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Effects of Yellow Witchweed (*Alectra vogelii*) Strains on Performance of Improved Cowpea (*Vigna unguiculata* (L) Walp.) Genotypes

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ABSTRACT

Witchweed (*Alectra vogellii)* has continuously remained a great challenge for cowpea production in sub-Saharan Africa. Developing resistant and stable high yielding cowpea genotypes in *Alectra* infested areas requires evaluation of available cowpea germplasm for resistance against the weed. To achieve this, an experiment was conducted in the screen house at Ilonga Agricultural Research Institute (ARI-Iloga), Tanzania in 2017 to determine how selected cowpea genotypes fair in soils infested with different *Alectra strains*. The experiment comprised of two factors namely *A. vogellii* strains as the main factors and cowpea genotypes as sub-factors and was carried out as a spilt plot experiment arranged in randomized complete block design with three replications. Results revealed significant differences amongst cowpea genotypes on days to first *Alectra* emergence and number of emerged *Alectra* shoots. The cowpea genotypes B 301, Mkanakaufiti, Vuli AR1, Vuli AR2 and Vuli-1 allowed *Alectra* emergence at 42.83, 37.25, 36.75, 37.42 and 33.17 days after planting (DAP), respectively. There were variations in number of *Alectra* shoots supported by genotypes, as 1.0, 5.0, 4.0, 5.0 and 14.0 for B301, Mkanakaufiti, Vuli AR1, Vuli AR2 and Vuli-1, respectively. The genotype B 301 recorded the lowest number of *Alectra* shoots, reached 50% flowering earlier and had the highest seeds and pods weight and highest number of pods per plant. Contrarily, the genotype Vuli-1 produced the highest number of seeds per pod and was the first to reach 95% physiological maturity. The genotype B 301 was identified to possess a high level of resistance to *A.vogelii* infestation and accordingly was deemed as a useful source of resistance genes in cowpea resistance breeding programs.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.), is both a delicacy and livelihood crop for many households in Sub Saharan Africa where it contributes to food and nutrition security (Adeigbe et al., 2011; Alemu et al., 2016; Silver et al., 2018). This is associated with its good protein quality with a high nutritional value, nitrogen fixing ability, tolerance to drought and heat, quick growth, and rapid ground cover (Magashi et al., 2014; Lado et al., 2016). In harsh environments, the crop yields comparably higher than other food legumes (Shiringan & Shimelis, 2011). Therefore, cowpea provides multiple benefits to smallholder farmers in terms of food, income, and livestock feed, and improving and maintaining soil fertility (Adeigbe et al*.,* 2011; Olasupo et al., 2016; Thio et al., 2016; Lado et al., 2016).

Despite the importance of the crop, it is yet affected by a number of biotic and abiotic constraints that lead to low yields of both grain and fodder (Animasaun et al., 2015; Horn et al., 2015). Among the most important biotic factors that limit the productivity of cowpea in Tanzania, yellow witchweed *(Alectra vogelii),* is the principal parasitic weed. The weed attacks cowpea especially in semi-arid areas with low or acute nutrient deficiency in the Sub-Saharan Africa region (Kutama et al*.,* 2014; Mbwando et al., 2016; Njekete et al., 2017). The weed needs to be controlled before it flowers and produce seeds. If uncontrolled the weed will produce seeds which will results into soil contamination with the *Alectra* seeds. Once the soil is contaminated with the seeds, soil seed bank will increase and weed seeds will spread to new areas which will results into poor land quality and consequently food insecurity (Atera et al., 2013; Mbega et al., 2016). *A. vogelii* causes tremendous damage to the host plants before it emerges from the soil affecting its vigour and performance as it emerges (Kwaga, 2014).

