USE OF *AMARANTHUS* LINES AS TRAP CROP FOR THE CONTROL OF *ALECTRA VOGELII* (BENTH) IN COWPEA [*VIGNA UNGUICULATA* (L.) WALP] PRODUCTION

By

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DEPARTMENT OF BIOLOGICAL SCIENCES
AHMADU BELLO UNIVERSITY, ZARIA
NIGERIA

JANUARY, 2013.

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DEPARTMENT OF BIOLOGICAL SCIENCES,
AHMADU BELLO UNIVERSITY, ZARIA, KADUNA STATE,
NIGERIA.

JANUARY, 2013.

DECLARATION

I hereby declare that this thesis entitled **'Use of *Amaranthus* lines as Trap Crop for the Control of *Alectra vogelii* (Benth) in Cowpea [*Vigna unguiculata* (L.) Walp] Production'** has been performed by me in the Department of Biological Sciences, under the supervision of Prof. S. O. Alonge and Dr. P. A. Wuyep. The information derived from the literature has been duly acknowledged in the text and a list of references provided.To the best of my knowledge, no part of this project thesis has been previously presented for another degree or diploma in any university.

_____ _____

Audu Yunusa Date

CERTIFICATION

This research thesis entitled **'USE OF *AMARATHUS* LINES AS TRAP CROP FOR THE CONTROL OF *ALECTRA VOGELII* (BENTH) IN COWPEA *[VIGNA UNGUICULATA* (L.) WALP] PRODUCTION'** meets the regulations governing the award of degree of Master of Science (Biology Education) of Ahmadu Bello University, Zaria, and is approved for its contributions to knowledge and literary presentation.

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ABSTRACT

COWPEA (*Vigna unguiculata)* is an important source of protein in Africa, but its production is being limited by the parasitic plants, particularly *Striga gesnerioides* and *Alectra vogelii*. Crop rotation with trap crops has been used for the suicidal germination of seeds of these parasitic plants. Therefore, two laboratory screening and pot experiments were conducted in two trials in the Department of Biological Sciences, Ahmadu Bello University, Zaria, Nigria, to evaluate the possibility of using *Celosia/Amaranthus* lines as trap crops to control *Alectra vogelii* (Benth) on cowpea. One *Celosia* TLV8 and five *Amaranthus* lines (NH-48, NH-493, NH-452, Tete and Black seeded), distilled water (negative control) and SAMPEA 7 (positive control), were screened in the laboratory using the cut-root technique. The pot experiments were conducted to determine the effectiveness of pre-treating *Alectra* infested bag soils with four population levels high population (15 plants/pot), medium population (10 plants/pot), low population (5 plants/pot) and the control with zero plant of *Celosia/Amaranthus* lines in reducing *Alectra* seeds in the soils before planting cowpea. The pre-treated *Alectra* seeds were exposed to root exudates of *Celosia/Amaranthus* lines that were sampled at 3, 5 and 7 week after planting (WAP). The cowpea plants under the pot experiment were sampled for growth parameters at 7 and 9 WAP. Generally, higher percentage germination of *Alectra* seeds was observed from the root content of *Celosia*/*Amaranthus* lines at 5 WAP than that obtained at 3 WAP and 7 WAP. The range of percentage germination of *Alectra* seeds by the tested lines, was 11.66-12.00% for SAMPEA 7, 7.00-14.00% for *Amaranthus*/*Celosia lines* and 1.13-1.38% for Distilled water i.e Negative control at 3 WAP. However, it was 24.00-29.00% for

SAMPEA 7, 6.66-17.66% for *Amaranthus/Celosia* lines and 1.12-1.20% for Distilled water (Negative control) at 5 WAP and 13.00-20.00% for SAMPEA, 7.33-15.00% for *Amaranthus/Celosia* lines, and 1.11-1.22% for Distilled water(Negative control) at 7 WAP. The susceptible cowpea variety SAMPEA 7, exhibited higher stimulation of *Alectra* seeds germination than all the tested *Celosia/Amaranthus* lines but this was followed by that of *Amaranthus* line Tete and NH-48. However, all the *Amaranthus* lines and SAMPEA 7 (Positive control) produced significantly higher percent germination of *Alectra* seeds than the distilled water (Negative control) . Observations from the pot experiment showed that, *Alectra* infected sampled cowpea plants from the medium populaton had a tendency to produce the highest shoot fresh weight and number of root nodules,compared with the controls while the low population produced the tallest plant. *Alectra* infected sampled cowpea plants from the high population treatment produced the shortest plants with the lowest shoot fresh weight and number of root nodules but had the highest root fresh weight. However, the *Alectra* uninfected sampled cowpea plants from the Negative control treatment generally produced higher shoot fresh weight, root fresh weight, plant height and root nodules number than the other treatments. Generally, the Positive control treatment produced the highest percent *Alectra* infection, attached and emerged *Alectra* number compared with that of the other treatments. On the other hand, the pre-treatment of pot soil with *Celosia* and *Amaranthus* lines at the various population levels tended to produce cowpea plants that had higher number of flowers, pod numbers, pod weight, total grain yields and 1000-seed weight than both controls. In conclusion, this study showed that, *Celosia* and the *Amaranthus* lines caused suicidal germination of *Alectra* seeds and therefore could serve as trap crop for *Alectra vogelii*.

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LIST OF ABBREVIATIONS

ANOVA:	Analysis of Variance
IITA:	International Institute of Tropical Agriculture
FAO:	Food and Agriculture Organisation
N.B:	Nota bene (take special note of)
WRO:	Weed Research Organization
MoAIFS:	Ministry of Agriculture, Irrigation and Food Security.
GLM:	General Linear Model
DMRT:	Duncan Multiple Range Test
WAP:	Weeks After Planting
L.B:	Local Black

CHAPTER ONE

I.0 INTRODUCTION

1.1 Botany and Origin

Cowpea (*Vigna unguiculata* (L.) Walp) is a leguminous crop belonging to family Fabaceae. It is an important pulse crop in many areas of the world. Field peas, stock peas and southern peas are few of the names by which *V. unguiculata* is known. *V. unguiculata* pubescens and protracta are species of wild cowpea with their stems, leaves, and pods with hairs. The hairs are silky straight, soft and appressed to the surface of the stem and pods.The taxon has thick root stock and its stigmas are strongly beared and thus easily recognizable from all other taxa. However, variety protracta is an annual or a perennial herb up to 2cm long, with a prostrate growth habit. Its inflorescene rachis is shorter than 0.7cm and peduncle about 4-15 cm long. The lateral leaflet is oblique, slightly to deeply lobed on the inside, only up to 7cm long and 6cm wide. Terminal leaflets are ovate to subhastate or hastate (Singh *et al*., 1997).

The genus of the cowpea *Vigna* is a relatively large pan-tropical genus, with the majority of its species being found in Africa (Padulosi and Ng, 1997). The name cowpea probably originated from the fact that the plant was an important source of hay for cows, in the United States of America and in other parts of the world (Pursglove, 1968). Its origin seems to be in Northern Africa where it is still cultivated to this day (Coulibaly *et al.,* 2002). Regardless of its precise origin, cowpea was probably cultivated by 7,000 to 6,000 BC and arrived in India about 4,000 years ago with the grain species (Pant *et al.,* 1982). www.sbmp. org.br/cbab/ siscbab/upload s/b142 3ce-4 205-4269.pdf. India appears to be a

secondary center of genetic diversity. It is believed that, cowpea was used as fodder crop for cattle prior to domestication for human consumption.

The original forms were probably spreading short day plants that readily shatter their seeds (Pant *et al.,* 1982). www.sbmp. org.br/cbab/ siscbab/upload s/b142 3ce-4 205-4269.pdf.

Cowpea is an important food legume in West and Central Africa (Mayers *et al.,* 1996). This region represents over 78% of the 12.5 million ha of cowpea grown worldwide (Cisse and Hall, 2003).

1.2 Level of Cowpea Production

The annual global cowpea grain production is estimated at 3 million tonnes (Singh *et al.,* 1997), of which West Africa account for about 9.3 million ha, with annual production of about 2.9 million tones representing 96.67 (IITA, 2003). In Nigeria, cowpea is gradually attaining economic importance, particularly in the Southern states of Nigeria, even though the bulk of the production is done in semi-arid zone of Northern Nigeria (Ibikunle *et al.*, 2008). The production trend in Nigeria from 1961 to 1995 has experienced about 44.1% increase in area planted, and 41% increase in yield (Ortiz, 1998).

According to Inailizume *et al.* (1999), several factors account for the impressive significant advances made by International Institute of Tropical Agriculture (IITA) over the last two decades in improving cowpea productivity in sub-saharan Africa. The current global annual production of cowpea was about 3.6 metric tonnes of which Africa accounts for about 64%. Similarly, it was reported that Nigeria, being the largest producer of cowpea in the world accounts for more than 2 million metric tonnes which represents about

50% of the total world cowpea production annually (Adeola *et al.,* 2012). Singh (1994) also indicated that a number of varieties had been developed which combine diverse plant type, different maturity period and resistance to several disease, insect pest and parasite as well as good agronomic traits.

1.3 Economic Importance of Cowpea

The average nutritional content of mature cowpea seed consists of 24% protein, 1.9% fat, 6.3% fibre, 63.6% carbohydrate, 0.00074% thiamine, 0.00012% riboflavin and 0.0028% niacin. They are rich in amino acids: lysin and tryptophan, and are most palatable when eaten in combination with cereals (Bressani, 1985).Therefore, cowpea has a potential to contribute to the alleviation of malnutrition specifically among the poor, since protein shortage is a major feature in the diet of developing countries than shortage of calories (energy food). This leads the problem of malnutrition and pronounced spread of human diseases (Fleck, 1981).

According to the Food and Agriculture Organization (FAO), 23% of the population of developing economy consumes 20% below the level of food intake required to sustain life among other activities, this is a problem which has persisted to date (FAO, 2001; Okori, 2005).

The relatively high protein content of cowpea, supplement the diet of many African people who consume cereals, roots and tubers that are high in carbohydrate and low in protein. Cowpea is used for both food and forage and is also beneficial in maintaining soil fertility (Berner and Williams, 1998).

On account of its ability to fix nitrogen efficiently up to 240kgN/ha, cowpea provides a high proportion of its own nitrogen requirement, besides leaving a fixed deposit in

the soil of up to 60-70kgN/ha for the succeeding crop (Rachie, 1985). As a result of this, cowpea is grown in rotation or mixed with many cereal and tuber food crops. Cowpea can be used as a green manure or as cover crop in checking erosion (Dugje *et al.,* 2009).

The haulms are fed to livestock as a nutritious fodder (IITA, 2003). Cowpea can be used at all stages of growth, as a vegetable crop, the tender green leaves are important food source in Africa and are prepared as a pot herb, like spinach, and the immature pods are used in the same way as snapbeans, often being mixed with other foods (Bressani, 1985). Green cowpea seeds are boiled as a fresh vegetable or may be canned or frozen and the dry mature seeds are also suitable for boiling and canning, while the cowpea seed is a nutritious component in human diet, as well as a nutritious livestock feed (Bressani, 1985).

1.4 Limiting Factors to Cowpea Production

In Africa, cowpea yield is generally low due to some biotic and abiotic factors. The abiotic factors include eratic rainfall, high soil temperature, and low soil fertility. The biotic factors are insect pests, parasitic weeds such as *Striga* etc. and diseases caused by various organisms such as bacteria, fungi, viruses and nematodes. Other factors include low acceptability of cowpea and low acceptance of new techniques (Berner and Williams, 1998).

Parasitic weeds (*Alectra* and *Striga*) constitute serious bottle neck in cowpea production resulting in low yield of cowpea and this lead to the biggest constraint to grain production (Olmstead et *al*., 2001). Atokple et al. (1991) reported yield losses of

up to 100% in a susceptible cowpea variety and up to 90% in moderately resistant cowpea varieties when *Striga gesnerioides* population was over ten per plant (Olmstead *et al.,* 2001). Several arable lands have been abandoned as a result of high infestation of these noxious weeds (Emechebe *et al.,* 1983). According to Rambakudzibga *et al.* (2002), *Alectra vogelii* is a serious pest in cowpea production in Africa. The parasite infection does not decrease cowpea dry matter production, but it significantly altered dry matter partition by increasing the proportion of root dry matter (Rambakudzibga *et al.* (2002) . Alonge *et al.* (2004) reported that heavy *Striga* infestation greatly reduced the root and shoot dry weight of most varieties of cowpea. In a study carried out between 1994 and 1995 to investigate cowpea reactions to *Striga gesnerioides.* They observed that irrespective of the sowing dates, there was greater reduction in the leaf area and root nodules of the susceptible than the resistance cowpea varieties. Furthermore, they observed that, *S. gesnerioides* infestation reduced the root nodulation and shoot dry weight of a lot of cowpea varieties especially in the late planted varieties (Alonge *et al.,* 2004).

1.5 Menace of *Alectra vogelii* in Cowpea Production

Alectra vogelii is one of the most serious production constraints to cowpea. Yield losses resulting from this parasite ranges from 41% (Lagoke *et al.*, 1997), to total crop loss of the highly susceptible cultivar such as black eye (Riches, 1990). The yield reduction is mediated through the delayed onset of flowering, reduced number offlowers and pods, and reduced mass of pods and grain (Mugabe, 1983). The destruction of cereal crops in parts of subtropical and tropical Africa and Asia by

these parasitic weeds of genus *Striga* (Olmstead *et al*., 2001), and *A. vogelii* led to their receiving the nickname 'Witchweed' (Parker and Riches, 1993b). Seeds of these hemiparasites infest two — thirds of the arable land of Africa (Press *et al.,* 2001), and constitute the biggest single biological cause of crop damage in the continent.

Alectra vogelii (Benth) is an obligate parasite of grain legumes, particularly cowpea (*Vigna unguiculata* L.*Walp)*, groundnut (*Arachis hypogaea* (L.), soyabean (*Glycine max* (L.) Merrill), Bambara (*Voandzia subterranea* L.) and green gram (*Vigna radiata* (L.) Wilczek) (Kureh *et al.,* 2005b).

Cowpea is also attacked by *Striga gesnerioides*, were the two parasites (*Striga* and *Alectra*) co-exist. *Alectra* is particularly more destructive in the northern Guinea and Sudan savanna agro-ecological regions where the damage is high due to marginal soil nutrient status and low rainfall. Emechebe *et al.* (1983) reported that *Alectra* obtained water, mineral nutrient and carbohydrate from the host plant through the haustoria. The growth of the parasite (*Alectra*) is as a result of root exudate from the host plant that stimulates the germination, when it receives sufficient chemical signals. The germination of *Alectra* and *Striga* seeds is in about two days (Emechebe *et al*., 1983).

Alectra has its greatest impact in low-input subsistence farming systems, where many farmers' fields have been blighted (Kureh *et al.,* 2005a). High crop yield losses, caused by *A. vogelli,* have been reported in cowpea and groundnut. Many cultivated fields have been abandoned because of high infestation from *A. vogelii* and related parasitic weeds such as *Striga hermonthica. Striga* also causes serious yield losses in cereals in the northern Guinea of West and Central Africa (Kureh *et al.,* 2005a).

1.6 Control Measures

Field infested by these weeds (*Alectra* and *Striga)* during the cropping season is difficult to clean. This is due to the dormancy mechanism and mode of parasitism. *Striga hermonthica* produces 40,000-60,000 seeds per plant, *A. vogelii* produces about 10 times as many, and these render control measures such as crop rotation, constant weeding, use of pre-and post-emergence herbicides and suicidal germination either inefective or too expensive for small scale farmers (Singh *et al.,* 1993; and Kureh *et al.,* 2005a). Thus, the use of resistant cultivars should provide an effective and economical means of control (Singh *et al.,* 1993; and Kureh *et al.,* 2005b).

The production of large quantity of seeds by parasitic weeds and the dormancy mechanism for several years in the soil, make it inpossible for a single method to adequately control them. Therefore, a number of integrated methods are required for effective control (Magani and Lagoke, 2009). Crop rotation with trap and catch crops has long been proposed and practiced as control measures for parasitic weeds (Kroschel, 2001).

Catch crop: Catch crops are host plants of parasitic weeds which induce germination and in turn get attacked. When catch crops are ploughed under, the succeeding crop benefits from the improvement of the soil. Catch crops are harvested after 6-8 weeks before the parasite emerge and reproduce. In this way they reduce the efficiency of the parasitic seed bank in the soil. (Musselman, 1980)(http://www.fao.org).

Trap crops are plants that induced a natural germination of seeds of parasitic plants in the presence of root exudates containing germination stimulant in the absence of host plant to reduce the seed bank of parasitic plant in the soil (Botanga *et al.,* 2003).

Potential trap crops of *Striga* are the legumes that can be used in rotation with susceptible host. Such legumes for *S. hemonthica* include the rotation of soyabeans – pigeon pea – Bambara groundnut-groundnut. For *S. gesnerioides* are rotation with groundnut-pigeon pea soyabeans (Musselman, 1980))(http://www.fao.org).

1.7 Statement of Problem

The control of the parasite is often difficult because of the vascular connection between the parasite and the host. Since whatever is applied to the parasite will reach the host (Hautier *et al*., 2010). As a result, the crop plants are faced with difficulty competing with witchweed in poor soils and where intensive farming and expansion in marginal soils have encouraged the spread of the parasite. Thus, this makes the control of the parasite difficult since each plant can produce up to half a million seeds that can remain dormant in the soil for decades (Kure *et al.,* 2005b). The dormancy and intimate physiological interaction with the host plant are the main constrains that limit the development of successful measures that can be accepted and used by the subsistence farmers (Kroschel, 2001).

1.8 Justification

Considering the ineffectiveness of the measures it therefore becomes necessary to seek for an alternative and more sustainable control method. Therefore, this research was carried out to evaluate the possibility of controlling *A. vogelii* by the use of

Amaranthus lines, in order to reduce the prevalence of the weed and increase the yield of cowpea.

The genus *Amaranthus* consist of nearly 60 species, that can be broadly categorize into grain, green leaf vegetable and wild types. *Amaranthus* is cultivated as a minor food crop in Central and South America, Mexico and parts of Asia and Africa and is extensively grown as green leaf vegetable in many tropical countries. (Berker *et al.,* 1981). They are grown occasionally by farmers in West Africa but not in Southern Africa. Nigeria has been reported as the centre of diversity, corroborated by the prevalent use of local names and the enormous genetic diversity available here (Berker *et al.,* 1981).

Amaranthus is easy to cultivate and is a rich vegetable crop containing minerals such as calcium and iron, vitamims such as carotene, niacin, ascorbic acid, riboflavin and folic acid. It is a fast growing crop with high yield potentials. The research findings will be useful for recommendation to scientists and practicing farmers for use in the control of the parasitic weed *Alectra vogelii.*

1.9 Aim and Objectives of the Study

Aim. To determine the effect of *Amaranthus/Celosia* lines as a trap crop in the control of *Alectra vogelii* on cowpea.

The objectives of this study were.

1 To determine the effect of *Amaranthus/Celosia* lines on the germination of *A.vogelii* seeds

2 To determine the effect of *A. vogelii* on the growth and yield of cowpea in soil pre-treated with *Amaranthus/Celosia* lines

1.10 Hypotheses

1 The presence of *Amaranthus/Celosia* lines does not affect the germination of *A. vogelii* seeds.

2 The presence of *Amaranthus/Celosia* lines has no effect on the growth and yield of cowpea in *Alectra* infested soil.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Parasitic Weeds

Parasitic weeds of the familiy Scrophulariaceae [*Alectra*, *Striga*, (witchweed)] are considered to be among the most serious agricultural pests of economic importance in many parts of the world. The genus *Striga* includes about 40 species, of which 11 species are parasites on agricultural crops (Parker and Riches, 1993a; Raynal-Rogues 1996,).

