *Voandzeia subterranea* (L) Thou. *Zeitschrift fu' r Pflanzenphysiologie* 99, 225-233.
- Harper JM (1981). *Extrusion of foods*. CRC Press, Inc. Boca Raton, F.L. Vol. 1: 212.
- Kim SK (2000). Horizontal resistance, misunderstanding, approach and importance. In: Kim, S. K., Robinson, K., Atkinson, V. O., Adetimirin, C., and Salle, G. (ed.) *Combating striga parasitic weeds through horizontal resistance*. Proceedings of the International workshop on horizontal resistance for controlling parasitic weeds held at Hotel President World Centre, Brussel, Belgium. 1997:35-53.

- Kim SK, Adetimirin VO (1997). *Striga hermthica* seed inoculum rate effects on maize hybrids tolerance and susceptibility expression. *Crop Sci.* 37:1066-1071.
- Kabambe VH, Katunga L, Kapewa T, Ngwira AR (2008). Screening legume for integrated management of witchweeds (*Alectra vogelii* and *Striga asiatica*) in Malawi. *Afr. J. Agric. Res.* 3(10):708-715.
- Karanja JK, Ngululu SN, Gatheru M (2010). Farm yard manure reduces the virulence of *Alectra vogelii* (Benth) on cowpea (*Vigna unguiculata*). Paper presented at Bondo University College conference, February, 2010.
- Lagoke STO, Shebayan JY, Magani I (1993). *Striga* problem and control in Nigeria. Paper presented at the Third General Workshop of Pan Africa *Striga* control Network, Harare, Zimbabwe.
- Magani EI (1994). Effect of fertilizers and herbicides on the reaction of cowpea varieties (*Vigna unguiculata* L Walp) to *Alectra vogelii* Benth; Doctor of Philosophy Thesis, Department of Agronomy, Ahmadu Bello University, Zaria. pp.133-138.
- Mbwaga AM, Kaswende J, Shayo E (2000). A reference manual on striga distribution and control in Tanzania. Kilosa, Tanzania: Ilonga Agricultural Research Institute.
- Mugabe NR (1983). Effect of *Alectra vogelii* (Benth.) on cowpea (*Vigna unguiculata* (L.) Walp.) I. Some aspects on reproduction of cowpea. *Zimbabwe J. Agric. Res.* 21:135-147.
- Mainjeni CE (1999). The host range of *Alectra vogelii* Benth. From Malawi and resistance in common bean and cowpea. MSc. Thesis, University of Bath, UK. p. 83.
- Musell H (1980). Tolerance to Disease. In: Horsfall, J. and Cowling, E. B. (Ed.). How plant defend themselves. An Advanced Treatise Academic Press, New York. 5:39-52.
- Okonkwo SNC, Raghavan V (1982). Studies on the germination of seeds of the root parasites. *Alectra vogelii* and *Striga gesnerioides*. I Anatomical changes in the embryo. *Am. J. Bot.* 69:1636-1645.
- Omoigui LO, Kamara AY, Massawe FS, Ishiyaku MF, Boukar O, Alab SO, Ekeleme F (2007). Evaluation of cowpea genotypes for their reaction to *striga gesnerioides* in the dry savanna of northeast Nigeria. *Africa Crop Science Conference Proceedings* 8:273-278.
- Rambakudzibga AM, Manschadi AM, Sauerborn J (2002). Host-parasite relations between cowpea and *Alectra vogelii*. *European Weed Research Society Weed Research*, 42:249-256.
- Riches CR (1989). The biology and control of *Alectra vogelii* Benth (*Scrophulariaceae*) in Botswana. Ph.D. Thesis, University of Reading, UK, p.208.
- Riches CR, Hamilton KA, Parker C (1992). Parasitism of grain legumes by *Alectra* species (*Scrophulariaceae*). *Ann. Appl. Biol.* 121:361-370.
- Rubiales D, Perez D, Luque A, Fernandez-Aparica M, Sillero JC, Roman B, Kharrat M, Khalil S, Joel DM, Riches CR (2006). Screening techniques and sources of resistance to parasitic weeds in grain legumes. *Euphytica* 147: 187-199.
- Salako E.A (1984). Observation on the effect of *A. vogelii* infestation on the yield of groundnut. *Trop. Pest Manage.* 30: 209-211.
- Sanginga N, Dashiell K, Diels J, Vanlauwe B, Lyasse O, Carsky RJ, Tarawali S, Asafo-Adjei B, Menkir A, Schulz S, Singh BB, Chikoye D, Keatinge D, Rodomiro O (2003). Sustainable resource management coupled to resilient germplasm to provide new intensive cereal-grain legume-livestock systems in the dry savanna. *Agric. Ecosyst. Environ.* 100: 305-314.
- Singh BB (2002). Breeding cowpea varieties for resistance to *striga gesnerioides* and *Alectra vogelii*. In Challenges and opportunities for enhancing sustainable cowpea production. Fatokun, C. A. (Ed.). IITA, Ibadan, Nigeria. pp.154-166.
- Tarawali SA, Singh BB, Gupta SC, Tabo R, Harris F, Nokoe S, Fernández-Rivera S, Bationo A, Manyong VM, Makinde K, Odion EC (2002). Cowpea as a key factor for a new approach to integrated crop-livestock systems research in the dry savannas of West Africa. In: Fatokun CA, Tarawali SA, Singh BB, Kormawa PM, Tamo M (eds) Challenges and Opportunities for enhancing Sustainable Cowpea Production. International Institute of Tropical Agriculture, Ibadan, Nigeria, pp. 233-251.
- Visser JH (1978). The biology of *Alectra vogelii* (Benth.). an angiospermous root parasite. *Beitrage Zur Chemischem Kommunikation in Biologie und Oekosystemen*, Witzenhausen, Germany, pp.279-294.
- Visser JH, Doerr I, Kollmann R (1977). On the parasitism of *Alectra vogelii* (Benth.) (*Scrophulariaceae*) I. Early development of the primary haustorium and initiation of the stem. *Zeitschrift fur Pflanzphysiologie* 84:213-222.
- Visser JH, Doerr I, Kollmann R (1990). Compatibility of *Alectra vogelii* with different leguminous host species. *J. Plant Physiol.* 135:737-745.
- Yohanna MK, Olussoji O, Balarabe T, Shebayan J, Lagoke STO (2010). Genotype Effect on the Reaction of Groundnuts to *Alectra vogelii* (Benth.) Infestation in a Sub-humid Environment. *J. Am. Sci.* 6:10.