Several control measures against Alectra vogellii have been developed which include application of fertilizers, herbicide and cultural practices among others. However, these measures are not economically feasible and sometimes not successful in controlling the weed (Kwaga, 2014). Therefore, the development and deployment of resistant cowpea varieties remain the most effective method to combat the problem presented by the weed and enhance food security among small holder farmers (Omoigui et al., 2012; Abdou, 2017). Despite of the efforts to popularize cowpea crop, the incidence and spread of *A. vogelii* appears to be on the increase due to aggressiveness of the weed and appearance of new and highly infective *A. vogellii* strains (Kabambe et al. 2013). Therefore, the aggressiveness and evolution of new virulent strains of *A. vogelii*, call for studying the response of the improved cowpea varieties to *Alectra* strains in selected areas. The purpose of this study was to determine the effect of *Alectra* strains infestation on performance of improved cowpea genotypes.

MATERIALS AND METHODS

Study area

A screen house pot experiment to determine the response of improved cowpea varieties against yellow witchweed was conducted at Ilonga Agricultural Research Institute (ARI Ilonga), in Morogoro, Tanzania, (06° 42'S, 37°02' E, Altitude 506 meters above sea level)

Alectra vogellii germination test

Petri dish method was used during germination test. This method allows more detailed studies on induction of germination. Preconditioning of *Alectra* seeds was performed under sterile conditions in a Laminar Air flow cabinet before the seeds become responsive to germination stimulants. The active seed germination stimulant of the parasitic weeds of *Orabanchaceae* called GR24 was used to test for germination of *Alectra* seeds. Five gram (5g) of *Alectra* seeds were surface sterilized in 5 % (v/v) sodium hypochlorite solution for 30 minutes in a test tube, with gentle agitation. Subsequently the seeds were rinsed thoroughly with 100 ml of sterile distilled water, then spread on a glass fiber filter paper (Whatman GFA), put into sterile Petridishes and wet with 2.5 ml of sterile distilled water. The Petridishes were then sealed with parafilm and wrapped with aluminium foil to prevent water losses and exclude light. There after the Petridishes were placed in an incubator for 14 days at 30 ^{0}C for conditioning. The period of conditioning allows the seed to germinate because seeds imbibe water before exposure to germination stimulant. After conditioning, the *Alectra* seeds were treated with a sterile germination stimulant (GR 24) to induce germination. Equal volume of 2.5 ml of the GR24 stimulant was added to each Petri dish of 9.0 cm having the pre-conditioned seeds. When the radicle protruded through the seed coat, the seeds were considered to have good germination.

General method of the experiment

About 500 *Alectra* seeds of each strain were thoroughly mixed separately with 250 ml of sterilized sieved sand to form the inoculum stock. The inoculum stock was used to inoculate the top 5 cm of each experimental pot which contained a mixture of soil and sand (3:1 v/v). After inoculation, the *Alectra* seeds were pre-conditioned for seven days before sowing the cowpea seeds to enhance *Alectra* seed germination. After the soil was inoculated with *Alectra* seeds, the pots were watered daily to field capacity for seven days consecutively to precondition the seeds to break their dormancy and ensure optimum germination.

Experimental design

The experiment was designed as a spilt plot experiment laid in a randomized complete block design (RCBD) with three replications. *Alectra* strains (4 strains namely strain 1, 2, 3 and 4) were used as main plot (factor A) and the cowpea genotypes were used as sub plot (factor B). Five cowpea genotypes were used as treatments in this experiment, namely; Vuli AR1, Vuli ARI 2, Mkanakaufiti, and with local checks B 301 (resistant) and Vuli- 1 (susceptible). The genotype Vuli-1 is the locally adapted and a widely grown cowpea cultivar. Three (3) seeds of cowpea were sown per pot in 3 replications and at uniform depth in holes 5 cm deep. The seedlings were thinned out and two were maintained per pot at two (2) weeks after germination. The soil was kept moist by watering regularly every two days or when necessary.

Data collection and analysis

Data collected include; plant height, number of leaves per plant, number of branches per plant, number of nodes per plant, leaf area index (LAI), days to 50% flowering of cowpea plants, days to 95% physiological maturity, days to *Alectr*a emergence, and number of *Alectra* per plant. The cowpea plants were harvested at physiological maturity, when more than 95% of the pods were dry and brown.