2.2 Geographical Distribution and Main Host

Parasitic weeds have evolved specificity to crops and plants in the natural vegetation. *Striga hermonthica* (Del.) Benth. *S. asiatica* (L.) Kuntze and *S. gesnerioides* (L.) Vatke, in the given order, are the most economically important species in the semi-arid and sub-humid tropics. The former two species are almost entirely specific to grasses (cereals) such as *Sorghum (Sorghum bicolor* (L.) Moench), maize (*Zea mays* L.), pearl millet (*Pennisetum americanum* L.), rice (*Oryza sativa* L.), sugar cane (*Saccharum officinarum* L.) and others, while the third one is parasitizing dicot hosts, mainly cowpea (*Vigna unguiculata* (L.) Walp.), tobacco (*Nicotiana tabacum* L.) and sweet potato (*Ipomea batatas* (L.) Lam.) (Ejeta and Butler, 1993). Africa was described as the place of origin of the agriculturally important *Striga* species, particularly the Sudano-Ethiopia region, where also *Sorghum* was postulated to be originated (Vasudeva -Rao and Musselman, 1987). *Striga hermonthica* is widespread in the semi-arid zones of northern tropical Africa and it is also found in the south-

western part of the Arabian Peninsula (Mohamed *et al.,* 2001). *S. asiatica*, on the other hand, has a wide distribution in the eastern to southern part of Africa, Asia, Australia and the United States (Musselman, 1987). The third species, *S. gesnerioides*, occurs in Africa, the Arabian Peninsula, the Indian subcontinent, and has been introduced to the United States (Musselman and Parker, 1981).

The species of the genus *Alectra* are found mainly in tropical Africa and subtropical southern Africa. *A. sessiliflora,* and *A. fluminensis* are also found in subtropical Asia and tropical and subtropical South America, respectively (Parker and Riches, 1993a). *Alectra vogelii* Benth is the most important species parasitizing mainly grain legumes in sub-Saharan Africa, which include cowpea, Bambara groundnut (*Vigna subterranea* (L.) Verdc.), soybean (*Glycine max* (L.) Merr.), mung bean (*Vigna radiata* (L.) Wilczek), groundnut (*Arachis hypogaea L.*) and common bean (*Phaseolus vulgaris L.*), (Parker and Riches, 1993a).

The Mediterranean region is considered to be one of the centres of origin of *Orobanche* species. The species are distributed worldwide from temperate climate to the semi-arid tropics. The distribution of *Orobanche crenata* Forsk is restricted to the Mediterranean regions, the Middle East and East Africa (Ethiopia), while other species have a wider spread. Today, the species *O. crenata, O. ramosa L., O. aegyptiaca Pers., O. cernua Loefl., O. cumana Wallr., O. minor Sm.* and *O. foetida Poir* are the major biotic limiting factors to the production of legumes such as faba bean (*Vicia faba L.*), chikpea (*Cicer arietinum L.*), lentil (*Lens culinaris Medick.*), and crops of the family Solanaceae [tomato (*Lycopersicon esculentum* Mill.), potato

(*Solanum tuberosum L.*), and tobacco (*Nicotiana tabacum L.*) and Asteraceae, mainly sunflower (*Helianthus annuus L.*) (Parker and Riches, 1993a).

2.3 Botany of Parasitic Weeds

After a period of growth, these parasitic plants (*Alectra* and *Striga*), usually branch below the ground and emerged as a bunch above the ground. *Striga* leaves are very small, succulent, scale-like, and appressed to the stem. *Alectra* leaves are a bit larger and more open, with opposite leaves, irregular large yellow flowers and dust like seeds. Flowers are normally produced when the plants emerge above the ground, purple for *Striga* which differentiate the plants from *Alectra* with yellow flowers. Seeds are produced in capsule, each of which may have 400-500 seeds and over 90,000 seeds may be produced by a single plant depending upon the branching and growth of the plants. The seeds are very small, measuring 0.15-0.25mm in length (Singh and Emechebe, 1997). Mature *A. vogelii* plants were 0.3 to 0.5m and with multiple stem branching at the base. Subsoil plant parts were a deep orange colour plant. Flowers were light prominent lemon yellow with horse shore shape stigma and leaves were light green. The numerous seeds produced by *Alectra* and *Striga* plants are well protected by thick seed coat and may be viable in the soil for several years depending on the climatic condition, until they are induced to germinate by exudates from the roots of the host (Okonkwo and Nwoke, 1978, Bebawi, 1987).

2.4 Life Cycle of Parasitic Weeds

The seeds of the root-parasitic weeds vary in their ability to germinate immediately after they have reached maturity. Seeds of *Striga* and *Orobanche* are dormant and

require a period of after-ripening or so called post-harvest ripening period, whereas seeds of *Alectra vogelii* can germinate immediately after harvest when germination requirements are met (Riches, 1989). Seed germination occurs when ripened seeds are preconditioned by exposure to warm moist conditions for several days, followed by exogenous chemical signals produced by host roots and some non-hosts (germination stimulant) (Worsham, 1987). Upon germination, a germ tube, which is in close proximity to the host roots, elongates towards the root of the host, develops an organ of attachment; the haustorium serves as a bridge between the parasite and its host.

Growth occurs largely at the meristern during the germination of the seeds, this result in seedlings with elongated radicle (Okonkwo and Raghavan, 1982). The elongations of the radicle show a chemotropic response to a concentration gradient of root exudates. Once in contact with host roots the radicles penetrate and stimulate cell division in the host root. The new host cell together with growing parasitic tissue form a large haustorium, uniting the parasite with tissues in the host's stele which permits transfer of water and nutrients from host to parasite. *Alectra* radicles stimulate profuse root formation by the host and form a larger haustorium than *Striga*. The haustorium is used to deprive the host of water, mineral, nutrients and carbohydrates, causing drought stress and wilting of the host (Frost *et al.,* 1997). Stunted shoot growth, leaf chlorosis and reduced photosynthesis are also phenomena that can be observed on susceptible host plants which contribute to reduction of grain yield (Frost *et al.,* 1997). Most of the seeds in the soil will not be reached by the stimulant, but can remain viable for up to 15 years, forming a seed reservoir for the next cropping seasons. After several weeks of underground development, the parasite

emerges above the soil surface and starts to flower and produce seeds after another short period of time. Seed production is prodigious, up to 100 000 seeds or even more can be produced by a single plant and lead to a reinfestation of the field. Thus, if host plants are frequently cultivated, the seed population in the soil increases tremendously and cropping of host plants becomes more and more uneconomical (Kroschel, 2001).

2.5 Effect of Parasitic Weeds on Host Plant

Alectra and related parasitic weeds including *Striga* are presently among the most important biological constraints to food production in Africa. A serious damage is been done to food and many animals feeds by these parasitic weeds (*Alectra* and *Striga*) of the family Scrophulariaceae.

Total yield loss is not uncommon in fields heavily infested by these parasites when susceptible varieties are planted (Emechebe *et al.,* 1983). *Alectra* has been reported to cause yield loss of up to 100% in susceptible cowpea varieties and 90% in moderately susceptible varieties when the level of attack was up to ten *Alectra* plants per cowpea plant (Emechebe *et al.,* 1991). High crop yield losses caused by *Alectra* have been reported in legumes including cowpea, broad and velvet beans, groundnut, bambara groundnut and grams (Riches, 1987; Lagoke *et al.,* 1991). During April and May 2000 *A. vogelii* was observed parasitizing several wild *Arachis* species in a field at the Chitedze Agricultural Research station, near Lilongwe, Malawi (Subrahmanyam, 2001).

Cowpea suffers considerable damage due to *Striga* and *Alectra*, and the yield reduction can be up to 100% in serious cases (Ramaiah *et al.,* 1983). Also,

Geipert *et al.,* (1996), reported the infestation of food legumes by *O. crenata* causing yield loss of 14,389 tonnes ($ 8.6 million). As a result of the complete devastation caused by *Orobanche* in many areas, production method had to be modified and/or cultivation of some susceptible host had to be abandoned.

The effect of *Alectra* is equally devastating in heavily infested cowpea fields, as has been observed in Botswana (Parker and Riches, 1993a), Kenya (Bagnall-Oakely *et al.,* 1991) and Nigeria. In the fields that are heavily infested with both *Striga* and *Alectra*, the crop is mostly infected by *Striga,* if the host cultivar is equally susceptible to both parasites (Emechebe *et al*., 1991). However, if the host cultivar is resistant or moderately resistant to *Striga* and susceptible to *Alectra* as in the case of (IT82D-849 and Suvita-2), *Alectra* infection is very severe, causing substantial yield losses (Emechebe *et al.,* 1991). Therefore, in West and Central Africa, where *Striga* as well as *Alectra* are present, control measures to be adopted have to be effective.

Kureh *et al.* (2005a) reported that 2000 *Alectra* seeds were adequate to parasitize and significantly reduce growth of soyabeans by over 70%. In another study, Kureh *et al.* (2005b) also reported reduction in growth and nodulation of some soyabean genotype under controlled *Alectra* infestation. In Tanzania, yield looses of up to 50% have been reported (Mbwaga and Shayo*,* 2000). Bagnall-Oakely *et al.* (1991) reported total crop lost in parts of Kenya.

Also, yield looses of up to 15% yield loss has been reported in groundnut in Nigeria (Salako, 1984), while in South Africa 30-50% reductions in yield of bambara were reported.

The extent of yield reduction depends upon the time and level of infection. Aggarwal and Ouedraogo (1989) reported a mean yield loss of 30% due to *Striga* infection in, Burkina Faso, with 50% loss in the most susceptible local variety. Observations in northern Nigeria indicate even greater yield losses. Total yield lost of cowpeas has been reported from Sokoto, Kano, Katsina Borno, and Bauchi states due to the *Striga*/*Alectra* complex (Emechebe *et al.,* 1991).

Striga gesnerioides can be a very serious parasite of cowpea causing chlorosis and then severe wilting and necrotic lesions. According to Gebremedhin *et al.* (2000) host growth and productivity was negatively affected by lower rates of photosynthesis, increased respiration, altered assimilate partitioning and early senescence of leaves of crop plants, that often collapse under drought stress leading to complete crop failure.

Plant carbohydrates is lost mainly in the form of sucrose (Ba, 1983 and Okonkwo, 1966). Hibberd *et al.* (1995) reported that root parasites induce low rate of dry weight accumulation in the plant due to competition for host solutes, which bring low rates of photosynthesis in host. The same author also observed that, the growth of *Orobanche* usually coincide with flowering of the host plant. This usually results in flower dropping and low pod production in the host due to low water uptake.

The attack of *Orobanche* on host plant leads to the following physiological changes; decrease in phosphorous, potassium, RNA, protein, carbohydrate and glutamic acid. However, the association between host-parasite is a unique one since the parasite have to depend largely on the host for its nourishment. Ba (1983) reported that, the establishment of a vascular connection between both the parasite and the host allow the parasite to absorb water, mineral and carbohydrates that are essential for its development. A study carried out by Manschadi *et al.* (1996a) over the growth cycle between cowpea and *Alectra* on dry matter production and partitioning. *Alectra vogelli* attachment on the cowpea roots was first detected 30 days after crop emergence, and the first shoot emerged 44 days after crop emergence. Thus, new *A. vogelii* attachment onto cowpea root continued to be produced throughout the growth of the crop. *A. vogelii* did not decrease cowpea dry matter production, but it significantly altered dry matter partitioning by increasing the proportion of root dry matter, thereby leading the infection to significant reduction in dry matter accumulation in cowpea pods. And the loss of dry matter in cowpea pods was largely accounted for by dry matter gain in *A. vogelii* shoots (Manschadi *et al.* 1996b).

Alonge *et al.* (2004) reported that the percentage change in shoot dry matter production of most resistant varieties was either the maximum increase or comparable with the respective maximum increase at 5WAP in the early planted cowpea in 1994 and at 5 and 7 week in late planted in 1994. However, the authors further revealed that at 9 WAP in each trial, only few resistance varieties had their percentage change in shoot dry weight significantly higher than the respective worst reduction, in a study

carried out between 1994 and 1995 to investigate cowpea reaction to *Striga gesnerioides*.

Alonge *et al.* (2004) further reported that only 1 or 2 of the resistant cowpea varieties had the percentage increase in root weight significantly higher than the respective worst reduction observed on each sampling dates in the late planted in 1993. The author also further pointed out that only about 4 – 6 resistant/tolerant varieties had the change in root dry weight significantly higher than the respective worst reduction observed on each sampling date in the early planted in 1995.

Striga infestation reduced the root nodules of most cowpea varieties (except the resistant varieties B301 and IT90k – 76) at 5WAP in the Late Planted in 1994, although there was significant increase in only few resistant and tolerant varieties at 7 and 9WAP, compared with the respective worst reduction on each sampling date.

2.6 Control Methods

Compared with non-parasitic weeds, the control of parasitic weeds has proved to be exceptionally difficult. The ability of the parasite to produce a tremendously high number of seeds, which can remain viable in the soil for more than ten years, and their intimate physiological interaction with their host plants are the main difficulties that limit the development of successful control measures that can be accepted and used by subsistence farmers (Kroschel, 2001). However, several control methods have been tried for the control of parasitic weeds, including cultural and mechanical (crop rotation, trap and catch cropping, fallowing, hand-pulling, nitrogen fertilization, time and method of planting, intercropping and mixed cropping), physical

(solarization), chemical (herbicides, artificial seed germination stimulants, e.g. ethylene, ethephon, strigol), use of resistant varieties, and biological methods (Parker and Riches, 1993b).

Alectra vogelii has a similar life cycle to that of *Striga species.* The control measures proposed for *Striga sp.* are also applicable to *Alectra sp.* (Botha, 1948). The most common control measures used by small scale farmers in Nigeria are the hand-pulling, hoe-weeding and uprooting of the weeds. These methods are tedious, labour intensive, and time consuming, and can only be applied to low infestation (Lagoke *et al*., 1991).

2.7 Chemical Control of Parasitic Weeds

The used of chemicals to control witchweeds can be divided into two general categories, that is pre-emergence and post-emergence (Ayensu *et al.,* 1984).

Pre-emergence herbicides that are capable of controlling these parasitic plants include the dinitroaniline (DAN's) and Diphenylethers (Eplee *et al.,* 1991). These herbicides, act as barrier to prevent *Striga* and *Alectra* emergence.

Post-emergence herbicides most commonly used to stop the reproduction of the parasites are the salt formulations of 2, 4-D (Choudhary and Lagoke 1980 and Lagoke *et al.,* 1993). These chemical are applied to parasitic weeds foliage at about the time of flowering at the rate of 0.5-10 kga. i./ha.

Metalachlor has been found in field trials to provide sufficient suppression of *Striga* attachment (Eplee *et al.,* 1991). Pendimethalin is a pre-emergence herbicide that was observed to provide sufficient suppression of *Striga* attachment in field trials. When

applied at 1.7kg a.i/ha it gave a 100% reduction of early *Striga* emergence (Eplee *et al.,* 1991).

The application of nitrogen fertilizer up to about 60-100kg/m^{-1} affect the metabolism of the parasite by reduction of potassium thereby obstructing the osmotic balance of the parasite. *Alectra vogelii* growth was suppressed by phosphorous in phosphate when applied to the soil (Ntombi, 1983). According to Magani (1994), the use of high nitrogen fertilizer has proved effective in reducing the number of plants infected and *Alectra* shoot count but resulted in cowpea grain yield depression.

Seed treatment has also been used for the control of *Alectra species* and *Striga species*. According to Konate (1986), farmers in Sokoto State, claimed that soaking the seeds of cowpea in brime or extract of *Parkia filicoides* reduced *Striga* infestation, while in Mali, the use of Nere (*Parkia biglobosa*) powder has been effective.

2.8 Source of Resistance to *Striga* and *Alectra*

Resistant varieties of cowpea have also been used to control the effect of these weeds. Riches (1987) found that cowpea genotypes B301 and B359 local germplasm lines from Botswana, to be resistant to *A. vogelii* in that region. Singh and Emechebe (1990a, 1990b), also confirmed the resistance of B301 in both field and pot experiments in Nigeria. Bailey and Terry (1990) reported combined resistance to *Striga* and *Alectra* in B301 at the Weed Research Organisation (WRO) in United Kingdom.

However, a number of other lines were identified which are less susceptible to *Striga* as shown by a lower number of *Striga* plants attached as well as delayed emergence

of *Striga* (Emechebe *et al.*, 1991). These lines display varying degree of resistance to *Striga* strain found in Kano, Nigeria. IT82D-849 is resistant to *Striga* but susceptible to *Alectra*, whereas IT86D-534, IT86D-371 and IT84D-666 are moderately resistant to *Striga* and highly resistance to *Alectra*. Suvita-2 is highly resistant to the *Striga* strain from Burkina Faso, moderately resistant to *Striga* from Nigeria, but highly susceptible to *Alectra*. IT82D-957 is highly susceptible to both, and yield loss due to both parasitic plants can be significant.

The International Institute of Tropical Agriculture (IITA) has developed and distributed 6 improved cowpea germplasm lines IT90K-59 (Reg. No. GP-253, P1583496), IT90K-82-2 (Reg. No. GP-254, p632853), IT93k-693-2 (Reg. No. GP-254, P.1632858), IT97k-20s-8 (Reg. No. GP. =256,P1642159), IT97K-499-35 (Reg. No. GP-257, P.1642160) and IT97K-819-118 (Reg. no. GP -258, P1642161) to various national programs with combined resistance to two parasitic plants *Striga gesnerioides* and *Alectra vogelii*. Of these, two lines were developed by the partial backcross method using a local landrance, B301 from Botswana, as the source of resistant to *Striga* and *Alectra* and the other lines were subsequently developed through regular hybridization and selection using the derived lines as resistant source (Singh, 2002).

Resistance to *S. gesnerioids* is controlled by a single dominant gene and resistance to *A. vogelii* is controlled by duplicate dominant genes which are different from the gene conferring *S. gesnerioides* resistance (Singh *et al.,* 1993).

2.9 Artificial Germination Stimulant

The application of germination stimulants to induce suicidal seed germination of parasitic weeds appear attractive because of their safety, decomposition in the soil within a short period of time and their high biological activity at a very low rate (Egley *et al.,* 1990). An outstanding example so far was the use of ethylene gas in North Carolina to eradicate *S. asiatica*, through injection of the gas below the soil surface using special sophisticated machinery (Egley *et al.,* 1990). At research level, the method was also tested in Africa. However, the result achieved in Kenya was only 50-60 percent reduction of the seed bank, which was much less than that routinely achieved in the United States (Egley *et al.,* 1990). However, in some parts of Africa, ethylene was found to be more effective than trap crops in reducing the *Striga* seed bank (Odhiambo and Ransom, 1997). Thus, its use in heavily infested areas would likely be highly economical provided that its distribution challenges and application technology were to be resolved, since the actual cost of the chemical is small ($12.4 per ha) (Ransom, 1999).

Nijmegen 1, recently synthesized by Zwanenburg and Wigchert (1998) and GR 24, which are structurally related to the natural stimulant Strigolactone, are the most potent active synthetic germination stimulants for many species of *Striga* and *Orobanche* at low concentration ($10^{-9}10^{-6}$ mol 1-1) (Wigchert *et al.,* 1999). The naturally-produced Strigolactone cannot be isolated for commercial application because of its extremely low concentration in *Sorghum* (Wegmann, 2002). However, large-scale preparation of Nijmegen 1 is relatively easy and possible at low cost, which may facilitate field application (Nefkens *et al.,* 1997; Wigchert *et al.,* 1999).

Under field conditions, application of 2.5L/m^2 of 50 ppm solution of Nijmegen 1 depleted the soil seed bank of *Orobanche* by an average of 35 percent (0-30 cm depth) (Miele *et al.,*2001) which corresponded to maximum germination induced by it in *in-vitro* studies. Proper formulation of the stimulant could perhaps increase efficacy and distribution in the soil. Recently, Wegmann (2002) reported very promising results when the formulated Nijmegen 1 (by the BASF AG), was applied under field conditions. In-depth knowledge of Nijmegen 1 behaviour in the soil such as its adsorption, mobility and fate and how to spray the compound with a manageable carrier volume may help in understanding its relative efficacy under contrasting soil and environmental conditions (Streibig, 2002).

2.10 Natural Germination Stimulant

In Africa, non host particularly legume cultivars selected for their efficiency in inducing *Striga hermonthica* (Del.) Benth seed germination are being used in rotation with cereals to control *Striga hermonthica*. The use of non host legumes for *S. gesnerioides* control also has been suggested, but virtually no attention has been placed on cereal species, which are commonly grown in rotation or as crop mixtures with cowpea. Root exudates of the species *Abrus pricatorius, Cajanus cajan, Calapogenium sp. Glycine max, Pueraria sp.,* and *Vigna unguiculata* have been identified as effective in stimulating *S. gesnerioides* seed germination. When the seeds of *S. gesnerioides* were placed on roots of different plant species, germination was observed on roots of *C. cajan*, *D. sanguinalis, G. max, R. exaltata L., Sorghum bicolor* and *V. unguiculata*. (Berner and Williams, 1998).

Muller (1993) reported that large quantity of stimulants were produced for 18 days on planting cowpea in soil inoculated with *Alectra,* while *Striga* stimulants is given off in small quantity over a long period of time. The first germination stimulant isolated from a host was a series of oily and unstable substituted hydrobenzoquinones collectively called sorgoleone, exuded as hydrophic droplets from the tip of root hairs of *Sorghum.* Sesquiterpene derivative strigol was the naturally occurring stimulant identified (Butler, 1995).

Musselman (1980) and Parker and Riches, (1993b) reported that in the absence of a specific germination stimulant, germination does not occur even under favourable environment condition. Thus the effectiveness of germination stimulant is dependent on the relative concentration of the stimulant and inhibitor presents (William, 1959)

2.11 Catch Crop

Catch crops are crops that are susceptible to the parasite and thus become infected. Before the parasite has the chance to flower and to set seeds, the farmer should up-root the catch crop to destroy the parasite (Oswald *et al.,* 1999). The most promising catch crop for *Striga hermonthica* control is the use of Sudan grass (*Sorghum sudanense L.*) (Last, 1961, Oswald *et al.,* 1999). However, catch cropping has rarely been used by small scale farmers to control *Striga* because the technique is not well known or understood and holds serious disadvantages, if not adapted to a specific cropping system (Oswald *et al.,* 1999).

2.12 Trap Crop

Trap crop is a crop which stimulates *Striga* seeds germination but cannot be infected by the parasite. Trap cropping is a control measure adopted against parasitic weeds such as *Alectra* and related parasitic weeds. Soyabeans has been shown to reduce the seed bank of *Striga hermonthica* a semi-parasitic weed in cereals such as *Sorghum* and millet, by causing suicidal germination. After induction of germination of *Striga* seeds, it prevents the attachment of the parasite to its roots which lead to death of the parasite (Kureh *et al.,* 2005a).

The most promising trap crops reported for *Striga* species are recently listed by Kroschel (2001). Trap crops for *Striga* include rotation with groundnut, bambara groundnut, pigeon pea and soyabean. It is obvious that farmers from countries or regions with possibilities for marketing *Striga* trap crops like cotton and soybean have an overall advantage in adopting such farming systems (Kroschel and Sauerborn, 1996). It has been concluded that large differences between cultivars in their 'trapping' ability exists and that the characterization and recommendation of the best cultivars should be a routine activity for researchers focusing on *Striga* and *Orobanche* infested areas (Berner *et al*., 1995). It should also be borne in mind, however, that farmers prefer many traits in a particular cultivar such as high yield potential, earliness, colour, cooking time, etc., which need to be considered when making recommendations to farmers (Ransom, 1999). *Alectra vogelii* may also be controlled through the use of trap crop such as dolichos bean (*Lablab purpureus [L.] Sweet*), cotton (*Gossypium hirsitum L.*), Okra (*Hibiscus esculentus L.*) and faba bean

(*Vicia faba*) sunflower (*Helianthus annuus L.*) Pea (*Pisum sativum L.*) (Parker and Riches, 1993b; Berner *et al.*, 1994).

However, Berner *et al.* (1997a) reported that, the production of high value medicinal herbs with *S. hermonthica* germination induction properties in the soil infested with *S. hermonthica* seed offer growers an alternative crop as well as potentially reducing *S. hermonthica* seed reserves.

Berner *et al.* (1997b) further explain that 383 traditional Chinese medicinal herbs extract were used to test their ability to induce or inhibit the germination of *S. hermonthica* seeds. Thus water extract from 27 herbs inhibited *S. hermonthica* germination. The undiluted extract from *Curcuma longa L.* completely inhibited *S. hermonthica* germination and undiluted extracts from 15 other herbs reduced germination by more than 50% compared with the positive control.

Girma *et al.* (2005) reported that *Orobanche* shoot count was significantly reduced in the third season in research work carried out between 2002-2004 on a field using selected 10 trap crops on a naturally infested soil to test the potential of trap crops in the exhaustion of the seed bank presiding tomato field. The author further observed that, among the potential experimental trap crops maize (Zea-mays) and snap bean (*Phaseolus vulgare*) showed very remarkable reduction in soil seed bank of *O. ramose* and *O. cernua* by 74 and 71%, respectively. The other potential trap crop also performed well in the reduction of seed bank of *O. ramose* and *O. cernua* more than 60%.

Kureh *et al.* (2005b) reported that sixteen genotypes supported few or no *Alectra* shoot count while six were susceptible in field study carried out between 1995 and

1996 in the northern Guinea Savanna of Nigeria to determine the response of 22 soyabean genotypes to *Alectra* infestation. However, the soya beans genotypes that supported high number of *Alectra* shoots recorded lower grain yield than those with fewer *Alectra* shoot which on the other hand can be used as trap crops to control *Alectra* on soil affected by the parasite.

In a study carried out by Kabambe *et al.* (2008), in screening legumes for integrated management of witchweed (*Alectra vogelii* and *Striga asiatica*). The result of the experiment indicates that among the crops soyabean are the most susceptible to *Alectra*, and within the soyabean, Bossier, Ocepara-4 and 501/6/12, were the least susceptible with <1.0 plant m^{-2}, compared to 5.0 plants m^{-2} with 427/5/7. The author further explains that all pigeon peas and green manure crops of mucuna and *Crotalaria* are immune to *Alectra*. Therefore, farmers with *S. asiatica* and *A. vogelii* infestation in their fields should use resistant soyabean types (*Bossier, Ocepara*-4), pigean peas or green manures as trap crop for *S. asiatica* while avoiding damage or build up of *Alectra* seeds on their farms. Furthermore, the result of the experiment also produced a higher yield of soyabean (*Bossier* and *Ocepara*-4) to over 2.2t ha^{-1}. Potential yields of soyabean yields range between 2000-4500kg/ha (Ministry of Agriculture, Irrigation and food security, MoAIFS, 2005).

Dhanapal and Struik. (2006), reported that among the trap crops used to stimulate the germination of parasitic weeds, *O. cernua* Loefl, in both the laboratory and glass house experiments without the addition of chemical in the experiment, the traps crops used, strongly increased germination of the parasites. The author further indicated that, greengram (*Vigna radiata*) and sunhemp (*Crotalaria juncea*) were especially

effective in inducing the germination of *O. cernua* seeds in a rotation of tobacco-fallow-trap crop-tobacco.

Alabi *et al.* (2007) reported that higher stimulation of *Striga* seeds germination was observed from the root content of *Celosia*/*Amaranthus* line at 3WAP, than that obtained at 5 and 7 WAP, in a laboratory screening of *Celosia*/*Amaranthus* lines at growth stages for suicidal germination of *Striga gesnerioides* seeds. The authors further explained that, the germination of *Striga* seeds by the tested crop lines ranged from 12.67-30. 33% at 3 WAP, 8-15.67% at 5WAP and 8-12.67% at 7 WAP, and that of the susceptible cowpea variety SAMPEA 7 as the control ranged from 36-47.67% at 3WAP, 26-26.67% at 5 WAP and 18.67-23.67% at 7 WAP. The susceptible cowpea variety SAMPEA 7 resulted in significantly higher *Striga* seeds germination than all the tested *Celosia*/*Amaranthus* lines.

Botanga *et al.* (2003) reported that, higher *S. hermonthica* seed germination was recorded with roots obtained from 3-weeks-old-plants and *S. hermonthica* seeds preconditioned for the same period, than the corresponding 2 week crop growth stage and precondition period, in a screening of forty genotypes of cotton (*Gossypium hirsutum* L. and *G. barbadense* L.) as trap crop. They used a cut-root technique to investigate the variability among the genotypes for their ability to stimulate suicidal germination of *S. hermonthica* and to determine the inheritance of the traits.

In an experiment carried out also by Kureh *et al.* (2000), the result indicates that, intercropping, maize with soya beans supported lower incidence and infestation of *Striga* syndrome reaction score than the sole maize, in on-station verification of the use of soyabean trap-crop for the control of *Striga* in maize. The authors further

expressed that, the mixture of maize with soyabean produced significantly (P=0.05) higher grain yield than sole maize crop under *Striga* infestation. Also, the mixture of local *Sorghum* variety with soyabean or cowpea produced significantly (P=0.05) higher head weight, 1000-seed weight and grain yield than sole *Sorghum*.

Also, further research works revealed that intercropping of maize with non-host crops has been reported to increase the efficiency of land use through the improved soil productivity and reduction of *S. hermonthica* soil seed bank as a result of suicidal germination of *Striga* seeds by non-host (Lagoke *et al.*, 1997; Oswald *et al.*, 1997, Ariga *et al.*, 1997).

Parkinson *et al.* (1989) reported effectiveness of soyabean, cotton and bambara groundnut in causing abortive germination of *Striga* seeds when grown in rotation with susceptible crop or as an intercrop. Carson (1988) reported that, the spreading vegetation of non-host crops (trap-crops) also smoother emerging *striga* plants. According to Olupot *et al.* (2001) *Celosia argentia* (Amaranthaceae) reduced *Striga* emergence on *Sorghum* by 55% and increased the yield of a susceptible *Sorghum* variety by 35% in the field.

Ariga *et al.* (1997) reported that aqueous extracts from cotton, cowpea and soyabean roots, stem and leaves contain high concentration of germination stimulant, he also observed a range of variations within species in their ability to stimulate germination of *S. hermonthica* seeds.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Field Experiment

3.1.1 Experimental site

The experiment was carried out in the Biological garden, Biological Sciences Department, Ahmadu Bello University (ABU), Samaru-Zaria (11^{o} 11`N, $07^{o}$ 38`E, 686m above sea level) in the Northern Guinea Savanna ecological zone of Nigeria.

3.1.2 Source of seeds

The seeds of *Alectra vogelii* and cowpea variety SAMPEA 7 were obtained from Institute for Agricultural Research, Ahmadu Bello University, Zaria, while seeds of *Amaranthus* lines were obtained from National Horticultural Reseach Intitute, Bagauda, Kano Sub-station. The *Amaranthus* lines include: NH-48, NH-493, NH-452, TETE, blackseededand *Celosia* (soko) TLV8.

3.1.3 Preparation of plots for *Celosia*/*Amaranthus* lines

Six (6) beds; (2m by 1m) each, were prepared in the Biological garden, Biological Sciences Department A.B.U., Zaria after clearing a portion of the land, for planting of the *Amaranthus* /*Celosia* lines seeds and cowpea SAMPEA 7.

3.1.4 Planting of *Amaranthus*/*Celosia* lines

The seeds of each line of *Celosia/Amaranthus* were broadcasted on a bed and covered with soil, using hand. Four (4) seeds each of cowpea SAMPEA 7 as the control were also planted per hole in rows on a bed. After a week of growth the plants were thinned

to at least 100 seedlings per bed of *Amaranthus/Celosia* lines, and two seedlings per stand of cowpea in rows on cowpea bed.

3.2 Laboratory Experiment (cut root technique)

Before the planting of the *Celosia/Amaranthus* lines and cowpea SAMPEA 7 seeds, the *Alectra* seeds were surface disinfected to eliminate microbial contaminants. The disinfectant: 1% sodium hypochlorite was prepared and 30ml of it was decanted into a large petri dish. The disinfectant was added to *Alectra* seeds and stirred for two (2) minutes. Floating seeds and debries were discarded. The mixture was poured into a funnel lined with filter paper and the seeds were washed with distilled water.

After a week of planting *Amaranthus* and cowpea variety SAMPEA 7, the *Alectra* seeds were pre-conditioned using incubator set at 27^0C in the Biological Sciences laboratory. The petri-dishes were autoclaved at 121^0C for 15 minutes. Petri-dishes were lined with two (2) 9cm diameter Whatman filter papers. Glass micro-fibre filter papers were punched into small discs, and these were arranged as shown in Fig. 1. The *Alectra* seeds were spread on top of the discs arranged on the filter papers in the petri dishes.

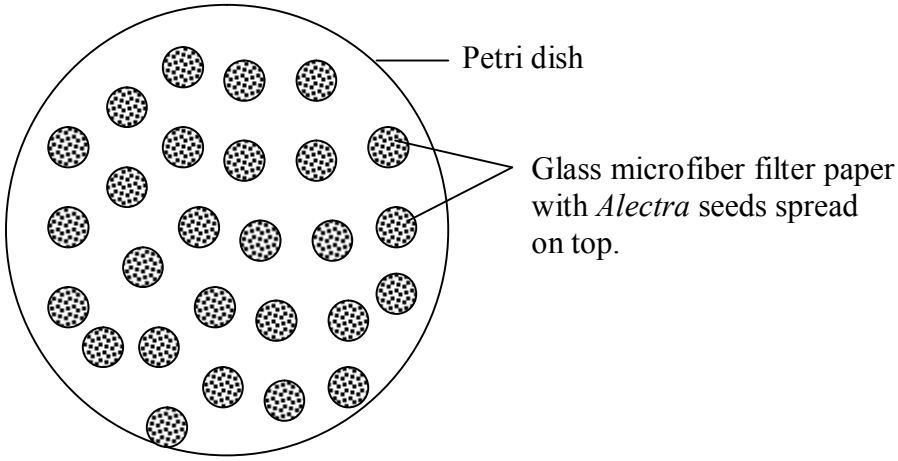


Figure. 1: The set-up for the pre-condition of *Alectra* Seeds

The function of the micro-fibre filter paper was to prevent the growth of micro-organisms like fungi and bacteria. About 3-4 drops of distilled water were added to the filter papers containing the *Alectra* seeds, and these were left in the incubator until the day the *Amaranthus* varieties and cowpea SAMPEA 7 plants were sampled. The *Amaranthus* and cowpea plants were sampled at 3, 5 and 7 weeks after planting (WAP). The sampled plants were washed with tap water. Each plant root was cut into 1cm length using scissors, and at least 1g of each *Amaranthus* lines and cowpea SAMPEA 7 roots was placed in the well made with Aluminium foil in the middle of the Petri-dish about 1-2cm diameter and 1.5cm high (Fig. 2).

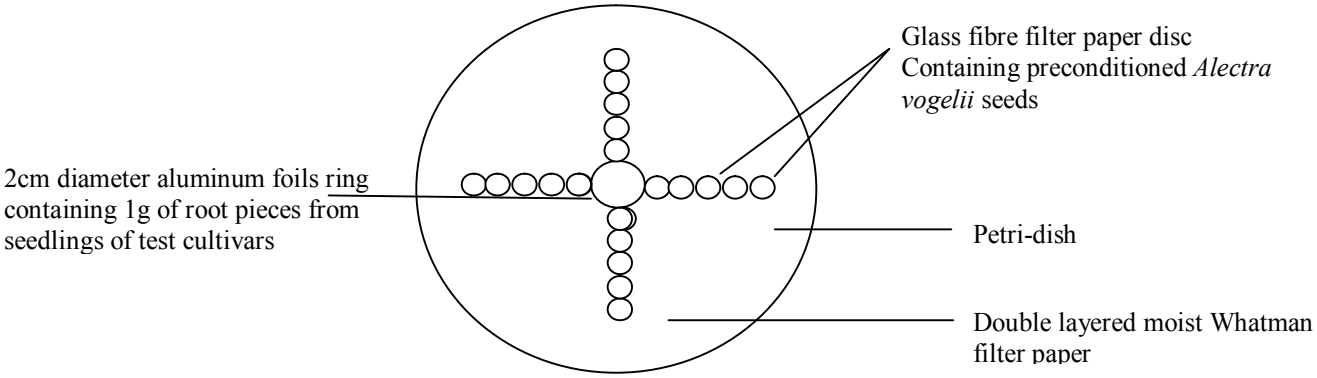


Figure. 2: The set up for testing efficacy of *Amaranthus* lines root content in stimulating *Alectra vogelii* seeds germination

The incubated *Alectra* seeds were arranged in a radii of 4 discs which radiate out from the central well (Fig. 2). The radii form a cross of discs with the well at the centre. Each radius of discs contains four (4) discs placed edge to edge, with the first disc touching the edge of the central well. Each petri-dish was replicated 3 times. A set-up with distilled water in petri-dish with *Alectra* seeds sprayed on was prepared to serve as negative control.

About 3-4 drops of distilled water was added to the root in the well, to make the root exudate to move towards the *Alectra* seeds and this was to facilitate the stimulation of germination and the growth of *Alectra* seeds. After the setting up of the petri-dishes, the seeds were conditioned in incubator set at 27^0C for 24 hours after which the petri-dishes were opened and the counting of the germinated *Alectra* seeds was done.

3.3 Green House Experiment

3.3.1 Polythene bags preparation for growing cowpea plants

Sand was collected from Kubani reservoir area and top soil was collected from the Botanical Garden, Ahmadu Bello University, Zaria. The top soil was sieved using sand siever and mixed with sand at 1:1 ratio. Bags (size: 20cm diameter, 11cm hight). This was used to fill the polythene bags (which served as pot) for the experiment. Sample of the soil mixture was set aside for physico-chemical analysis.

3.3.2 Preparation of *Alectra* seed inoculum

About 10g of *Alectra* seeds was weighed into polythene bag and 250g sieved dried river sand was also weighed into the polythene bag, *Alectra* seeds and 250g sand were poured into a large polythene. These were mixed thoroughly by shaking in different direction for about 3 minutes. The same process was followed to obtain enough *Alectra* seeds inoculums for the experiment.

3.3.3 Treatment and experimental design

One *Celosia* and five *Amaranthus* lines were used at four levels: high population (15 plants/pot) medium population (10 plants/pot) and low population (5 plants/pot) and control with zero plant. Each treatment levels of the *Amaranthus* lines consist of

eight (8) pots, replicated three (3) times for all the lines. This gave a total of 576 pots that were used for the experiment and arranged in a completely randomized design.

3.3. 4 Sowing

Hole of about 2cm deep was made at the center of each polythene bag and the *Alectra* seeds inoculum in a leveled soft drink bottle top was carefully poured into the hole and covered. In the same polythene bags, *Amaranthus* seeds were sown. The number of *Amaranthus* seeds to be planted/bag doubled the number of plants planned for each bag. After germination, the *Amaranthus* seedlings, were thinned to the required number and allowed to grow for 7 weeks before the termination of their growth. After the removal of the *Amaranthus* plants from the bag, seeds of cowpea variety SAMPEA 7 were sown in the bags.