Yield in a crop is governed by yield components (Oladejo et al., 2011). Yield variables measured include the number of pods per plant, pods length, number of seeds per pod, 100 seeds weight, and seed yield. The number of pods per plant was obtained by randomly selecting five plants within the sub-plot and counting the pods on them. The average number of pods per plant was then determined. Also, 10 pods from each sub plot per replication were selected and their lengths measured with a meter ruler. For the average number of seeds per pod, twenty pods from each sub plot per replication were shelled and the seeds counted and their averages calculated. Four lots of 100 seeds from the shelled pods of each sub- plot were counted and weighed. The average was then taken as the weight of 100 seeds. After harvesting pods from each sub- plot, were shelled, the seeds were weighed and the average was calculated to determine the final yield and expressed in grams per plant (g plant^{-1}). These data were then analysed using GenStat Discovery 16th Edition. Means were separated using Turkey Honest Significance Difference test at 5% level of significance.

RESULTS AND DISCUSSION

There were significant differences (P = 0.001), among cowpea genotypes in response to *Alectra* strains (Table 1). Results showed that, four resistant genotypes (B301, Mkanakaufiti, Vuli AR1 and Vuli AR2) were also infested by *A. vogelii.* Cowpea genotypes supported *Alectra* emergence whereas Vuli-1 supported the earliest emergence of the weed, followed by Vuli AR1, and the latest was B301. The effect of cowpea genotypes on *Alectra* emergence was first observed in strain 4 of *A. vogelii*, followed by strain 2 and latest in strain 1. The difference in days to emergence was observed among the strains of *A. vogelii* and among cowpea genotypes. Such differences were also reported by Alonge et al*.* (2001) that cowpea varieties have genotypic differences in their response to *A. vogelii*. These observed responses of cowpea genotypes to *A. vogelii* strains indicate that the genes controlling these parasites are non-allelic and independent of one another (Omoigui et al., 2012; Mbwambo et al., 2016; Ugbaa et al., 2020).

There was significant (P=0.001) effect of *Alectra vogelii emergence* on cowpea genotypes (Table 1). Genotype Vuli 1 was the earliest, supported the *A. vogelii* emergence 33.2 days after planting (DAP) and the genotype B302 was the latest (42.8 DAP). Cowpea genotypes differ in days to emergence due to the differences in the thickness of the seed coat and tissue layers among the genotypes (Onyishi *et al.,* 2013). Also, the difference in days to *A. vogelii* emergence is the result of the ability of cowpea genotypes to stimulate the germination of *Alectra* seeds and subsequently allowing for the emergence of shoots. The days to *Alectr*a emergence in B 301 coincided with its days to flower onset (Table 1 and 2). Thus, B301 is having the attributes of low production of stimulants for the germination of *Alectra* seeds as well as attachment and prevention of haustoria formation and subsequent development of the seedling of the parasite. Previous studies on cowpea, soybean, and groundnuts reported the emergences of *A. vogelii* at 55 DAP, 75 DAP and 109 DAP, respectively (Kabambe et al., 2008) which contrast with 37.5 DAP found in this study. This would suggest that, the *A. vogelii* strains used in this study were very aggressive, or cowpea genotypes were able to allow the emergence of *A. vogelii* strains due to their ability to produce high levels of stimulants.

Table 1: Effect of cowpea genotypes on the emergence and number of *Alectra* shoots per plant

Strains (a)	Days to *Alectra* emergence	Number of 35 DAP	shoots per 49 DAP	plant at 63 DAP
1	39.33 a	1.47a	6.47 a	9.00 a
2	36.93 a	1.73 a	5.67 a	7.00 a
3	37.73 a	3.49 a	6.94 a	7.33 a
4	35.93 a	4.13a	6.75 a	7.93 a
Grand mean	37.48	2.71	6.46	7.82
CV%	5.6	52.80	19.40	17.30
SE±	2.09	1.43	1.25	1.35
P- value	0.33	0.16	0.64	0.37
Genotypes (b)				
B 301	42.83 c	0.67 a	1.33 a	1.25 a
Mkanakaufiti	37.25 b	2.62 a	4.08 b	6.83 b
Vuli AR 1	36.75 b	2.42 a	5.33 b	5.0 b
Vuli AR 2	37.42 b	2.58a	5.33 b	6.25 b
Vuli-1	33.17 a	5.25 b	16.17 c	19.75 c
Grand mean	37.48	2.71	6.46	7.82
CV%	7.90	85.50	45.10	37.6
SE±	2.97	2.32	2.91	2.94
P- value	0.001	0.001	0.001	0.001

Means in the same column followed by the same letter(s) are not statistically different (P< 0.05) by Duncan's New Multiple Range Test.

There were significant differences (P = 0.001), on the effect of genotypes on number of *Alectra* shoots at 35 DAP, 49 DAP and 63 DAP. At 35 DAP, Vuli-1 had the highest number of *Alectra* shoots per plant (SPP), followed by Mkanakaufiti and the lowest SPP was recorded in B301 (Table 2). At 49 DAP, Vuli-1 had highest number of *Alectra* shoots per plant, followed by Vuli AR1 and Vuli AR2 which had the same number of *Alectra* shoots per plant and the lowest was recorded in B301. At 63 DAP, Vuli-1 had higher number of *Alectra* shoots per plant, followed by Mkanakaufiti and lowest in B301. The resistance in genotype B 301 has been reported to be controlled by a single major gene, which may not be durable (Gnanamanickam et al., 1999) because resistance conferred by a single major gene (vertical resistance), frequently fails to provide long term control to parasitic weeds. If such varieties are grown over a broad area they potentially lead to serious breakdown of resistance. Therefore, breeding for vertical gene resistance requires pyramiding of more than one gene from diverse resistance sources into a single genotype as vertical resistance is associated with a common phenomenon of the resistance breakdown (Gnanamanickam et al., 1999). This would provide a better option so as to delay breakdown, broaden the resistance genetic base and provide much needed durable resistance.

Interaction effect on cowpea genotypes and *A. vogelii* showed that, days to *Alectra* emergence were different among cowpea genotypes and *Alectra* strains (Figure 1). However, *Alectra* emerged earlier in Vuli-1 with strains 2, 3 and 4, followed by the same genotype Vuli-1 with strain 1 and Vuli AR1 with strain 4, all with the same number of days to *Alectra* emergence, whereas *Alectra* emerged latest in B301.

Interaction effect of cowpea genotypes and strains of *Alectra vogelii* on number of *Alectra* shoots per plant is presented in Figure 2. The genotypes Vuli AR1 with strain 1 and B301 with train 3 had the lowest number of *Alectra* shoots. At 35 DAP, more *Alectra* shoots per plant were observed in Vuli-1 with strain 4, followed by Vuli AR1 with strain 4 and lowest in three different genotypes which are B 301 with strain 1 and 3, Vuli AR1 with strain 1 and 3 and Vuli AR2 with strain 2. At 49 DAP, Vuli-1 with strain 1, 2, 3 and 4, recorded more *Alectra* shoots per plant followed by Mkanakaufiti with strain 3. At 63 DAP, Vuli-1 had the highest number of *Alectra* shoots per plant in all strains, followed by Mkanakaufiti and the lowest was in B 301.

The plant height of cowpea was significantly affected by the different *Alectra* strains (Table 2). The tallest plant was observed in strain 3, followed by strain 4 and shortest plant was observed in strain 1. With respect to genotypic effects, tallest plants were observed in Vuli AR1, followed by Mkanakaufiti and the shortest plants were in Vuli 1.

Genotypes did not differ significantly in number of leaves per plant (Table 3). However, Vuli AR 1 had numerically higher number of leaves per plant compared with the other genotypes. This characteristic is important for the genotype if its leaves are used as vegetables and also can be used as livestock feed during the dry season of the semi-arid areas when fodders are scarce. The genotype Vuli AR1 also recorded the highest mean leaf area index (LAI) whilist the lowest leaf area index was recorded in genotype Vuli- 1. Varietal differences among the cowpea genotypes or differences in anatomical, morphological and physiological features affect the leaf area resulting to differences on leaf area index of the genotypes (Onyishi et al., 2013).