3.3.5 Thinning

Four cowpea seeds (SAMPEA 7) were planted in each polythene bag. At 2 WAP, the seedlings were thinned to 2 plants per bags after which the seedlings were allowed to grow till 7 WAP.

3.3.6 Observations

Watering of the soil and hand pulling of unwanted weeds in the bags were carried out at intervals. At 7 WAP of growth, cowpea plants were carefully uprooted. The sampled plants were washed with tap water and spread on clean table for the water to drain off.. These sampled plants were used to determine the following parameters:

- **Plant height:** The height of the plant were measured by the use of meter rule from the soil level to the apex of the plant stem.

- **Shoot fresh weight:** The plants were separated into root and shoot and the shoot fresh weight of the sampled plants were determined on the weighing balance.
- **Root Fresh weight:** The root fresh weight of the sampled plants were determined with the use of weighing balance.
- **Root nodules number:** This was done by counting the number of the nodules seen on the roots of each sampled plant.
- **Attached *Alectra* shoot number:** *Alectra* shoots on sampled cowpea plants root were counted at the sampling time.
- **Emerged *Alectra* shoot number:** The emerged *Alectra* shoots in each polythene bag were counted at 8 and 10 WAP.
- **Flower number:** Flowers produced from the first to the last on each cowpea plant were counted daily.

The second sampling took place at 9 WAP.

Yield parameters of cowpea plants

At harvest, the following were determined:

- **Number of pods:** The pods produced by cowpea plants in each polythene bag were counted and recorded.
- **Pod weight:** The weight of the pods were determined with the use of the weighing balance and recorded.
- **Total grain yield:** After threshing the pods and winnowing the seeds, the seeds weight was determined using weighing balance and this was used to calculate the grain yield/plant.

- **1000 Seed weight:** From the winnowed seeds, 1000 seeds were counted from each treatment and weighed on the weighing balance and the weight recorded.

3.7 Statistical Analysis

The data obtained from the above parameters was analysed using the General Linear Model (GLM) of Analysis of Variance (ANOVA). Duncan Multiple Range Test (DMRT) was used to rank the means. Correlation co-efficient relationship between the various parameters measured was determined.

CHAPTER FOUR

4.0 RESULTS

4.1 Soil Analysis

The soil analysis carried out showed that the textural class is clay -loam. The pH is very stronglgy acid and the prercentage of the exchangeable bases in low compostion which revealed that the soil fertility is low (Table1).

Table 1. Physical and chemical properties of soil (0-30cm depth) used for the experiment.

Soil property	Value
Particle size (g kg^{-1})	
Clay	380
Silt	320
Sand	300
Textural class	Clay -loam
Chemical composition	
Organic carbon (g kg^{-1})	75
pH in $CaCl_2$ 0.01M(1:2.5)	4.57
Nitrogen (g kg^{-1})	1.40
Available phosphorus (mg kg^{-1})	24.3
Exchangeable Bases (cmol kg^{-1})	
Potassium	0.38
Calcium	0.66
Magnesium	10.12

4.2 Laboratory Experiment

4.2.1 Percentage germination of *Alectra* seeds by *Celosia/ Amaranthus* lines

All the *Amaranthus* lines and SAMPEA 7 (positive control) resulted in significantly higher germination of *Alectra* seeds than the distilled water treatment (negative control) on each sampling date in the two trials. In Trial 1, at 3 WAP, the *Amaranthus* line Tete resulted in the highest percent germination of *Alectra* seeds. This was followed by that due to the positive control (SAMPEA 7), while the lowest among the *Amaranthus* lines was obtained from *Amaranthus* line NH-452. All the *Amaranthus* lines and SAMPEA 7 (positive control) produced comparable percent germination of *Alectra* seeds which was significantly higher than the distilled water (Negative control) with the least (Table 2).

At 5 WAP, the highest percentage germination of *Alectra* seeds due to the SAMPEA 7 treatment was significantly higher than that due to all the *Amaranthus* lines. This was followed by that due to *Amaranthus* line Tete. The least percent germination of *Alectra* seeds due to *Amaranthus* line NH-452 among the *Amaranthus* lines was also significantly higher than that due to distilled water treatment (Table 2).

However, at 7 WAP, the highest percentage germination of *Alectra* seeds due to SAMPEA 7 treatment was significantly higher than that due to all the *Amaranthus* lines. This was followed by that due to *Amaranthus* line NH-493, which was comparable with that of other *Amaranthus* lines, but significantly higher than that of the distilled water which resulted in significantly lower germination of *Alectra* seeds gthan all the treatments (Table 2).

Table 2. Percentage germination of *Alectra vogelii* seeds by root exudates of *Celosia/Amaranthus* lines at different cowpea growth stages.

Trial	Treatment	Percentage germination(%) of *Alectra* seeds at different cowpea growth stages		
		3 WAP	5 WAP	7 WAP
I	Control(+)	12.00ab	29.00a	13.33a
	Tete	14.00a	14.00b	9.00b
	NH-48	8.00bc	12.00b	9.00b
	Local Black	11.67ab	10.33bc	8.33b
	NH-452	7.67c	7.33c	8.66b
	NH-493	8.00bc	8.00c	9.66b
	Celosia	9.38bc	10.33bc	8.33b
	Control (-)	1.38c	1.20d	1.22c
	Mean	9.01	11.52	8.44
	SE±	1.97	1.39	0.77
II	Control (+)	11.66ab	24.66a	20.00a
	Tete	7.00d	17.66b	15.33b
	NH-48	9.00cd	11.00c	11.33c
	Local Black	11.33ab	10.33c	7.33d
	NH-452	11.66ab	9.33c	8.00d
	NH-493	12.00a	7.33c	8.33d
	Celosia	10.33bc	6.66c	8.66d
	Control(-)	1.13e	1.12d	1.11e
	Mean	9.26	11.01	10.01
	SE±	0.90	1.02	0.65
Combined	Control (+)	11.83a	26.83a	16.66a
	Tete	10.50ab	15.83b	12.17b
	NH-48	8.50b	11.50c	10.17bc
	Local black	11.50a	10.33c	7.83cd
	NH-452	9.66ab	8.33cd	8.33c
	NH-493	10.00ab	7.66d	9.00c
	Celosia	9.86ab	8.50cd	8.50c
	Control (-)	1.26c	1.16e	1.17d
	Mean	9.14	11.31	9.22
	SE±	1.44	1.21	0.71

Figures followed by the same letter(s) in each column on each sampling date, are not significantly different (P=0.05), using Duncan Multiple Range Test (DMRT).
WAP: Weeks After plantng

At 3 WAP in Trial 2, the *Amaranthus* line NH-493 indicate the highest percent germination of *Alectra* seeds which was significantly high than all the *Amaranthus*/*Celosia* lines . Distilled water resulted in significantly lower germination of *Alectra* seeds than all the other treatments (Table 2).

The highest percent germination of *Alectra* seeds due to SAMPEA 7 at 5 WAP was significantly higher than that due to all the other treatments. The highest percentage germination of *Alectra* seeds was followed by that due to the *Amaranthus* line Tete. The lowest due to distilled water was significantly lower than that of all the other treatments (Table 2).

At 7 WAP, the highest percent germination of *Alectra* seeds due to SAMPEA 7 was significantly higher than that due to the all *Amaranthus* lines. This was however followed by that due to *Amaranthus* line Tete and NH-48. The least percent germination of *Alectra* seeds due to distilled water was significantly lower than that obtained from all the other treatments (Table 2).

The combined ANOVA of the data showed that, at 3 WAP, the *Amaranthus* line local black resulted in the highest percent germination of *Alectra* seeds which was only significantly higher than the lowest percent germination due to distilled water ($P = 0.05$) (Table 2).

At 5 WAP, the highest percentage germination of *Alectra* seeds due to SAMPEA7 treatment was significantly higher than that due to the *Amaranthus* lines. This was followed by that due to *Amaranthus* line Tete. The least percent germination of

Alectra seeds due to *Amaranthus* line NH-493 among the *Amaranthus* lines was significantly higher than that observed from distilled water (Table 2).

At 7 WAP, the highest percentage germination due to SAMPEA 7 was significantly higher than that due to all the *Amaranthus* lines. However, this was followed by that due to *Amaranthus* line Tete and NH-48. The least percent germination of *Alectra* seeds due to *Amaranthus* line local black among the *Amaranthus* lines was significantly higher than that due to the distilled water (Table 2).

In both trials, the stimulation of *Alectra* seeds germination by the crop lines at 5 WAP was significantly higher than that at 3 and 7 WAP, which in turn were comparable. However, the plant age had significant effect on the percentage germination of *Alectra* seeds by the treatments since more of the germination stimulant was produced at 5WAP as compared to at 3 and 7 WAP (Table 2).

4.2.3 Pot experiment

Shoot fresh weight of *Alectra* infected sampled cowpea plants

The medium population reatment produced the highest shoot fresh weight at 7 WAP in trial 1, whereas high population treatment produced lower shoot fresh weight, and for most *Amaranthus* lines there was no *Alectra* infected cowpea plants under the high population
treatment.

Celosia

In Trial 1, the *Alectra* infected cowpea plants from the medium *Celosia* population treatment produced the highest shoot fresh weight at 7 WAP, which was only comparable with that observed from the positive control treatment.

The lowest shoot fresh weight observed from the plants under high *Celosia* population treatment was significantly lower than that observed from the other treatments (Table 3).

At 9 WAP, cowpea plants from the positive *Celosia* control treatment produced the highest shoot fresh weight which was significantly higher than the other treatments. The lowest fresh shoot weight observed from plants under high *Celosia* population treatment was only significantly lower than that observed from the positive control, but comparable with that of the other treatments (Table 3).

In Trial 2, cowpea plants from the positive *Celosia* control treatment produced the highest shoot fresh weight at 7 WAP, which was comparable with the other *Celosia* treatments observed (Table 3). Similarly, at 9 WAP, cowpea plants from the positive *Celosia* control treatment also produced the highest shoot fresh weight, which was comparable with the other treatments (Table 3).

The combined ANOVA of data in the two trials showed that, the infected cowpea plants from the positive *Celosia* control treatment produced the highest shoot fresh weight which was only significantly higher than the lowest due to low population treatment (Table 3).

Tete variety

In Trial 1, *Alectra* infected cowpea plants from the medium Tete population treatment produced the highest shoot fresh weight at 7 WAP,

Table 3. Effect of *Amaranthus* population levels on the shoot fresh weight of *Alectra*-infected cowpea plants.

Trial	Age (WAP)	Variety	Shoot fresh weight (g/plant)						
			Control		*Amaranthus* population level				
			Negative	Positive	Low	Medium	High	Mean	SE±
I	7	*Celosia*	NI	7.33a	5.57b	7.53a	3.73c	4.83	1.41
		Tete	NI	4.37a	3.80b	4.70a	NI	2.57	0.11
		NH-48	NI	2.70b	2.80b	3.80a	1.90c	2.24	0.12
		Local Black	NI	3.20a	3.87a	4.40a	NI	2.29	0.08
		NH-452	NI	2.87a	NI	NI	2.17b	1.01	0.61
		NH-493	NI	3.97a	3.97a	NI	NI	1.69	0.9
	9	*Celosia*	NI	10.80a	3.30b	4.17b	3.10b	4.27	0.47
		Tete	NI	6.97a	1.80b	NI	NI	11.75	0.69
		NH-48	NI	4.20a	NI	2.30b	2.30b	1.68	0.02
		Local Black	NI	3.27a	3.57a	1.00b	3.00a	2.17	0.12
		NH-452	NI	2.07a	NI	NI	NI	0.41	0.07
		NH-493	NI	4.07a	3.60b	NI	NI	2.63	0.01
II	7	*Celosia*	NI	23.40a	18.63a	20.77a	21.77a	16.9	1.29
		Tete	NI	17.23a	16.60a	21.03a	11.57b	13.27	1.20
		NH-48	NI	21.03a	23.80a	16.93a	18.77a	16.93	2.44
		Local Black	NI	21.00a	20.53ab	15.93ab	13.53b	14.20	1.66
		NH-452	NI	24.73a	23.37a	22.20a	20.90a	18.20	1.44
		NH-493	NI	2.10a	5.53a	3.50a	8.40a	3.91	1.80
	9	*Celsia*	NI	38.27a	30.50a	32.87a	34.53a	27.23	4.35
		Tete	NI	39.53a	32.03ab	19.03b	30.70ab	24.26	3.40
		NH-48	NI	26.80a	20.73a	25.23a	25.23a	19.33	2.36
		Local Black	NI	25.70a	22.00a	24.53a	23.00a	19.05	2.26
		NH-452	NI	20.73a	29.33a	37.30a	25.83a	27.62	1.78
		NH-493	NI	46.43a	13.43c	48.33a	27.43b	27.73	3.22
Combined		*Celosia*	NI	19.95a	14.50b	18.90a	15.78ab	13.83	2.36
		Tete	NI	16.19a	13.57ab	17.03a	10.57b	10.47	2.05
		NH-48	NI	12.07a	11.83a	13.68a	9.79a	9.84	1.69
		Local Black	NI	12.49ab	13.29a	11.47ab	9.88a	9.43	1.46
		NH-452	NI	12.60a	13.15a	14.88	12.22a	10.57	1.37
		NH-493	NI	18.14a	10.52b	17.40a	10.66b	11.34	2.54

N.B Mean followed by the same letter(s) in each row, in each trial are not significantly different (P = 0.05), using Duncan Multiple Range Test (DMRT) .
NI: No *Alectra* infected plants

which was only comparable with that observed from the positive control treatment and significantly higher than the low population treatment with the lowest. None of the sampled plant from high population of Tete treatment was infected with *Alectra* (Table 3).

Cowpea plants from the positive control of Tete treatment produced the highest fresh shoot weight at 9 WAP, which was significantly higher than that observed from the plants under the low population treatment with the lowest shoot fresh weight. None of the sampled plants from the other treatments was infected with *Alectra* (Table 3).

In Trial 2, *Alectra* infected cowpea plants from the medium Tete population treatment produced the highest shoot fresh weight at 7 WAP, which was only higher than that of the high population of Tete treatment (Table 3).

However, at 9 WAP, the lowest shoot fresh weight observed from medium population of Tete treatment was only significantly lower than the highest observed from the positive control treatment (Table 3).

The combined ANOVA of the data showed that in both trials, *Alectra* infected cowpea plants from the medium Tete Population treatment produced the highest shoot fresh weight which was only significantly higher than that due to the high population treatment with the lowest (Table 3).

NH-48 Line

In Trial 1, the *Alectra* infected sampled cowpea plants from the medium NH-48 population treatment produced the highest shoot fresh weight at 7 WAP, which was significantly higher than the other treatments. The lowest shoot fresh weight observed

from the high NH-48 population treatment was significantly lower than that of the other treatments observed (Table 3).

At 9 WAP, infected cowpea plants from the positive NH-48 control treatment produced the highest fresh shoot weight, which was significantly higher than the lowest from medium and high population treatments. None of the sampled plants from the low population of NH-48 treatment was infected by *Alectra* (Table 3).

In Trial 2, *Alectra* infected cowpea plants from the low population of NH-48 treatment produced the highest shoot fresh weight at 7 WAP, which was comparable with the other treatments. The medium population treatment produced the lowest shoot fesh weight. Similarly, at 9 WAP, *Alectra* infected cowpea plants from the positive control treatment produced the height shoot fresh weight which was comparable with that of the other treatments. (Table 3)

The combined ANOVA of the data showed that, in both trials the infected cowpea plants sampled from the medium population treatment produced the highest shoot fresh weight which was comparable with that of the other treatments (Table 3).

Local Black

In Trial 1, *Alectra* infected cowpea plants from the medium local black population treatment produced the highest shoot fresh weight at 7 WAP, which was comparable with that observed from the other treatments.

None of the sampled plants from the high population of Local Black treatments was infected with *Alectra* (Table 3).

Alectra uninfected cowpea plants from low local black population treatment produced the highest shoot fresh weight at 9 WAP, which was only significantly higher than that due to medium population treatments (Table 3).

In Trial 2, the infected plants among the sampled plants showed that cowpea plants from the positive local black control treatment produced the highest shoot fresh weight at 7 WAP, which was significantly higher than the lowest due to high population treatment. At 9 WAP, *Alectra* infected cowpea plants from the positive control treatment produced the highest shoot fresh weight which was comparable with the other treatments observed (Table 3).

The combined ANOVA of the data showed that, in both trials *Alectra* infected cowpea plants from the low Local black population treatments produced the highest shoot fresh weight which was only significantly higher than the lowest due to high population treatment (Table 3).

NH-452 Line

In Trial 1, *Alectra* infected cowpea plants from the positive NH-452 control treatment produced the highest shoot fresh weight at 7 WAP, which was significantly higher than the high population treatment. None of the sampled plants from the low and medium population of NH-452 treatments was infected with *Alectra*. However, at 9 WAP, only the positive NH-452 control treatment was observed with *Alectra* infected plants. None of the sampled plants from the other treatments was infected with *Alectra* (Table 3).

In Trial 2, *Alectra* infected cowpea plants from the positive NH- 452 control treatments produced the highest shoot fresh weight, which was comparable with the other treatments observed at 7 WAP (Table 3).

Similarly, at 9 WAP, *Alectra* infected cowpea plants from the medium NH-452 treatment produced the highest shoot fresh weight which was comparable with the other treatments observed (Table 3).

The combined ANOVA showed that in both trials, infected cowpea plants from the medium NH-452 population treatment produced the highest shoot fresh weight which was comparable with that of the other treatments (Table 3).

NH-493 Line

In Trial 1, *Alectra* infected cowpea plants from the low population and positive control NH-493 treatments produced the highest shoot fresh weight at 7 WAP, which were comparable. None of the sampled plants from the other treatments was infected with *Alectra.* At 9 WAP, *Alectra* infected cowpea plants from the positive NH- 493 control treatment produced the highest shoot fresh weight, which was only significantly higher than that of the low population treatment. None of the sampled plants from the other treatments was infected with *Alectra* (Table 3).

In Trial 2, *Alectra* infected cowpea plants from the high population treatment produced the highest shoot fresh weight which was comparable with the other treatments at 7 WAP (Table 3)

At 9 WAP, infected cowpea plants from the medium poplation treatment produced the highest shoot fresh weight, which was significantly higher than the other

treatments, but comparable only with the positive control treatment. The lowest shoot fresh weight due to low population treatment was significantly lower than the other treatments (Table 3).

The combined ANOVA of the data showed that, in both trials *Alectra* infected Cowpea plants from the positive NH-493 control treatment produced the highest shoot fresh weight which was comparable with that of the medium population treatment. The lowest shoot fresh weight due to low population treatment was comparable only with that of the high population treatment (Table 3).

Shoot fresh weight of *Alectra* uninfected sampled cowpea plants

Sampled *Alectra*-uninfected cowpea plants from the negative control treatment generally produced higher shoot fresh weight than those from the *Amaranthus* lines population treatments, whereas high population treatment produced the lowest shoot fresh weight.

Celosia

In Trial 1, the uninfected plants sampled showed that cowpea plants from the positive *Celosia* control treatment produced the highest shoot fresh weight at 7 WAP, which was significantly higher than the other treatments. This was followed by that observed from the negative control treatment. The reverse of this was true for *Amaranthus* lines. At 7 WAP, the lowest shoot fresh weight observed from the plants under medium *Celosia* population treatment was significantly lower than that of the other treatments (Table 4).

At 9 WAP, uninfected cowpea plants from the positive *Celosia* control treatment produced the highest shoot fresh weight, which was significantly higher than that of the other treatments. This was followed by that observed from the negative *Celosia* control treatment. The lowest shoot fresh weight observed from the plants under the high *Celosia* population treatment was comparable with that observed from the medium and low population treatments (Table 4).

In Trial 2, uninfected cowpea plants from the negative *Celosia* control treatment produced the highest shoot fresh weight at 7 WAP, and this was comparable with that observed from the positive control and medium population of *Celosia* treatments. The lowest shoot fresh weight observed from the low *Celosia* population treatment was comparable with that from the high population treatment.

However, at 9 WAP, *Alectra* uninfected cowpea plants from the negative control treatment produced the highest shoot fresh weight which was comparable with that of the low *Celosia* population treatment.

However, at 9 WAP, *Alectra* uninfected cowpea plants from the negative control treatment produced the highest shoot fresh weight which was comparable with that of the low *Celosia* population treatment. No uninfected plants was found among those sampled from positive control, medium and high population of *Celosia* treatments (Table 4). The combined ANOVA of the data showed that the uninfected cowpea plants from the high *Celosia* population treatment produced the lowest shoot fresh weight which was only significantly lower than the highest due to negative control treatment (Table 4).

Table 4. Effect of *Amaranthus* population levels on the shoot fresh weight of *Alectra* uninfected cowpea plants

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Trial	Age (WAP)	Variety	Shoot fresh weight (g/plant)						
			Control		*Amaranthus* population level				
			Negative	Positive	Low	Medium	High	Mean	SE±
I	7	*Celosia*	8.00b	12.73a	4.43d	3.00e	5.90c	6.63	0.34
		Tete	6.50a	5.80ab	5.13ab	3.77b	4.37ab	5.11	0.53
		NH-48	6.17a	2.53b	2.13b	2.60b	4.50a	3.59	0.44
		Local. Black	6.87a	4.97b	0.02d	3.53c	5.8ab	4.24	0.07
		NH-452	8.23a	3.07b	2.80b	2.53b	8.57a	5.04	0.30
		NH-493	8.57a	3.53b	4.53b	5.47ab	5.67ab	3.55	0.08
	9	*Celosia*	8.23b	11.80a	5.77c	4.40c	4.17c	5.23	0.47
		Tete	8.83a	6.57b	2.60c	3.23c	2.97c	4.84	0.08
		NH-48	7.43a	3.87b	2.60b	2.53b	2.13b	3.71	0.05
		Local. Black	8.10a	4.32bc	3.20c	5.20b	5.20b	5.20	0.05
		NH-452	7.60a	2.87b	1.67c	2.60bc	2.40bc	3.43	0.04
		NH-493	8.57a	4.67b	2.83d	3.07c	4.37bc	4.70	0.09
II	7	*Celosia*	31.33a	27.80a	13.53b	26.60a	17.20b	23.29	2.24
		Tete	31.33a	24.4b	18.80c	10.80d	11.60d	19.39	1.37
		NH-48	36.90a	17.87ab	21.77ab	10.70b	11.23b	18.59	2.52
		Local. Black	28.50a	17.33b	11.10b	11.10b	7.57b	12.90	2.45
		NH-452	36.03a	19.50b	14.13b	14.13b	17.07b	21.04	3.33
		NH-493	3.90a	3.23ab	2.60ab	2.60ab	2.07b	2.83	2.59
	9	*Celosia*	33.70a	NI	15.10a	NI	NI	9.76	6.10
		Tete	43.07a	27.27b	21.80c	27.27b	17.80c	27.44	1.21
		NH-48	34.97a	NI	NI	NI	19.50b	10.89	2.52
		Local. Black	33.97a	NI	21.47b	21.47b	NI	14.71	2.75
		NH-452	46.67a	21.73c	25.80b	24.07b	16.76c	23.01	2.81
		NH-493	42.20a	NI	13.80b	NI	23.39b	15.88	3.37
Combined		*Celosia*	20.32a	13.00b	9.71b	8.50b	6.82b	11.69	3.43
		Tete	22.43a	15.97b	12.08c	11.27cd	9.18d	14.19	1.14
		NH-48	21.37a	6.07b	6.63b	3.96b	3.34b	9.47	2.94
		Local. Black	19.36a	6.65bc	5.33c	10.33b	4.64c	9.26	2.31
		NH-452	24.63a	11.79b	7.18b	10.10b	9.69b	12.68	2.35
		NH-493	21.63a	7.78bc	10.83bc	6.12c	12.13b	11.70	2.80

Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple RangeTest (DMRT)
NI:No *Alectra* uninfected plants

Tete

In Trial 1, *Alectra* uninfected Cowpea plants from the negative control treatment produced the highest shoot fresh weight at 7 WAP, which was comparable with the other treatments except that due to the medium population treatments. The lowest shoot fresh weight was observed from the plants under the medium Tete population treatment (Table 4).

Alectra uninfested cowpea plants from the negative Tete control treatment produced the highest fresh shoot weight at 9 WAP, which was significantly higher than that observed from the other treatments. This was followed by that observed from the positive control treatments. The lowest shoot fresh weight due to low population of Tete treatment was only comparable with that observed from the medium and high population treatments (Table 4).

In Trial 2, *Alectra* uninfected Cowpea plants from the negative control treatment produced the highest shoot fresh weight, which was significantly higher than the other treatments at 7 WAP. This was however followed by that observed from the positive control treatment. The lowest shoot fresh weight observed from plants under the medium population treatment was only comparable with that observed from the high population treatment (Table 4).

At 9 WAP, uninfected cowpea plants from the negative Tete population treatment produced the highest shoot fresh weight, which was significantly higher than that of the other treatments. This was followed by that due to positive control and medium population treatments. The lowest shoot fresh weight observed from the high

population treatments was only comparable with that observed from the low population treatment (Table 4).

The combined ANOVA of the data showed that, the uninfected cowpea plants from the negative control treatment in both trials produced the highest shoot fresh weight, which was significantly higher than that of the other treatments. This was followed by that due to positive control treatment. The lowest shoot fresh weight observed from the high population treatment was comparable with that due to medium population treatment (Table 4).

NH-48 Line

In Trial 1, *Alectra* uninfected cowpea plants from the negative NH-48 control treatment produced the highest shoot fresh weight at 7 WAP, which was only comparable with that observed from the high population treatment. The lowest shoot fresh weight due to low NH-48 population treatment was comparable only with positive control and medium population treatments (Table 4).

At 9 WAP, *Alectra* uninfected cowpea plants from the high NH-48 population treatment produced the lowest shoot fresh weight which was only significantly lower than the highest due to the negative control treatment (Table 4).

In Trial 2, the uninfected cowpea plants from the negative NH-48 population treatment produced the highest shoot fresh weight at 7 WAP, which was significantly higher than that due to medium and high population treatments that are in turn comparable. At 9WAP, *Alectra* uninfected cowpea plants from the positive control treatment produced the highest shoot fresh weight which was only significantly higher than that due to high population treatment (Table, 4). No *Alectra* uninfected

cowpea plant was sampled from positive control, low and medium population of NH-48 treatments at 9 WAP.

The combined ANOVA of the data showed that, in both trials the uninfected cowpea plants from the high population treatment produced the lowest shoot fresh weight which was only significantly lower than the highest from negative control treatment (Table 4.8).

Local Black

In Trial 1, *Alectra* uninfected cowpea plants from the negative local black control treatment produced the highest fresh shoot weight at 7 WAP, was only comparable with that observed from the high local black population treatment. The lowest shoot fresh weight due to low local black population treatment was significantly lower than the other treatments (Table 4.).

At 9 WAP, uninfected cowpea plants from the negative local black control treatment produced the highest fresh shoot weight, which was significantly higher than the other treatments. The lowest shoot fresh weight due to low population treatment, was only comparable with that due to positive control treatment (Table 4)

In Trial 2, *Alectra* uninfected cowpea plants from the negative local black control treatment produced the highest shoot fresh weight at 7 WAP, which was significantly higher than the other treatments. This was however followed with that observed from the positive control treatment the lowest shoot fresh weight due to high population treatment was only significantly lower than the highest due to negative control treatments (Table 4).

At 9 WAP, uninfected cowpea plants from the negative control treatment produced the highest shoot fresh that was significantly higher than that observed from the other treatments that were comparable. None of the sampled plants from the positive control and high population of Local Black treatment was infected with *Alectra* (Table 4).

The combined ANOVA of the data showed that, the uninfected Cowpea plants in both trials, from the negative Local black control treatment produced the highest shoot fresh weight which was significantly higher than that of the other treatments. The lowest-shoot8fresh weight due to high population treatments was comparable only with that of the low population and positive control treatments (Table 4).

NH-452 Line

In Trial 1, the uninfected plant sampled showed that cowpea plants from high NH-452 population treatment produced the highest shoot fresh weight at 7 WAP, which was only comparable with that observed from the negative control treatment. The lowest shoot fresh weight due to medium NH-452 population treatment was comparable with that of the positive control and low population treatment (Table 4).

However, at 9 WAP, uninfected cowpea plants from the negative NH-452 control treatment produced the highest shoot fresh weight which was significantly higher than the other treatments. This was followed by that observed from positive control treatment. The lowest fresh shoot weight due to low NH- 452 population treatment was only significantly lower than that due to negative and positive control treatments (Table 4).

In Trial 2, at 7 WAP, the uninfected cowpea plants from the low and medium NH-452 population treatment produced the lowest shoot fresh weight, which was only significantly lower than the highest due to the negative NH-452 treatment. At 9 WAP, *Alectra* uninfected negative NH-452 control treatment produced the highest shoot fresh weight, which was significantly higer than the other treatments. The lowest shoot fresh weight due to high population treatment was only comparable with that of the positive control treatment (Table 4).

The combined ANOVA of the data showed that, in both trials the uninfected plants sampled showed that cowpea plants from the low NH -452 population treatment produced the lowest shoot fresh weight which was only significantly lower than the highest due to the negative control treatment (Table 4).

NH-493 Line

In Trial 1, the lowest shoot fresh weight at 7 WAP due to positive control treatment was only significantly lower than the highest due to the negative NH-493 control treatment (Table 4).

At 9 WAP, uninfected cowpea plants from the negative NH- 493 control treatment produced the highest shoot fresh weight, which was significantly higher than the other treatments. The lowest shoot fresh weight observed from plants under the low population treatment was only comparable with that due to the medium population treatment (Table 4).

In Trial 2, *Alectra* uninfected cowpea plants from the negative control treatment produced the highest shoot fresh weight at 7 WAP, which was only significantly higher than the lowest due to high population treatment. At 9 WAP, uninfected

cowpea plants from the negative control treatment produced the highest shoot fresh weight, which was significantly higher than the other treatments. The lowest shoot fresh weight due to low population treatment was significantly lower than the other treatments (Table 4). No *Alectra* uninfected plants was found among sampled plants from positive control and medium NH-493 population treatments.

The combined ANOVA of the data showed that, in both trials, the uninfected cowpea plants from the negative NH-493 control treatment produced the highest shoot fresh weight which was significantly higher than the other treatments. The lowest shoot fresh weight due to medium population treatments was significantly lower than the other treatments (Table 4).

Root fresh weight of *Alectra* infected sampled cowpea plants

The positive control treatment produced higher root fresh weight than the other treatments in trial 1 whereas comparable root fresh weight was produced by the treatments in trial 2. However, combined ANOVA showed that Alectra infected cowpea plants sampled from the high population treatment produced the highest root fresh weight compared with the other treatments. Whereas the medium population treatment produced the lowest.

Celosia

In Trial 1, the infected plants among the sampled plant showed that cowpea plants from the medium *Celosia* population treatment produced the highest root weight, at 7 WAP, which was comparable with that of the other treatments. However, at 9 WAP, *Alectra* infected cowpea plants from the medium *Celosia* population treatment

produced the highest root fresh weight which was only significantly higher than the lowest due to positive *Celosia* control treatment (Table 5).

In Trial 2, infected cowpea plants from the low *Celosia* population treatment produced the highest root fresh weight at 7 WAP, which was only comparable with that of the medium population treatment. The lowest root fresh weight due to high population treatment was significantly lower than the other treatments. At 9 WAP, *Alectra* infected cowpea plants from the high *Celosia* population treatment produced the highest root fresh weight, which was only significantly higher than the lowest root fresh weight due to the medium *Celosia* population treatment (Table 5). The combined ANOVA of the data showed that, in both trials, the infected cowpea plants among the sampled plants from the high *Celosia* population treatment produced the highest root fresh weight which was comparable with that of the other treatments (Table 5).

Tete

In Trial 1, *Alectra* infected cowpea plants from the positive Tete control treatment produced the highest root fresh weight at 7 WAP, which was significantly higher than the other treatments. The lowest root fresh weight due to low population treatment was significantly lower than the other treatments. None of the sampled plants from the high population of Tete treatment was infected with *Alectra*. At 9 WAP, *Alectra* infected cowpea plants from the positive control treatment produced the highest root fresh weight which was only significantly higher than that of the low population

Table 5. Effect of *Amaranthus* population levels on the root fresh weight of *Alectra* infected cowpea plants

Trial	Age (WAP)	Variety	Root fresh weight (g/plant)						
			Control		*Amaranthus* population level				
			Negative	Positive	Low	Medium	High	Mean	SE±
I	7	*Celosia*	NI	0.77a	0.80a	1.00a	0.77a	0.67	0.11
		Tete	NI	0.70a	0.40c	0.60b	NI	0.34	0.02
		NH-48	NI	0.17d	0.30c	0.80a	0.50b	0.35	0.11
		Local. Black	NI	0.40a	0.57a	0.47a	NI	0.29	0.08
		NH-452	NI	0.47a	NI	NI	0.17b	0.13	0.03
		NH-493	NI	0.50a	0.47b	NI	NI	0.19	0.09
	9	*Celosia*	NI	0.55b	0.80ab	1.60a	0.67ab	0.72	0.23
		Tete	NI	6.97a	1.80b	NI	NI	1.75	0.11
		NH-48	NI	0.30b	NI	NI	0.40a	0.14	0.26
		Local. Black	NI	0.20a	0.37a	0.60a	0.47a	0.33	0.12
		NH-452	NI	0.67a	NI	NI	NI	0.13	0.07
		NH-493	NI	0.37b	1.40a	0.93ab	NI	0.34	0.17
II	7	*Celosia*	NI	5.87b	10.20a	10.13a	2.8c	5.8	0.98
		Tete	NI	4.60a	1.7a	3.40a	5.07a	2.95	0.88
		NH-48	NI	2.47b	4.07ab	6.53a	4.12ab	3.44	0.86
		Local. Black	NI	5.93a	7.03a	3.93a	5.73a	4.52	1.02
		NH-452	NI	10.63a	4.90b	6.10b	6.90b	5.71	0.84
		NH-493	NI	2.10a	5.53a	3.50a	8.40a	3.91	2.29
	9	*Celosia*	NI	29.70ab	25.20ab	5.40b	34.93a	23.00	5.73
		Tete	NI	5.90b	13.80ab	8.27b	23.27a	10.25	2.88
		NH-48	NI	16.40a	11.37a	19.47a	13.23a	12.09	1.98
		Local. Black	NI	19.53b	27.27ab	8.67b	49.34a	26.33	7.02
		NH-452	NI	8.37a	12.13a	6.30a	11.33a	2.83	1.61
		NH-493	NI	15.76a	7.33a	21.10a	16.07a	12.05	4.12
Combined		*Celosia*	NI	9.22a	9.25a	4.53a	9.79a	6.56	3.33
		Tete	NI	3.32b	4.08ab	3.07b	7.08a	3.51	1.71
		NH-48	NI	4.83ab	3.93b	6.70a	4.58ab	4.10	1.20
		Local. Black	NI	6.52ab	8.81ab	3.42b	13.91a	6.53	3.92
		NH-452	NI	5.03a	4.26a	3.10a	4.60a	4.30	0.98
		NH-493	NI	4.68a	3.68b	6.38a	6.12a	4.17	2.41

Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple RangeTest (DMRT).
NI:No *Alectra*-Infected Plants

treatment. None of the sampled plants from the medium and high population treatments was infected with *Alectra* (Table 5).

In Trial 2, the infected plants among the sampled plants showed that cowpea plants from the high Tete population treatment produced the highest root fresh weight at 7 WAP, which was comparable with that of the other treatments (Table 5).

At 9 WAP, infected cowpea plants from the high Tete population treatment produced the highest root fresh weight, which was comparable with that due to low Tete population treatment. The lowest root fresh weight observed from the positive control treatment was only significantly lower than the highest due to the high population treatment (Table 5).

The combined ANOVA of the data showed that, *Alectra* infected cowpea plants from the high population treatment in both trials, produced the highest root fresh weight which was comparable with that of low population treatment. The lowest root fresh weight due to medium population treatment was significantly lower than the highest due to high population treatment (Table 5).

NH- 48 Line

Trial 1, the infected plants among the sampled plant showed that cowpea plants from the medium NH- 48 population treatment produced the highest root fresh weight at 7 WAP which was significantly higher than that of the other treatments. However, this was followed by that of the high population treatment. The lowest NH- 48 root fresh weight due to positive control treatment was significantly lower than the other treatments (Table 5)

At 9 WAP, *Alectra* infected cowpea plants from the high NH-48 population treatment produced the highest root fresh weight, which was only significantly higher than the positive control treatment with the lowest root fresh weight. None of the sampled plants from the other treatments (Low and medium population) was infected with *Alectra* (Table 5).

In Trial 2, the infected cowpea plants from the medium NH-48 population treatment produced the highest root fresh weight at 7 WAP, which was only significantly higher than the lowest due to the positive NH-48 control treatment. At 9 WAP, *Alectra* infected cowpea plants from the medium NH-48 population treatment produced the highest root fresh weight, that was comparable with that of the other treatments (Table 5).

The combined ANOVA of the data showed that, in both trials, the infected plants among the sampled plant showed that cowpea plants from the medium population treatments produced the highest root fresh weight which was only significantly higher than the lowest due to low population treatment (Table 5).

Local Black

In Trial 1, *Alectra* infected cowpea plants from the low local black population treatment produced the highest root fresh weight at 7 WAP, which was comparable with the other treatments. However, none of the sampled plants from the high Local black population treatment was infected with *Alectra.* At 9 WAP, *Alectra* infected cowpea plants from the medium population treatment produced the highest root fresh weight, which was comparable with that of the other treatments (Table 5).

In Trial 2 at 7 WAP, *Alectra* infected cowpea plants from the low Local black population treatment produced the highest root fresh weight, which was comparable with that of the other treatments. However, at 9 WAP, *Alectra* infected cowpea plants from the high Local black population treatment produced the highest root fresh weight which was only comparable with that of low population treatment. The lowest root fresh weight due to medium population treatment was only comparable with that due to the positive control treatment (Table 5).

The combined ANOVA of the data showed that, in both trials, *Alectra* infected cowpea plants from the high Local black population treatments produced the highest root fresh weight which was only significantly higher than the lowest due to medium population treatment (Table 5).

NH- 452 Line

In Trial 1, the *Alectra* infected plants among the sampled plant showed that cowpea plants from the positive NH- 452 control treatment, produced the highest root fresh weight at 7 WAP, which was only significantly higher than that of the high population treatment. None of the sampled plants from the other treatments (Low and medium population) was infected with *Alectra*. At 9 WAP, *Alectra* infected cowpea plants was observed only from the positive control treatment (Table 5).

In Trial 2, *Alectra* infected Cowpea plants from the positive NH-452 control treatment produced the highest root fresh weight at 7 WAP which was significantly higher than that of the other treatments that were in turn comparable with the lowest due to low population treatment. However, at 9 WAP, *Alectra* infected cowpea plants

from the low NH-452 population treatment produced the highest root fresh weight which was comparable with that of the other treatments (Table 5).

The combined ANOVA of the data showed that, in both trials, the infected plants among the sampled plants showed that cowpea plants from the positive NH-452 control treatment produced the highest root fresh weight which was comparable with that of the other treatments (Table 5).