The results also indicated that there were significant differences ($P<0.05$) in days to 50% flowering among the genotypes whereas the earliest days to 50% flowering plants were recorded in genotype B 301, followed by Vuli AR1 while the latest were observed in Mkanakaufiti. The genotype Mkanakaufiti was also recorded as a late flowering on set genotype. The delayed onset of flowering in cowpea genotypes due to *Alectra* infestation, can lead to reduction in number of flowers, number of pods, weight of pods and seeds (Alonge *et al*. 2001). The number of seeds per pod was affected by of *A.vogelii*, and Mkanakaufiti genotype produced the least number of seeds per pod. The genotype B 301 attained 50% flowering earlier and the latest was Mkanakaufiti (Table 2). The mean value to 50% flowering in B 301 was 46.58 DAP. The days to 50% flowering as reported by Ishayaku andSingh (2003), on two cultivars of cowpea were 31 and 38 days. Thus, different host genes might result to differential maturity periods. The attribute of flowering is controlled by a single dominant gene in cowpea (Ishayaku & Singh 2003). The difference in the genotypes on time to flowering varies depending on the environmental factors like temperature, altitude, soil conditions, and photoperiod during the period for growth and development. Time to 50% flowering determines the maturing period of genotypes (Table 2). Thus, the days to 50% flowering provides an opportunity for selection of earliness on different cowpea genotypes. Earliness is an important trait as it facilitates mechanism of *Alectra* resistance through escape from *Alectra* and may enable selection for planting in *Alectra* infested areas. The earlier the genotype flowers, the earlier the physiological maturity is reached. But, the earliness character (days to flowering, pod filling and days to physiological maturity enables B 301 to flower, pod fill and mature early and therefore escape the effect of *A. vogelii*. The genotype B301 gave higher seed yield and this was attributed by its resistance to *A. vogelii*. Seed yield is the major universal breeding objective of the cowpea crop (Oladejo et al. 2011), being representing the final product from physiological and developmental process, which occur from time of sowing to maturity.

All four strains showed no significant differences ($P>0.05$), on seed yield and yield components (Table 3), however, significant differences between genotypes were observed for 100 seed weight, seed per pod, pod length and pod weight. The direct effect of *A. vogelii* is to reduce leaf area and photosynthetic activity which in turn reduces number of pods, number of seeds per pod, pod weight and seed yield in cowpea (Alonge et al*.,* 2001; Zitta et al., 2014).

Increasing major components of seed yield such as pods per plant, pod length, weight of pods, seeds per pod and 100 seeds weight, allows improving cowpea yield potential (Makanur et al., 2013). Similarly, Alonge et al. (2001) found that *Alectra* reduced number of pods per plant, pod weight, number of seeds per pod and seed yield in cowpea. The effect of genotypes showed that, the genotype Vuli ARI produced the longest pods per plant, followed by B301 and the shortest pods was recorded in Vuli AR2. The pod length is a genotypic characteristic. This implies that if the genotype has longer pod length, the seeds within the pods become widely spaced, compared to the genotypes with short pods. The character for long pod length is important in crop improvement because the longer pods more space is provided for seeds (Onyishi et al*.,* 2013).

There were significant differences among genotypes on number of seeds per pod and in 100-seed weight. The genotype B 301 produced the highest number of seeds per pod, followed by Vuli 1 and a fewer seeds per pod were produced by Mkanakaufiti. The genotype Vuli AR2 recorded the highest 100 seed weight thus high seed size, whereas the genotype B301 has very small seeds (Hela et al*.,* 2013), and consequently the reason for its lowest 100- seeds weight.