NH- 493 Line

In Trial 1, at 7 WAP, the *Alectra* infected plants were found only among the sampled plants from positive control and low population treatments. Plants from the positive NH- 493 control treatment produced the highest fresh root weight at 7 WAP, which was only significant higher than that of the low population treatments. At 9 WAP, *Alectra* infected cowpea plants from the low NH-493 population treatment produced the highest root fresh weight, which was only significantly higher than that of medium population treatment. However, the lowest shoot fresh weight due to positive control treatment was significantly lower than the other treatments. None of the sampled plants from the high NH-493 population treatment was infected with *Alectra* (Table 5).

In Trial 2, *Alectra* infected cowpea plants from the high NH-493 population treatment produced the highest root fresh weight at 7 WAP, which was comparable with that of the other treatments. Similarly, at 9 WAP, *Alectra* infected cowpea plants from the medium population treatment produced the highest root fresh weight, which was comparable with that of the other treatments (Table 5).

The combined ANOVA of the data showed that, in both trials, *Alectra* infected cowpea plants from the medium NH-493 population treatments produced the highest root fresh weight which was only significantly higher than that observed from the low population treatment (Table 5).

Root fresh weight of *Alectra* uninfected sampled cowpea plants

Generally, the negative control treatment produced highest root fresh weight than the other treatments.

Celosia

In Trial 1, uninfected plants sampled showed that cowpea plants from the positive *Celosia* control treatment produced the highest root fresh weight at 7 WAP, which was significantly higher than that of the other treatments. The lowest root fresh weight due to medium *Celosia* population treatment was significantly lower than that of the other treatments (Table 6).

However, at 9 WAP, *Alectra* infected cowpea plants from the medium *Celosia* population treatment produced the highest root fresh weight, which was comparable with that of the other treatments (Table 6). In Trial 2, *Alectra* uninfected cowpea plants from the positive *Celosia* control treatment produced the highest root fresh weight, at 7 WAP, which was significantly higher than the other treatments. However, this was followed by that observed from the medium *Celosia* population treatment that was only comparable with that observed from the negative control and low population treatments. The lowest root fresh weight due to high population treatment was significantly lower than the other treatments. At 9 WAP, uninfected cowpea plants from the negative *Celosia* control treatment produced the highest root fresh weight, which was only significantly higher than that of the low population treatment.

None of the sampled plants from the positive control, medium and high population treatments was uninfected with *Alectra* (Table 6).

The combined ANOVA of the data showed that, in both trials, the uninfected cowpea plants from the negative *Celosia* control treatments produced the highest root fresh weight which was comparable with that of low population treatment. The lowest root fresh weight observed from the high population treatments was comparable with that due to the positive control and medium population treatments (Table 6).

Tete

In Trial 1, the uninfected cowpea plants from the negative Tete control treatment produced the highest root fresh weight at 7 WAP, which was only significantly higher than that of the medium and high population treatments. The lowest root fresh weight observed from the high Tete population treatment was comparable only with that of the medium population treatment (Table 6).

At 9 WAP, uninfected cowpea plants from the negative Tete control treatment produced the highest root fresh, weight which was significantly higher than that of the other treatments. The lowest root fresh weight due to the low population treatment was comparable with that of the medium and high population treatments (Table 6).

In Trial 2, *Alectra* uninfected cowpea plants from the negative Tete control treatment produced the highest root fresh weight at 7 WAP, which was significantly higher than that of the other treatments. This was followed by that due to positive Tete control treatment. The lowest root fresh weight due to medium population treatment was comparable with that of the low and high population treatments (Table 6).

Table 6. Effect of *Amaranthus* population levels on the root fresh weight of *Alectra*-uninfected cowpea plants.

Trial	Age (WAP)	Variety	Root fresh weight (g/plant)						
			Control		*Amaranthus* population level				
			Negative	Positive	Low	Medium	High	Mean	SE±
I	7	*Celosia*	0.70b	1.10a	0.47b	0.17c	0.57b	0.60	0.06
		Tete	0.83a	0.67ab	0.80a	0.50b	0.47b	0.65	0.67
		NH-48	0.73a	0.33b	0.33b	0.33b	0.73a	2.45	0.07
		Local Black	0.80a	0.67a	0.20b	0.20b	0.67a	0.67	0.08
		NH-452	0.90a	0.63b	0.63b	0.63b	0.17b	0.51	0.07
		NH-493	0.83a	0.37b	0.57ab	0.77ab	0.80a	0.49	0.07
	9	*Celosia*	0.77a	0.97a	0.27a	1.03a	0.23a	0.65	0.27
		Tete	8.83a	6.57b	2.60c	3.23c	2.97c	21.80	0.08
		NH-48	0.77a	0.37b	0.17b	0.17b	0.17b	0.33	0.15
		Local Black	0.97a	0.27b	0.17b	0.20b	0.17b	0.36	0.05
		NH-452	1.03a	0.17b	0.13b	0.17b	0.10b	0.32	0.04
		NH-493	0.80a	0.47b	0.30b	0.20b	0.37b	0.43	0.14
II	7	*Celosia*	2.67b	3.50a	2.00b	2.70b	1.30c	2.43	0.17
		Tete	4.57a	2.87b	2.10bc	1.20c	2.03bc	2.31	0.30
		NH-48	4.97a	4.47ab	3.47ab	1.60b	4.37ab	3.78	0.74
		Local Black	3.77a	2.57ab	NI	2.17ab	1.40bc	1.98	0.41
		NH-452	7.37a	5.00ab	2.83b	2.20b	3.7ab	4.22	1.03
		NH-493	3.90a	3.23ab	2.37ab	2.60ab	2.07b	2.83	0.38
	9	*Celosia*	6.50a	NI	1.65b	NI	NI	22.22	0.04
		Tete	8.77a	3.57b	1.90b	4.33b	2.80b	21.37	0.64
		NH-48	8.43a	NI	NI	NI	6.07a	2.90	1.24
		Local Black	4.07b	NI	6.03a	3.70b	NI	2.79	0.43
		NH-452	6.77a	4.23ab	1.00c	4.57ab	4.00b	4.11	0.60
		NH-493	7.13a	NI	3.80a	NI	5.30a	3.25	1.00
Combined									
		Celosia	2.66a	1.39bc	1.83ab	0.98bc	0.53c	1.48	0.47
		Tete	3.78a	1.88b	1.25b	1.57b	1.44b	1.98	0.40
		NH-48	3.73a	1.29b	0.99b	0.53b	2.83a	1.87	0.80
		Local Black	2.40a	0.88bc	1.56ab	1.59ab	0.56c	1.40	0.46
		NH-452	4.02a	2.50b	1.10c	1.88bc	1.98bc	2.29	0.60
		NH-493	3.17a	1.02b	1.76b	0.89b	2.13ab	1.80	0.47

Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple Range-Test (DMRT).
NI: No *Alectra* uninfected plants

At 9 WAP, uninfected cowpea plants from the medium population treatment, produced the lowest root fresh weight, which was only significantly lower than the highest from the negative control treatment (Table 6).

The combined ANOVA of the data showed that, in both trials, the uninfected cowpea plants from the low population treatment produced the lowest root fresh weight which was only significantly lower than the highest due to negative control treatment (Table 6).

NH- 48 Line

In Trial 1, the uninfected Cowpea plants from the negative NH-48 control treatment and high population treatment produced the highest root fresh weight which was significantly higher than that of the other treatments (Table 6). The positive control, low and medium population treatments produced the lowest root fresh weight. Similarly, at 9 WAP, cowpea plants from the low, medium and high population treatments produced the lowest root fresh weight that was only lower than the highest observed from negative control treatment (Table 6).

In Trial 2, at 7 WAP, uninfected cowpea plants sampled showed that, the lowest root fresh weight due to medium population treatment was only significantly lower than the highest produced by the negative control treatment (Table 6).

At 9 WAP, uninfected cowpea plants from negative control treatment produced the highest root fresh weight which was only comparable with the high population treatment (Table 6). No uninfected plants was found among the plants sampled from the positive control low and medium population treatments at 9 WAP.

The combined ANOVA of the data showed that, in both trials, uninfected cowpea plants from the medium population treatments produced the lowest root fresh weight which was significantly lower than that due to high population treatment and the highest due to negative control treatment (Table 6).

Local Black

In Trial 1, *Alectra* uninfected cowpea plants from the negative Local black control treatment produced the highest fresh root weight at 7 WAP, which was only comparable with the positive control and high population treatments. The lowest root fresh weight due to low and medium local black population treatments was significantly lower than the other treatments (Table 6).

However, at 9 WAP, *Alectra* uninfected cowpea plants from the low and high local black population treatments produced the lowest root fresh weight, which was only significantly lower than the highest, due to negative control treatment (Table 6).

In Trial 2 at 7 WAP, the uninfected cowpea plants from the negative local black control treatment produced the highest root fresh weight, which was significantly higher than that of the high population treatment.The lowest root fresh weight due to high population treatment was significantly lower than the other treatments. None of the sampled plants from the low local black population treatment was infected with *Alectra.* At 9 WAP, uninfected cowpea plants from the low local black population treatment produced the highest root fresh weight that was significantly higher than that of the other treatments. None of the sampled plants from the positive control and high population treatments was uninfected with *Alectra* (Table 6).

The combined ANOVA of the data showed that, in both trials, cowpea plants from the negative Local black control treatment produced the highest root fresh weight which was comparable with that of low and medium population treatments. The lowest root fresh weight due to high population treatment was comparable with that due to positive control treatment (Table 6).

NH- 452 Line

In Trial 1, *Alectra* uninfected cowpea plants from the high NH- 452 population treatment produced the lowest root fresh weight at 7 WAP, which was only significantly lower than the highest due to negative control treatment (Table 6). Similarly, at 9 WAP, the observation was as at 7 WAP.

In Trial 2, the uninfected cowpea plants from the negative NH-452 control treatment produced the highest root fresh weight at 7 WAP, which was only significantly higher than that observed from low and medium population treatments. The lowest root fresh weight due to medium NH-452 population treatment was comparable only with that of low population treatment. At 9 WAP, uninfected cowpea plants from the negative control treatments produced the highest root fresh weight, which was significantly higher than that of the low and high population treatments. The lowest root fresh weight due to low population treatment was significantly lower than that of the other treatments (Table 6).

The combined ANOVA of the data showed that, in both trials, the uninfected plants sampled showed that cowpea plants from the negative NH-452 control treatment produced the highest root fresh weight which was significantly higher than the other

treatments. The lowest root fresh weight observed from the low population treatment was comparable with that due to medium and high population treatments (Table 6).

NH- 493 line

In Trial 1, the uninfected plants sampled showed that cowpea plants from the negative NH- 493 control treatment produced the highest root fresh weight at 7 WAP, which was only significantly higher than the lowest root fresh weight due to positive NH-493 control treatment (Table 6).

At 9 WAP, uninfected cowpea plants from the medium population treatment produced the lowest root fresh weight which was only significantly lower than the highest due to negative control treatment (Table 6).

In Trial 2, *Alectra* uninfected cowpea plants from the negative NH-493 control treatment produced the highest root fresh weight at 7 WAP, which was only significantly higher than the lowest due to high population treatment. However, at 9 WAP, *Alectra* uninfected cowpea plants from the negative NH-493 population treatment produced the highest root fresh weight which was comparable with that observed from the other treatment (Table 6).

The combined ANOVA of the data showed that, in both trials, the infected cowpea plants from the negative NH-493 control treatment produced the lowest root fresh weight which was only significantly lower than the highest due to the negative control treatment (Table 6).

Table 7. Effect of *Amaranthus* population levels on the plant height of *Alectra* infected cowpea plants.

Trial	Age (WAP)	Variety	Plant height (cm)						
			Control		*Amaranthus* population level				
			Negative	Positive	Low	Medium	High	Mean	SE±
I	7	*Celosia*	NI	17.33a	14.83a	18.00a	16.17a	13.27	0.74
		Tete	NI	14.00b	17.00a	14.00b	NI	9.00	0.20
		NH-48	NI	12.23b	13.50a	11.33c	NI	7.42	0.20
		Local. Black	NI	18.33a	15.30b	15.00b	NI	9.73	0.63
		NH-452	NI	11.83a	NI	NI	11.67a	4.70	0.61
		NH-493	NI	12.00a	13.00a	NI	NI	5.00	0.28
	9	*Celosia*	NI	17.57a	15.33a	17.67a	15.00a	13.11	0.73
		Tete	NI	13.23a	12.00b	NI	NI	5.05	0.15
		NH-48	NI	10.47b	NI	7.00c	12.83a	6.06	0.13
		Local. Black	NI	15.50a	16.83a	9.00b	17.67a	11.80	0.94
		NH-452	NI	13.50a	NI	NI	NI	2.70	0.20
		NH-493	NI	11.50a	10.00a	12.83a	12.83a	6.87	0.82
II	7	*Celosia*	NI	38.00b	55.33a	39.17b	42.50b	35.00	2.02
		Tete	NI	29.83b	39.90a	32.33b	28.67b	26.50	1.35
		NH-48	NI	26.33a	28.77a	27.70a	26.33a	21.82	2.95
		Local. Black	NI	28.50a	31.50a	29.50a	33.33a	24.63	2.64
		NH-452	NI	40.83a	44.27a	39.67a	28.00b	30.55	1.91
		NH-493	NI	48.67a	36.08ab	37.67ab	30.00b	30.47	3.31
	9	*Celosia*	NI	86.50a	102.00a	62.67a	60.83a	72.30	13.70
		Tete	NI	46.67a	74.67a	46.17a	47.67a	43.04	11.88
		NH-48	NI	42.50a	34.50a	38.83a	34.50a	30.07	3.54
		Local. Black	NI	40.83a	29.50a	36.17a	37.83a	28.87	1.39
		NH-452	NI	43.50a	43.33a	60.00a	41.50a	37.67	4.58
		NH-493	NI	60.33a	36.67b	54.5ab	44.00ab	39.10	4.92
Combined		*Celosia*	NI	39.85a	46.88a	34.38a	33.63a	30.10	7.06
		Tete	NI	25.93ab	35.89a	23.13b	19.08b	20.81	5.95
		NH-48	NI	22.08a	19.20a	22.13a	21.54a	16.79	2.37
		L. Black	NI	23.37a	25.79a	22.42a	22.21a	18.76	2.05
		NH-452	NI	27.42a	28.65a	24.92ab	20.29b	18.86	2.82
		NH-493	NI	33.12a	28.91b	26.25b	18.50b	20.36	2.94

N.B: Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple Range Test (DMRT).
NI:No *Alectra*-Infected Plants
L. Black: Local Black

Plant height of *Alectra* infected sampled cowpea plants

More *Amaranthus* lines resulted in *Alectra* infected cowpea plants under the high population treatment in Trial 1. However, the combined ANOVA showed that, *Alectra* infected sampled cowpea plants from the low population treatment produced highest plant height compared with that of other treatments, whereas those sampled from the high population treatment produced the lowest plant height.

Celosia

In Trial 1, *Alectra* infected cowpea plants from the medium *Celosia* population treatments produced the highest plants height at 7 WAP, which was comparable with that of the other treatments. Similarly, at 9 WAP, infected cowpea plant from the medium *Celosia* population treatment produced the highest plants height, which was comparable with that of other treatments (Table 7).

In Trial 2, at 7 WAP, the *Alectra* infected cowpea plants from the positive control *Celosia* treatment produced the lowest plants height that was only significantly lower than the highest due to low *Celosia* population treatment (Table 7).

At 9 WAP, *Alectra* infected cowpea plants from the positive *Celosia* control treatment produced the highest plants height, which was comparable with that of the other treatments (Table 7).

The combined ANOVA of the data showed that, in the both trials, *Alectra* infected cowpea plants from the low *Celosia* population treatment produced the highest plant height which was comparable with that of the other treatments (Table 7).

Tete

In Trial 1, *Alectra* infected Cowpea plants from the low Tete population treatment produced the highest plants height at 7 WAP, which was significantly higher than that of positive control and high population treatments. None of the sampled plants from the high population treatment was infected with *Alectra*. At 9 WAP, infected cowpea plants from the positive Tete control treatment produced the highest plants height which was only significantly higher than the low population treatment. None of sampled plant from the medium and high population treatment was infected with *Alectra* (Table 7).

In Trial 2, at 7 WAP, *Alectra* infected cowpea plants from the high Tete population treatment produced the lowest plant height, which was only significantly higher than the highest due to low poplation treatment. Similarly, at 9 WAP, infected cowpea plants from the low Tete population treatment also produced the highest plant height which was comparable with that of the other treatments (Table 7).

The combined ANOVA of the data showed that, in the both trials, the *Alectra* infected cowpea plants from the high Tete population treatment produced the lowest plant height which was only significantly lower than the highest treatments (Table 7).

NH- 48 Line

In Trial 1, *Alectra* infected cowpea plants from the low NH- 48 population treatment produced the highest plants height at 7 WAP, which was significantly higher than that of the other treatments (Table 7). The lowest plants height observed from plants under the medium NH-48 population treatment was significantly lower than that of the other

treatments. None of the sampled plants from the high population treatment was infected with *Alectra*. At 9 WAP, infected cowpea plants from the high NH-48 population treatment produced the highest plants height which was significantly higher than that of the other treatments. The lowest plant height due to medium population treatment was significantly lower than that of the other treatments. None of the sampled plants from the low population treatment was infected with *Alectra* (Table 7).

In Trial 2, *Alectra* infected cowpea plants from the low NH-48 population treatment produced the highest plants height at 7 WAP, which was comparable with that of the treatments. Similarly, at 9 WAP, *Alectra* infected cowpea plants from the positive NH-48 control treatment produced the highest plants height, which was comparable with that of the other treatments (Table 7).

The combined ANOVA of the data showed that, in the both trials *Alectra* infected cowpea plants from the medium NH-48 population treatment produced the highest plant height which was comparable with that of the other treatments (Table 7).

Local Black

In Trial 1, the *Alectra* infected plants among the sampled plants showed that cowpea plants from the positive local black control treatment produced the highest plants height at 7 WAP, which was significantly higher than that of the other treatments, that were comparable. None of the sampled plant from the high population treatment was infected with *Alectra*. At 9 WAP, infected cowpea plants from the high local black

population treatment produced the highest plants height, which was only significantly higher than that due to medium population treatment (Table 7).

In Trial 2, *Alectra* infected cowpea plants from the high Local Black population treatment produced the highest plants height which was comparable with that of the other treatments at 7 WAP. Similarly, at 9 WAP, infected cowpea plants from the positive control treatment produced the highest plant height which was comparable with other treatments (Table 7).

The combined ANOVA of the data showed that, in the both trials, the infected plants among the sampled plants showed that cowpea plants from the low local black population treatment produced the highest plant height which was comparable with that of the other treatments (Table 7).

NH- 452 Line

In Trial 1, *Alectra* infected cowpea plants from the positive NH-452 control treatment produced the highest plants height at 7 WAP, which was comparable with that observed from the high NH-452 population treatment. None of the sampled plants from the low and medium population treatments was infected with *Alectra*. At 9 WAP, *Alectra* infected cowpea plants was only observed from the positive NH-452 control treatment None of the cowpea plants from the other treatments was infected with *Alectra* (Table 7).

In Trial 2, the *Alectra* infected cowpea plants from the low NH-452 population treatment produced the highest plant height at 7 WAP, which was only significantly higher than that of the high population treatment. At 9 WAP, infected cowpea plants

from the medium NH-452 population treatment produced the highest plant height which was comparable with that of the other treatments (Table 7).

The combined ANOVA of the data showed that, in the both trials, *Alectra* infected cowpea plants from the low NH-452 population treatment produced the highest plant height which was only significantly higher than the lowest due to high population treatment (Table 7).