The effect of genotypes showed that, the highest mean values for 100 seeds weight were produced by Vuli AR 2, followed by Vuli AR 1, and the lowest was B 301. There was no significant difference in seed yield per plant between genotypes. Seed yield is an important trait in plants because it is the final aggregate product of many interwoven physiological, biochemical and development traits controlled by different arrays of genes. In order to achieve high seed yield, understanding traits of yield components is paramount (Oladejo et al., 2011). The genotype Vuli-1 was able to produce high seed yield per plant under *A. vogelii* infestation, so it can be considered as being tolerant to *Alectra.* Among the types of resistance, tolerance is considered as a type of horizontal resistance which is polygenic in contrast to vertical resistance which is monogenic (Kwaga et al., 2010). Normally, the horizontal resistance has co-existence between the host and the parasite and it is more sustainable than vertical resistance which breaks down faster with time (Kwaga et al*.,* 2010). Despite high parasitism of *A. vogelii*, the tolerant genotypes produce high yield, which implies they are efficient in the production of, assimilates to give high yields and in turn support the parasites (Kwaga et al., 2010). The genotype B 301 proved to be the best genotype for resistance against *A. vogelii.* It should be used as donor parent to provide the desirable traits to a recipient. Consequently, in order to achieve higher yields, the use of resistant varieties and controlling the weed with other management strategies should be practiced.

Table 2: Effect of strains of *Alectra vogelii* on some growth characteristics of cowpea genotypes

Strains	Plant height (cm)	Leaves plant^{-1}	Branches plant^{-1}	Nodes plant^{-1}	Leaf Area Index	Flower on set	50% flowering	95% maturity
1	49.300 a	20.890 a	7.218 a	6.600 a	4.380 b	43.400 a	50.000 a	69.070 a
2	60.680 ab	20.800 a	7.013 a	6.244 a	4.349 ab	43.600 a	49.670 a	68.800 a
3	68.180 b	22.470 a	8.284 b	7.071 a	4.342 ab	43.870 a	49.470 a	69.600 a
4	63.160 ab	20.640 a	8.340 b	6.367 a	4.231 a	43.870 a	49.470 a	68.800 a
Grand mean	60.330	21.200	7.710	6.570	4.330	43.680	49.650	69.070
CV%	12.000	5.300	4.300	6.800	1.400	1.300	1.100	1.200
SE±	7.240	1.115	0.328	0.447	0.059	0.561	0.563	0.802
P- value	0.080	0.255	0.004	0.215	0.085	0.701	0.638	0.604
Genotypes								
B 301	52.270 ab	20.870 a	7.019 a	6.322 a	4.217 c	44.330 b	46.580 a	70.000 c
Mkanakaufiti	65.360 c	20.970 a	7.267 a	6.456 a	4.436 d	46.330 c	53.750 d	76.330 d
Vuli AR 1	71.020 c	21.380 a	8.222 b	6.681 a	5.517 e	42.000 a	48.580 b	67.830 b
Vuli AR 2	62.250 bc	22.140 a	8.414 b	6.919 a	3.994 b	41.420 a	50.000 c	66.330 ab
Vuli-1	50.760 a	20.650 a	7.647 ab	6.475 a	3.464 a	44.330 b	49.330 bc	64.830 a
Grand mean	60.330	21.200	7.710	6.570	4.330	43.680	49.650	69.070
CV%	21.100	13.600	13.900	14.200	3.100	3.600	2.500	2.800
SE±	12.755	2.893	1.068	0.932	0.134	1.560	1.240	1.902
P- value	0.002	0.739	0.013	0.563	0.001	0.001	0.001	0.001

Means in the same column followed by the same letter(s) are not statistically different ($P < 0.05$) by Duncan's New Multiple Range Test.

Table 3: Effect of strains of *Alectra vogelii* on cowpea seed and yield components

Strain	number of pods plant^{-1}	weight of pods plant^{-1}(g)	length of pod plant^{-1} cm)	number of seeds pod^{-1}	100 seed weight (g)	Yield plant^{-1} (g)
1	6.356 a	12.080 a	17.020 a	13.830 a	14.210 a	8.077 a
2	6.356 a	12.860 a	15.790 a	12.000 a	14.380 a	8.499 a
3	6.356 a	13.310 a	16.580 a	13.530 a	14.120 a	8.883 a
4	6.356 a	12.340 a	16.380 a	13.010 a	13.950 a	8.370 a
Grand mean	6.550	12.650	16.440	13.090	14.160	8.460
CV%	15.500	20.600	3.700	8.900	3.200	18.200
SE±	1.015	0.606	0.606	1.166	0.453	1.540
P- value	0.956	0.937	0.197	0.325	0.708	0.932
Genotype						
B 301	7.078 a	15.410 b	17.230 bc	15.620 b	13.120 ab	9.253 a
Mkanakaufiti	6.933 a	11.700 a	15.620 ab	10.570 a	13.990 b	8.342 a
vuli AR 1	5.792 a	10.660 a	17.680 c	12.380 a	15.670 c	7.706 a
vuli AR 2	6.203 a	12.450 a	14.560 a	12.350 a	15.950 c	8.300 a
vuli-1	6.758 a	13.040 a	17.110 bc	14.540 b	12.100 a	8.687 a
Grand mean	6.550	12.650	16.440	13.090	14.160	8.460
CV%	23.700	21.500	12.900	19.000	10.900	20.200
SE±	1.555	2.719	2.117	2.492	1.547	1.709
P- value	0.242	0.003	0.005	0.001	0.001	0.282

Means in the same column followed by the same letter(s) are not statistically different (P< 0.05) by Duncan's New Multiple Range Test.

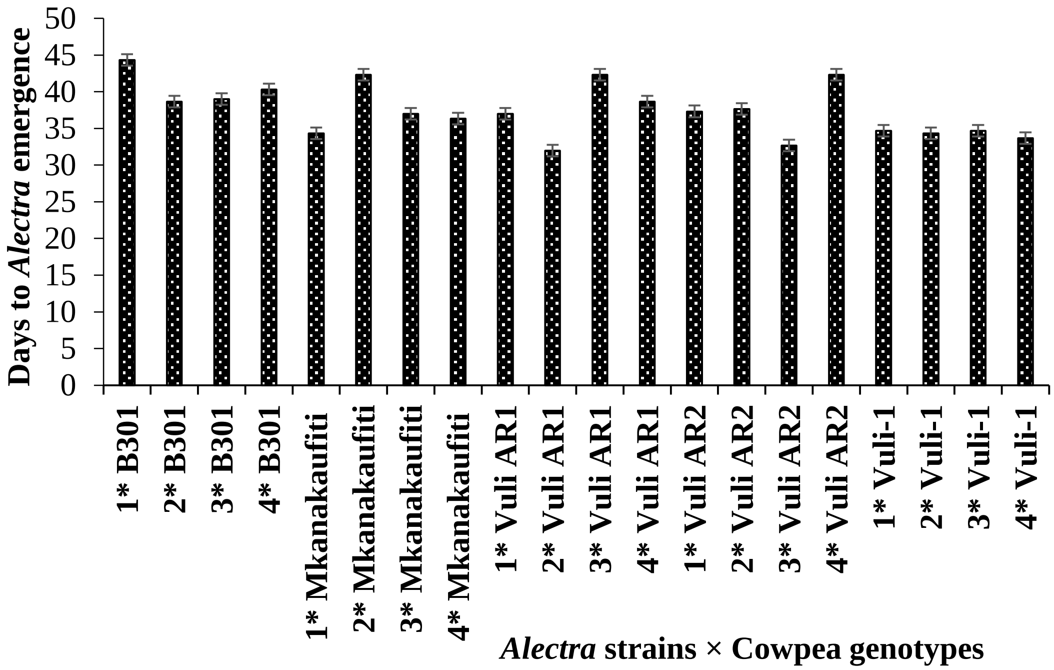

Figure 1: Interaction effect of cowpea genotypes and strains of *Alectra vogelii* on days to *Alectra* emergence