NH- 493 Line

In Trial 1, the infected plant among the sampled plants showed that cowpea plants from the low NH- 493 population treatment produced the highest plants height at 7 WAP, which was only comparable with that of the positive NH- 493 control treatment. None of the sampled plants from the other treatments (medium and high population) was infected with *Alectra*. However, at 9 WAP, infected cowpea plants from the medium and high NH-493 population treatments produced the highest plants height which was comparable with that of the other treatments (Table 7).

In Trial 2, *Alectra* infected cowpea plants from the positive NH-493 control treatment produced the highest plant height at 7 WAP, which was only significantly higher than the lowest plant height observed from the high population treatment (Table 7).

At 9 WAP, *Alectra* infected cowpea plants from the positive NH-493 control treatments produced the highest plant height, which was only significantly higher than the lowest plant height due to low population treatment (Table 7).

The combined ANOVA of the data showed that, in the both trials, the *Alectra* infected cowpea plants from the high NH-493 population treatment produced the lowest plant

height which was only significantly lower than the highest due to the positive control treatment (Table 7).

Plant height of *Alectra* uninfected sampled cowpea plants

Generally, negative control treatment produced the highest plant height. However, the combined ANOVA showed that low and high population treatments produced a comparable lower plant height, than the other treatment.

Celosia

In Trial 1, the *Alectra* uninfected plants sampled showed that cowpea plants from the positive *Celosia* control treatment produced the highest plants height at 7 WAP, which was comparable with that of negative control treatment (Table 8).

The lowest plants height due to medium *Celosia* population treatment was only significantly lower than that of the low, medium and high population treatments. At 9 WAP, uninfected cowpea plants from the positive *Celosia* population treatment produced the highest plants height, which was only significantly higher than that of medium and high population treatments. The lowest plants height was due to medium *Celosia* population treatment (Table 8).

In Trial 2, *Alectra* uninfected cowpea plants from the positive control treatment produced the lowest plants height at 7 WAP, which was only significantly lower than the highest due to low *Celosia* population treatment. At 9 WAP, uninfected cowpea plants from the negative *Celosia* control treatment produced the highest plants height which was only significantly higher than the low *Celosia* population treatment. None of the sampled plants from the other treatments (positive control, medium and high population) was uninfected with *Alectra* (Table 8).

Table 8. Effect of *Amaranthus* population levels on the plant height of *Alectra* uninfected cowpea plants.

Trial	Age (WAP)	Variety	Plant height (cm)						
			Control		*Amaranthus* population level				
			Negative	Positive	Low	Medium	High	Mean	SE±
I	7	*Celosia*	17.83ab	19.00a	16.50bc	14.50c	16.27bc	16.82	0.54
		Tete	18.00a	16.50ab	14.83b	12.17c	14.50bc	15.20	0.60
		NH-48	17.27a	10.50b	12.50b	13.17b	13.00b	13.20	0.62
		Local. Black	19.03ab	18.33ab	NI	15.17b	21.17a	14.76	1.41
		NH-452	18.00a	12.83c	12.50c	15.50b	12.83c	14.33	2.23
		NH-493	20.43a	10.93b	13.83b	14.50b	13.50b	14.64	0.84
	9	*Celosia*	17.53ab	21.00a	18.33ab	14.27c	15.67bc	17.36	0.90
		Tete	18.83a	14.67b	12.67b	12.83b	12.50b	14.30	0.64
		NH-48	17.23a	12.17b	10.83bc	11.50bc	9.83c	12.31	0.53
		Local. Black	17.70ab	16.50ab	14.67b	14.50b	20.33a	16.74	1.09
		NH-452	18.33a	11.83b	11.50b	13.00b	13.17b	13.57	1.11
		NH-493	18.30a	11.33b	12.33b	11.67b	12.50b	13.22	0.50
II	7	*Celosia*	44.67b	33.50b	57.50a	41.00b	37.00b	42.73	3.09
		Tete	37.50a	32.00a	33.50a	25.50b	21.50b	30.00	1.39
		NH-48	43.50a	25.00b	28.33b	29.67b	25.50b	30.43	1.56
		Local. Black	34.67a	30.33ab	NI	24.00ab	20.83b	21.97	2.56
		NH-452	40.00a	31.77a	28.16a	28.16a	29.67a	31.65	3.27
		NH-493	48.50a	33.33b	38.08ab	27.50b	30.00b	35.47	3.08
	9	*Celosia*	77.67a	NI	22.50b	NI	NI	20.03	3.03
		Tete	63.43a	32.17c	34.00c	43.97b	32.50c	41.022	0.38
		NH-48	41.50a	NI	NI	NI	21.67b	12.63	0.71
		Local. Black	43.33a	NI	27.67b	33.67b	NI	20.93	1.75
		NH-452	48.30a	26.00b	26.80b	36.13ab	37.40ab	26.23	2.65
		NH-493	60.17a	NI	37.50b	NI	36.83b	26.90	3.15
Combined		*Celosia*	39.43a	18.38c	8.70b	17.44c	17.23c	24.23	2.24
		Tete	34.44a	23.83b	23.75b	23.62b	20.25c	25.18	1.51
		NH-48	29.88a	11.96c	12.92c	13.58c	17.50b	17.17	1.89
		Local. Black	28.68a	16.29c	10.59d	21.86b	21.86b	18.6	2.90
		NH-452	30.79a	20.61b	19.74b	23.33b	23.33b	24.35	2.21
		NH-493	36.85a	13.90c	23.21b	13.42c	23.21b	22.12	3.25

N.B: Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple Range-Test (DMRT).
NI: No *Alectra* uninfected plants

The combined ANOVA of the data showed that, in the both trials, uninfected cowpea plants from the negative *Celosia* control treatment produced the tallest plant which was significantly higher than that of the other treatments. The lowest plant height due to high population treatment was comparable with that due to the medium population and positive control treatments (Table 8).

Tete

In Trial 1, the uninfected plants sampled showed that cowpea plants from the negative Tete control treatment produced the highest plants height at 7 WAP which was only comparable with that due to positive control treatment. The lowest plants height due to medium Tete population treatment was only comparable with that of medium population treatment (Table 8).

At 9 WAP, uninfected cowpea plants from the positive Tete control treatment produced the lowest plants height, which was only significantly lower than highest due to negative control treatment (Table 8).

In Trial 2, *Alectra* uninfected cowpea plants from the negative Tete control treatment produced the highest plant height at 7 WAP which was comparable only with the positive control and low population treatments but significantly higher than that of the other treatments. At 9 WAP, the highest plants height due to negative Tete control treatment was significantly higher than the other treatments. However, this was followed by that due to medium population treatment. The lowest plants height due to positive control treatments was comparable with that of the high and low population treatments (Table 8).

The combined ANOVA of the data showed that, in the both trial, uninfected cowpea plants from the negative Tete control treatment produced the highest plant height which was significantly higher than that of the other treatments. The lowest plant height due to high population treatment was significantly lower than that of the other treatments (Table 8).

NH- 48 Line

In Trial 1, the *Alectra* uninfected cowpea plants from the positive NH-48 control treatment at 7 WAP, produced the lowest plants height, which was only significantly lower than the highest due to negative control treamtnet. At 9 WAP, cowpea plants from the negative NH-48 control treatment produced the highest plants height which was significantly lower than the highest due to negative control treatment. This was followed by that due to positive control treatments. The lowest plants height observed from the high population treatment was comparable with that of low and medium population treatments (Table 8).

In Trial 2, *Alectra* uninfected cowpea plants from positive NH-48 control treatment produced the lowest plant height which was only significantly lower than the highest due to the negative control treatment. At 9 WAP, the highest plants height observed from the negative NH-48 control treatment was significantly higher than that of the high population treatment. None of the sampled plants from the other treatments (positive control, low and medium population) was uninfected with *Alectra* (Table 8).

The combined ANOVA of the data showed that, in the both trials, the uninfected cowpea plants from the negative NH-48 control treatment produced the highest plant

height which was significantly higher than that of the other treatments. The lowest plant height due to positive control treatment was comparable with that of the low and medium population treatments (Table 8).

Local Black

In Trial 1, *Alectra* uninfected cowpea plants from the high local black population treatments produced the highest plants height at 7 WAP, which was only significantly higher than that of the medium population treatment. The lowest plants height was observed from the positive control treatment. None of the sampled plants from the low population treatment was infected with *Alectra* (Table 8).

At 9 WAP, *Alectra* uninfected cowpea plants from the medium local black treatment produced the lowest plants height, which was only significantly lower than the highest due to the high population treatment (Table 8).

In Trial 2, the uninfected Cowpea plants from the negative Local Black control treatment produced the highest plant height at 7 WAP, which was only significantly higher than the lowest due to high population treatment. None of the sampled plants from the low population treatment was uninfected with *Alectra*. At 9 WAP, uninfected cowpea plants from the low Local Black population treatment produced the lowest plant height, which was only significantly lower than highest due to negative control treatment (Table 8). None of the sampled plants from the positive control and high population treatments was uninfected with *Alectra*.

The combined ANOVA of the data showed that, in the both trials, the uninfected cowpea plants from the negative local black control treatment produced the highest plan height which was significantly higher than that of the other treatments. The

lowest plant height due to low Local black population treatment was significantly lower than that of all the other treatments (Table 8).

NH- 452 Line

In Trial 1, the *Alectra* uninfected plants sampled showed that cowpea plants from the negative NH- 452 control treatment produced the highest plants height at 7 WAP, which was significantly higher than the other treatments. The lowest plants height observed from the low NH- 452 population treatment was comparable with that of the positive control and high population treatments (Table 8).

However at 9 WAP, uninfected cowpea plants from the low NH-452 population treatment produced the lowest plants height, which was only significantly lower than the highest due to negative control treatment (Table 8).

In Trial 2, *Alectra* uninfected cowpea plants from the negative NH-452 control treatment produced the highest plant height at 7 WAP, which was comparable with that of the other treatments (Table 8).

At 9 WAP, uninfected cowpea plants from the positive control treatment produced the lowest plants height which was only significantly lower than the highest due to negative control treatment (Table 8).

The combined ANOVA of the data showed that, in the both trials, uninfected cowpea plants from the low NH-452 population treatment produced the lowest plant height which was only significantly lower than the highest due to negative control treatment (Table 8).

NH- 493 Line

In Trial 1, *Alectra* uninfected cowpea plants from the positive NH-493 control treatment produced the lowest plants height at 7 WAP, which was only significantly lower than the highest due to negative control treatment (Table 8)

Similarly, at 9 WAP, uninfected cowpea plants from the positive NH- 493 control treatment produced the lowest plants height which was only significantly lower than the highest due to negative control treatment (Table 8).

In Trial 2, at 7 WAP, the uninfected cowpea plants from the medium NH-452 population treatment produced the lowest plant height, which was only significantly lower than the highest due to negative control treatment. At 9 WAP, uninftected cowpea plant from the high NH-493 population treatment, produced the lowest plant height which was only significantly lower than the highest due to the negative control treatment. None of the sampled plants from positive control and medium population treatments was infected with *Alectra* (Table 8).

The combined ANOVA of the data showed that, in the both trials, the infected cowpea plants from the negative NH-493 control treatment produced the highest plant height which was significantly higher than that of the treatments. The lowest plant height due to medium population treatment was only comparable with that of the positive control treatment (Table 8).

Root nodule number of *Alectra* infected sampled cowpea plants

Generally, the combined ANOVA showed that *Alectra* infected sampled cowpea plants from low and medium population tended to produce the highest root nodule

number compared with the other treatments whereas those sampled from high population treatment produced the lowest root nodule number.

Celosia

In Trial 1, the *Alectra* infected sampled cowpea plants from the medium *Celosia* population treatments produced the highest root nodule number at 7 WAP, which was comparable with that of the other treatments. However, at 9 WAP, infected cowpea plants from the medium *Celosia* population treatment produced the highest root nodule number which was only significantly higher than the lowest due to high *Celosia* population treatment (Table 9).

In Trial 2, *Alectra* infected cowpea plants from the low *Celosia* population treatment produced the highest root nodule number at 7 WAP, which was comparable with the other treatments. At 9WAP, *Alectra* infected cowpea plants from the medium population treatment produced the highest root nodule number, which was significantly higher than that of the other treatments. The lowest root nodule number due to low *Celosia* population treatment, was significantly lower than that of the other treatments (Table 9).

The combined ANOVA of the data showed that, in both trials, *Alectra* infected cowpea plants from the medium *Celosia* population treatment produced the highest root nodule number which was comparable with that of the other treatments (Table 9).

Tete

In Trial 1, *Alectra* infected cowpea plants from the medium Tete population treatment produced the highest root nodule number at 7 WAP, which was significantly higher than the other treatments. The lowest root nodule number due to low population

Table 9. Effect of *Amaranthus* population levels on the root nodule number of *Alectra* Infected cowpea plants

Trial	Age (WAP)	Variety	Root nodule number						
			Control		*Amaranthus* population level				
			Negative	Positive	Low	Medium	High	Mean	SE±
I	7	*Celosia*	NI	34.00a	27.67a	40.33a	16.67a	23.73	7.29
		Tete	NI	21.00b	10.00c	25.00a	NI	11.20	0.40
		NH-48	NI	46.00a	14.00c	35.00b	11.00c	21.20	1.60
		Local.	NI	13.00a	17.00a	18.67a	NI	9.80	3.52
		Black	NI	16.67a	NI	NI	13.00b	3.93	0.99
		NH-452	NI	29.67ab	14.00b	35.00a	11.08b	17.93	4.90
		NH-493							
	9		NI	12.30ab	14.00a	19.33a	6.50b	10.43	1.72
		Celosia	NI	20.50a	13.00b	NI	NI	6.70	0.90
		Tete	NI	12.67a	NI	2.00c	4.00b	3.73	0.70
		NH-48	NI	7.33a	9.67a	7.00a	6.33a	6.07	2.71
		Local.	NI	9.00a	NI	NI	NI	1.80	0.80
		Black	NI	12.00a	20.50a	21.00a	NI	10.60	2.26
		NH-452							
		NH-493							
II	7	*Celosia*	NI	11.33a	21.33a	11.67a	20.33a	12.93	11.29
		Tete	NI	11.67a	25.00a	19.33a	20.33a	15.27	3.39
		NH-48	NI	28.00a	22.67ab	18.33b	31.00a	20.00	2.18
		Local.	NI	19.00b	28.33a	20.67ab	23.33ab	18.27	2.06
		Black	NI	27.33a	29.67a	29.67a	47.00a	26.73	5.13
		NH-452	NI	23.67ab	16.00b	28.33a	22.00ab	18.00	2.33
		NH-493							
	9		NI	14.33b	6.67c	21.00a	15.00b	11.4	10.73
		Ccelosia	NI	50.00a	17.67b	20.00b	18.67b	21.27	4.89
		Tete	NI	19.33ab	26.00a	23.00ab	13.67b	16.40	2.80
		NH-48	NI	18.00a	18.00a	19.67a	11.33a	13.40	2.08
		Local.	NI	17.33a	30.00a	27.67a	14.00a	17.80	4.56
		Black	NI	16.00a	21.33a	18.67a	18.33a	14.87	3.57
		NH-452							
		NH-493							
Combined.		*Celosia*	NI	17.99a	17.42a	23.08a	14.62a	14.62	4.22
		Tete	NI	16.42b	25.79a	16.08b	9.75b	13.61	3.76
		NH-48	NI	26.50a	15.67b	15.67b	14.92b	15.33	2.91
		Local. Black	NI	14.42b	18.25a	16.50a	10.25b	11.98	2.84
		NH-452	NI	17.58a	14.92a	18.33a	16.00a	12.57	3.47
		NH-493	NI	20.33ab	17.96bc	25.75a	12.83c	15.37	3.33

Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple Range-Test (DMRT).
NI:No *Alectra*-Infected Plants

treatment was significantly lower than that of the other treatments. None of the sampled plants from the high population treatments was infected by the *Alectra*.

However, at 9 WAP, *Alectra* infected cowpea plants from the positive Tete control control treatment produced the highest root nodule number, which was only significantly higher than that of the low population treatment. None of the sampled plants from the other treatments (medium and high population) was infected with *Alectra* (Table 9).

In Trial 2, the *Alectra* infected sampled cowpea plants from the low Tete population treatment produced the highest root nodule number at 7 WAP, which was comparable with that of the other treatments. At 9 WAP, infected cowpea plants from the low Tete population treatment produced the lowest root nodule number which was only significantly lower than the highest due to negative conrol treatment (Table 9).

The combined ANOVA of the data showed that, in both trials, the *Alectra* infected plants from the high population treatment produced the lowest root nodule number which was only significantly lower than the highest due to low population treatment (Table 9).

NH- 48 Line

In Trial 1, the *Alectra* infected cowpea plants sampled from the positive NH-48 control treatment produced the highest root nodule number at 7 WAP, which was significantly higher than that of the other treatments. However, the lowest root nodule number observed from the high NH-48 population treatment was only comparable with that of the low population treatment. At 9 WAP, infected cowpea plants from the

positive NH- 48 control treatment produced the highest root nodule number which was significantly higher than that of the other treatments. The lowest root nodule number due to medium NH-48 population treatment was significantly lower than that of the other treatments. None of the sampled plant from the low population treatments was infected with *Alectra* (Table 9).

In Trial 2, infected cowpea plants from the high NH-48 population treatment produced the highest root nodule number which was only significantly higher than the lowest due to medium population treatment. At 9WAP, *Alectra* infected cowpea plants from the low NH-48 population treatment produced the highest root nodule number which was only significantly higher than the lowest root nodule number observed from the high population treatment (Table 9).

The combined ANOVA of the data showed that, in both trials, the *Alectra* infected plants sampled from the high NH-48 population treatment produced the lowest root nodule number which was only significantly lower than the highest due to positive control treatment (Table 9).

Local Black

In Trial 1, the *Alectra* infected sampled cowpea plants from the medium local black population treatment produced the highest root nodule number at 7 WAP, which was comparable with that of the other treatments. None of the sampled plants from the high population treatment was infected with *Alectra.* At 9 WAP, infected cowpea plants from the low local black population treatment produced the highest root nodule number which was comparable with that of the other treatments (Table 9).

In Trial 2, *Alectra* infected cowpea plants from the low local black population treatment produced the highest root nodule number was only significantly higher than the lowest due to negative control treatment.

At 9 WAP, cowpea plants from the medium local black population treatment produced the highest root nodule number which was comparable with that of the other treatments (Table 9).

The combined ANOVA of the data showed that, in both trials, *Alectra* infected cowpea plants from the low local black population treatment produced the highest root nodule number which was only comparable with that observed from the medium population treatment. The lowest root nodule number due to high population treatment was also comparable with that due to positive control treatment (Table 9).

NH- 452 line

In Trial 1, *Alectra* infected cowpea plants from the positive NH- 452 control treatment produced the highest root nodule number at 7 WAP, which was significantly higher than that of the high population treatment which produced the lowest root nodule number. None of the sampled plants from the other treatments (low and medium population) was infected with *Alectra*. At 9 WAP, *Alectra* infected cowpea plants was observed only from the positive NH-452 control treatment. None of the sampled plants from the other treatments was infected with *Alectra* (Table 9).

In Trial 2, *Alectra* infected cowpea plants from the high population treatment produced the highest root nodule number at 7 WAP, which was comparable with that of the other treatments. At 9WAP, infected cowpea plants from the low NH-452

population treatment produced the highest root nodule number which was comparable with that of the other treatment (Table 9).

The combined ANOVA of the data showed that, in both trials, the *Alectra* infected plants sampled from the positive NH-452 control treatment produced the highest root nodule number which was comparable with that of the other treatments (Table 9).

NH-493 Line

In Trial 1, the infected sampled cowpea plants from the medium NH-493 population treatment produced the highest root nodule number at 7 WAP, which was only comparable with that of the positive treatment. The lowest root nodule number due to high NH-493 population treatment was only significantly lower than that of the highest. At 9 WAP, *Alectra* infected cowpea plants from the medium NH-493 population treatment produced the highest root nodule number which was comparable with that of the other treatments (Table 9).