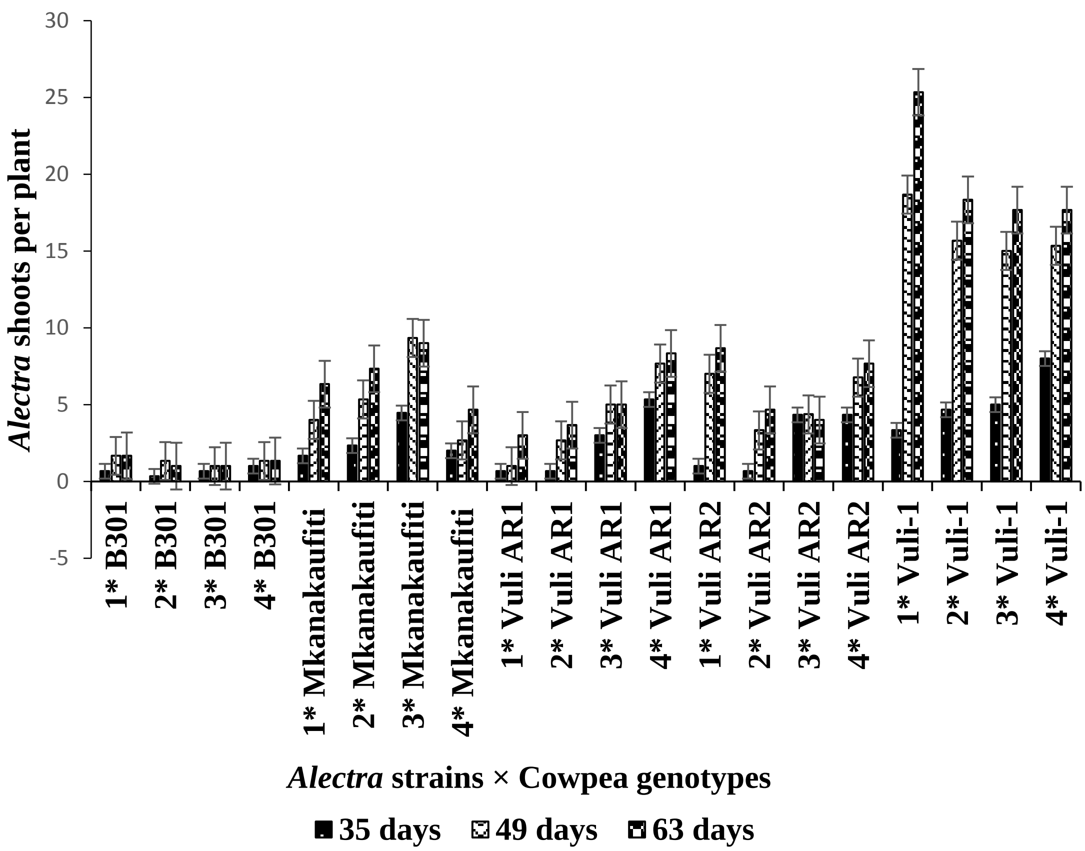

Figure 2: Interaction effect of cowpea genotypes and strains of *Alectra vogelii* on number of *Alectra* shoots per cowpea plant

CONCLUSIONS

Strains of *A. vogelii* did not differ significantly on all the studied variables. Significant genotypic effects were evident for the entire variables studied except for pods per plant and yield per plant. Significant interaction between genotypes and strains was evident for leaf area index and number of shoots at 63 days after planting. *A. vogelii* had significant effect on pod length, number of seeds per pod, 100 seed weight however there was no significant effect on total yield per plant. There was variation in number of days to emergence of *A. vogelii* among cowpea genotypes. Genotype B 301 a resistant genotype showed that, strain 3 reduces its number of pods per plant. The study showed that, each strain responds differently to each cowpea genotype. Apart from the effects of *A. vogelii*, the differences in performance are even due to cowpea inherent genetic differences. Venture requires to develop a genotype and extensively testing it across a wider geographic area using many populations of *Alectra*. This will ensure stability and durability of the variety without easy breakdown once it is moved to another area with more virulent strains. The combination of different resistance mechanisms into a single cultivar will provide durable outcome of the resistance in the field. This can be achieved by pyramiding resistant genes in cowpea using existing molecular markers.

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CONFLICT OF INTEREST

Authors have no any contending effect on that work

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