In Trial 2, *Alectra* infected cowpea plants from the medium NH-493 population treatment produced the highest root nodule number which was only significantly higher than the lowest due to low population treatment. At 9WAP, infected cowpea plants from the low population treatment produced the highest root nodule number which was comparable with that of other treatments (Table 9).

The combined ANOVA of the data showed that, in both trials, *Alectra* infected cowpea plants from the medium NH-493 population treatment produced the highest root nodule number which was comparable with that of the positive control treatment.

The lowest root nodule number due to high population treatment was comparable with that due to low population treatment (Table 9).

Root nodule number of *Alectra* uninfected sampled cowpea plants

Generaly, negative control treatment produced the highest root nodule number. However, the combined ANOVA showed that positive conrol treatment produced the lowest root nodule number compared with that of the other treatments.

Celosia

In Trial 1, the uninfected sampled cowpea plants from the positive *Celosia* control treatment produced the highest root nodule number at 7 WAP, which was only significantly higher than that of low and medium population treatments. The lowest root nodule number observed from the medium *Celosia* population treatment was significantly lower than that observed from the other treatments. At 9 WAP, uninfected cowpea plants from the negative

Celosia control treatment produced the highest root nodule number which was only comparable with that observed from the positive *Celosia* control treatment. The lowest root nodule number due to high population treatment was comparable with that of low and medium population treatments (Table 10).

In Trial 2, the uninfected cowpea plants from the medium *Celosia* population treatment produced the highest root nodule number at 7 WAP, which was only comparable with the low population treatment. The lowest root nodule number observed from positive control treatment was comparable with that observed under negative control and high population treatments (Table 10).

At 9 WAP, uninfected cowpea plants from the negative *Celosia* control treatment produced the highest root nodule number which was only significantly higher than that of the low population treatment. None of the sampled plants from the other treatments (positive control, medium and high population) was infected by the *Alectra* (Table 10).

The combined ANOVA of the data showed that, in both trials, the uninfected cowpea plants from the medium *Celosia* population treatment produced the lowest root nodule number which was only significantly lower than the highest due to negative control treatment (Table 10).

Tete

In Trial 1, the *Alectra* uninfected cowpea plants from the negative Tete control treatment produced the highest root nodule number at 7 WAP, which was comparable only with that of the positive control treatment. The lowest root nodule number due to medium and high population treatments were significantly lower than that of the other treatments.

At 9 WAP, *Alectra* uninfected cowpea plants from the negative Tete control treatments produced the highest root nodule number which was only comparable with the positive Tete control and high population treatments. The lowest root nodule number due to low Tete population treatments was only comparable with that of the low population treatment (Table 10).

In Trial 2, at 7 WAP, the uninfected plant sampled showed that cowpea plants from the high Tete population treatment produced the highest root nodule number,

Table 10. Effect of *Amaranthus* Population levels on the root nodule number of *Alectra* uninfectd cowpea Plants.

Trial	Age (WAP)	Variety	Root nodule number						
			Control		*Amaranthus* population level				
			Negative	Positive	Low	Medium	High	Mean	SE±
I	7	*Celosia*	33.00ab	47.00a	25.67b	2.33c	30.67ab	27.60	4.08
		Tete	45.00a	43.33a	28.67b	14.33c	14.33c	21.33	2.86
		NH-48	38.00a	12.67bc	11.33bc	19.33b	3.00c	16.87	3.61
		Local. Black	40.00a	41.67a	NI	12.67b	33.67a	25.60	4.67
		NH-452	43.67a	6.33b	17.00b	7.33b	NI	14.87	5.50
		NH-493	31.67a	11.67b	11.33b	19.33ab	3.00b	15.40	2.24
	9	*Celosia*	41.67a	26.33a	13.67b	9.00b	7.67b	19.67	4.58
		Tete	39.00a	33.67a	4.00c	10.33bc	25.33ab	22.40	3.89
		NH-48	45.66a	6.33b	6.33b	8.33b	8.00b	14.93	2.93
		Local. Black	37.33a	2.00b	5.08b	5.00b	5.67b	11.00	2.04
		NH-452	43.33a	6.67b	2.00b	5.00b	2.00b	11.80	1.78
		NH-493	40.67a	6.67b	6.67b	5.00b	5.00b	12.80	2.72
II	7	*Celosia*	21.00b	18.00b	47.50a	48.00a	24.00b	31.70	2.20
		Tete	27.33a	32.00a	18.33a	30.00a	33.67a	28.27	3.65
		NH-48	27.67a	6.33b	23.33a	13.33ab	22.60a	18.65	5.28
		Local. Black	36.67a	30.00ab	NI	11.67b	26.67ab	21.00	4.40
		NH-452	39.33a	22.00a	18.00a	18.00a	32.00a	24.00	8.28
		NH-493	29.67a	22.67a	20.00a	19.67a	21.33a	22.67	4.56
	9	*Celosia*	38.00a	NI	7.00b	NI	NI	9.00	3.86
		Tete	43.33a	11.00b	10.00b	26.00ab	35.00a	25.07	4.15
		NH-48	24.00a	NI	NI	NI	31.00a	11.00	2.44
		Local. Black	20.33a	NI	32.67a	26.00a	NI	15.80	4.26
		NH-452	40.00a	13.33bc	8.00c	26.67ab	40.00a	25.60	2.67
		NH-493	23.67ab	NI	20.00b	34.33a	34.33a	15.60	3.27
Combined		*Celosia*	33.42a	22.83b	23.46b	14.83b	15.58b	22.02	4.33
		Tete	38.67a	20.25bc	15.25c	20.17bc	27.10b	26.65	4.84
		NH-48	33.83a	6.33c	10.25bc	10.25bc	16.12b	15.36	3.70
		Local. Black	33.58a	18.45b	9.42c	13.82bc	16.50bc	18.35	4.26
		NH-452	41.58a	12.08b	11.25b	11.92b	18.50b	19.07	5.27
		NH-493	31.42a	10.25b	14.50b	11.00b	15.92b	16.62	3.90

Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple Range-Test (DMRT).
NI: No *Alectra* uninfected plants
L. Black: Local Black

which was comparable with that of the other treatments. At 9 WAP, cowpea plants from the negative Tete control treatment produced the highest root nodule number which was significantly higher than that of positive control and low population treatments.

The lowest root nodule number observed from the low population treatment was comparable with that of positive control and medium population treatments (Table 10).

The combined ANOVA of the data showed that, in both trials, uninfected cowpea plants from the negative *Tete* control treatment produced the highest root nodule number which was significantly higher than that of the other treatments. The lowest root nodule number due to low population treatment was significantly lower than that of negative control and high population treatments (Table 10).

NH- 48 Line

In Trial 1, the *Alectra* uninfected cowpea plants from the negative NH-48 control treatment produced the highest root nodule number at 7 WAP, which was significantly higher than that of the other treatments. This was followed by that due to medium NH-48 population treatment. The lowest root nodule number observed from the high population treatment was significantly lower than that of negative control and medium population treatments (Table 4.9). At 9 WAP, positive NH-48 control and low population treatments produced the lowest root nodule number, which was only significantly lower than the highest due to negative control treatment (Table 10).

In Trial 2, at 7 WAP, *Alectra* uninfected cowpea plants from the negative NH- 48 control treatment produced the highest root nodule number, which was only significantly higher than the lowest due to positive NH-48 control treatment (Table 10). At 9 WAP, cowpea plants from the high NH- 48 population treatment produced the highest root nodule number which was only comparable with the negative control treatment. No *Alectra* uninfected plants was found among those sampled from positive control, low and medium population of NH-48 treatments (Table 10).

The combined ANOVA of the data showed that, in both the trials, the uninfected cowpea plants from the negative NH-48 control treatment produced the highest root nodule number which was significantly higher than that of the other treatments. The lowest root nodule number due to positive control treatment was comparable with that of the low and medium population treatments (Table 10).

Local Black

In Trial 1, *Alectra* the uninfected cowpea plant sampled from the positive local black control treatment, produced the highest root nodule number at 7 WAP, which was only significantly higher than the lowest due to medium population treatment. None of the sampled plants from the low population treatment was infected with *Alectra*. However, at 9 WAP, uninfected cowpea plants from the positive local black control treatment produced the lowest root nodule number, which was only significant lower than the highest due to the negative control treatment (Table 10).

In Trial 2, *Alectra* the uninfected cowpea plants from the negative local black control treatment produced the highest root nodule number at 7 WAP, which was only

significantly higher than the lowest due to medium local black population treatment. None of the sampled plants from the low local black population treatment was infected with *Alectra.* At 9 WAP, uninfected cowpea plants from the low local black population treatment produced the highest root nodule number, which was comparable with that of the other treatments. None of the sampled plants from the positive control and high population treatments was uninfected with *Alectra* (Table 10).

The combined ANOVA of the data showed that, in both trials, the uninfected cowpea plants from the negative control treatment produced the highest root nodule number which was significantly higher than that of the other treatments. The lowest root nodule due to low population treatment was comparable with that due to medium and high population treatments (Table 10).

NH- 452 Line

In Trial 1, *Alectra* the uninfected cowpea plants from the positive NH-452 control treatment, produced the lowest root nodule number at 7 WAP, which was only significantly lower than the highest due to negative control treatment. None of the sampled plants from the high population treatment was infected with *Alectra*. Similarly, at 9 WAP, cowpea plants from the low and high NH-452 population treatments, produced the lowest root nodule number which was only significantly lower than the highest due to negative control treatment (Table 10).

In Trial 2, *Alectra* uninfected cowpea plants from the negative NH-452 control treatment produced the highest root nodule number which was comparable with that

of the other treatments at 7 WAP. At 9 WAP, cowpea plants from the negative NH-452 control treatment produced the highest root nodule number which was comparable with that of medium and high population treatments. The lowest root nodule number due to low population treatment was comparable with that of positive control treatment (Table 10).

The combined ANOVA of the data showed that, in both trials, uninfected cowpea plants from the low population treatment produced the lowest root nodule number which was only significantly lower than the highest due to the negative control treatment (Table 10).

NH-493 Line

In Trial 1, the *Alectra* uninfected cowpea plants sampled from the high NH-493 population treatment produced the lowest root nodule number at 7 WAP, which was only significantly lower than the highest due to negative control treatment.

However, at 9 WAP, uninfected cowpea plants from the medium and high NH- 493 population treatments, produced the lowest root nodule number, which was only significantly lower than the highest due to the negative control treatment (Table 4.19).

In Trial 2, the uninfected cowpea plants from the negative NH-493 population treatment produced the highest root nodule number at 7 WAP, which was comparable with that of the other treatments. At 9 WAP, uninfected cowpea plants from the high and medium population treatments produced the highest root nodule number which were significantly higher than that of the other treatments. The lowest root nodule

number due to low NH- 493 population treatment was comparable with that of the negative control treatment (Table 10).

The combined ANOVA of the data showed that, in both trials, *Alectra* uninfected cowpea plants from the positive NH-493 control treatment produced the lowest root nodule number which was significantly lower than the highest due to negative control treatment (Table 10).

Percentage infection of cowpea plants by *Alectra*

Generally, there was higher percent *Alectra* infection from positive control treatment particularly in Trial 1, but along with medium population treatment in Trial 2, and the lowest percentage infection was associated with both high and low population treatments.

Trial 1

***Celosia*:** The infected cowpea plants from the positive control treatment produced thehighest percent *Alectra* infection which was comparable with that of the other treatments (Table 11).

In trial 2, the infected cowpea plants from the positive control and high population treatment produced the highest percent *Alectra* infection which were only significantly higher than the lowest due to low population treatment in Trial 2 (Table 11).

The combined ANOVA of the data showed that, in both trials, Cowpea plants from the positive control treatment produced the highest percent *Alectra* infection which was comparable with the other treatments (Table 11).

Tete: Infected cowpea plants from the positive control treatment produced the highest percent *Alectra* infection which was significantly higher than the other treatments thatare comparable. None of the sampled plants from the high population treatment was infected with *Alectra* in Trial 1 (Table 11)

In trial 2, infected cowpea plants from the medium and high population treatments produced the highest percent *Alectra* infection which were comparable with that of the other treatments in Trial 2 (Table 11).

The Combined ANOVA of the data showed that, in both trials, infected Cowpea plants from the positive Tete control treatment produced the highest percent *Alectra* infection which comparable with that of the other treatments (Table 11).

NH-48 Line: The infected cowpea plants from the positive control treatment produced the highest percent *Alectra* infection which was only comparable with that of the high

population treatment. Low population treatment resulted in the lowest percentage *Alectra* infection (Table 11)

In Trial 2, the infected cowpea plants from the medium population treatmet produced the highest percentage *Alectra* infection which was only significantly higher than the high population treatment with the lowest in Trial 2 (Table 11).

The combined ANOVA of the data showed that, in both trials, Cowpea plants from the positive NH-48 control treatment produced the highest percent *Alectra* infection which was comparable with that of the other treatments (Table 11).

Local Black: Infected cowpea plants from the low population treatment produced the highest percent *Alectra* infection which was only significantly higher than the medium and high population treatment with the lowest in Trial 1 (Table 11)..

In trial 2, infected cowpea plants from the positive control treatment produced the highest percent *Alectra* infection which was comparable witht that of the other treatments in Trial 2 (Table 11).

The combined ANOVA of the data showed that, in both trials, Cowpe plants from the low local black population treatments produced the highest percent *Alectra* infection which was comparable with that of the other treatments (Table 11).

NH-452 Line: The infected cowpea plants from the positive control treatment produced the highest number of *Alectra* which was only significantly higher than the high population treatment with the lowest in Trial 1. None of the sampled plants from the other treatments was infected with *Alectra* (Table 11).

In trial 2, the infected cowpea plants from the high population treatment produced the highest percent *Alectra* infection which was comparable with that of the other treatments in Trial 2 (Table 11).

The combined ANOVA of the data showed that, in both trials, Cowpea plants from the high NH-452 population treatment produced the highest percent *Alectra* infection which was comparable with that of the other treatments (Table 11).

Table 11. Effect of *Amaranthus* population levels on the percentage infection of cowpea plants inoculated with *Alectra*

Trial	Variety	Percentage infection						
		Control		*Amaranthus* population level				
		Negative	Positive	Low	Medium	High	Mean	SE±
I	*Celosia*	NI	61.11a	50.00a	50.00a	50.00a	42.22	5.36
	Tete	NI	33.33a	16.67b	11.11b	NI	12.22	1.93
	NH-48	NI	33.33a	11.11c	16.67b	27.78ab	17.78	2.10
	Local Black	NI	50.00ab	77.78a	27.78b	27.78b	36.89	8.16
	NH-452	NI	33.33a	NI	NI	16.67b	10.00	3.33
	NH-493	NI	33.33a	27.78ab	44.45a	11.11b	23.33	5.77
II	*Celosia*	NI	94.44a	61.116a	77.77a	94.44a	65.55	3.84
	Tete	NI	66.67a	50.00a	77.78a	77.78a	54.44	7.26
	NH-48	NI	77.77a	66.67ab	77.78a	50.00b	67.71	5.77
	Local Black	NI	83.33a	66.67a	61.11a	77.78a	57.78	10.12
	NH-452	NI	61.11a	61.11a	33.33a	84.44a	47.10	3.62
	NH-493	NI	66.67ab	77.78a	83.33a	44.44b	54.44	6.67
Combined	*Celosia*	NI	77.78a	55.56a	63.89a	72.22a	53.89	4.14
	Tete	NI	50.00a	33.34a	44.45a	38.89a	33.34	13.73
	NH-48	NI	55.55a	38.89a	47.22a	38.89a	36.11	12.37
	LocalBlack	NI	66.67a	72.22a	44.45a	52.78a	62.67	11.10
	NH-452	NI	47.22a	30.56a	16.67a	80.56a	35.00	2.83
	NH-493	NI	50.00ab	52.78ab	63.89a	27.78b	38.00	10.53

Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple Range-Test (DMRT).
NI:No *Alectra*-Infected Plants

NH-493 line: The infected cowpea plants from the medium population treatment produced the highest percent *Alectra* infection which was only significantly higher than the lowest due to the high population treatment (Table 11).

In trial 2, infected cowpea plants from the medium population treatment produced the highest percent *Alectra* infection which was only significantly higher than the high population treatment with the lowest in Trial 2 (Table 11).

The combined ANOVA of the data showed that, in both trials, Cowpea plants from the medium NH-493 population treatments produced the highest percent *Alectra*-infection which was only significantly higher than the lowest due to high population treatment (Table 11).

Number of attached *Alectra* shoots

The data on the number of *Alectra* shoots attached to sampled cowpea plants showed that, positive control treatment produced the highest number of *Alectra* in Trial 1, while high population treatment produced higher number of *Alectra* shoot than the other treatments in Trial 2.

***Celosia*:** In Trial 1, cowpea plants from the medium population treatment produced the highest number of *Alectra* shoots which was only significantly higher than the lowest due to high population treatment in Trial 1 (Table 12).

In Trial 2, cowpea plants sampled from the low population treatment produced the highest number of attached *Alectra* shoots which was significantly higher than the lowest due to the medium and high population treatments that were in turn comparable (Table 12).

The combined ANOVA of the data from the two trials showed that, cowpea plants sampled from the low population treatment produced the highest number of attached *Alectra* shoots which was only significantly higher than the lowest due to the high population treatment (Table 12).

Tete: In Trial 1, cowpea plants sampled from the positive control treatment produced the highest number of attached *Alectra* shoots which was significantly higher than the other treatments that are in turn comparable. None of the sampled plants from the high population treatment was infected with *Alectra* (Table 12).

In Trial 2, cowpea plants sampled from the high population treatment produced the highest number of attached *Alectra* shoots which was significantly higher than the lowest due to positive and low population treatments that were in turn comparable (Table 12).

The combined ANOVA of the data from the two trials showed that, cowpea plants sampled from the high population treatment produced the highest number of attached *Alectra* shoots which was comparable with that of the other treatments (Table 12).

NH-48 line: In Trial 1, cowpea plants sampled under the positive control treatment produced the highest number of attached *Alectra* shoots which was only significantly higher than that of the low and medium population treatments which in turn are comparable (Table 12).

In Trial 2, cowpea plants under the medium population treatment produced the highest number of *Alectra* shoots which was only significantly higher than the lowest due to positive control and low population treatments. (Table 12).

Table 12. Effect of *Amaranthus* population on the number of attached *Alectra* shoots on cowpea plants innoculated with *Alectra*

Trial	Variety	Number of attached *Alectra* shoots						
		Control		*Amaranthus* population level				
		Negative	Positive	Low	Medium	High	Mean	SE±
I	*Celosia*	NI	1.95a	1.90a	2.30a	0.43b	1.32	0.18
	Tete	NI	3.33a	1.00b	0.67b	NI	0.80	0.21
	NH-48	NI	2.50a	1.00b	1.00b	1.67ab	1.23	0.30
	L. Black	NI	2.00a	1.93a	2.00a	1.67a	1.52	0.21
	NH-452	NI	2.50a	NI	NI	0.67b	0.63	0.17
	NH-493	NI	2.17a	1.67b	1.00c	1.00c	1.17	0.09
II	*Celosia*	NI	3.73b	5.33a	2.33c	1.57c	2.59	0.20
	Tete	NI	1.63b	2.23b	2.97ab	5.03a	2.37	0.63
	NH-48	NI	1.70b	1.73b	3.40a	2.93a	1.95	0.17
	L. Black	NI	2.97b	2.60b	2.83b	5.23a	2.65	0.43
	NH-452	NI	2.00c	1.11b	1.77a	1.44a	1.26	0.17
	NH-493	NI	3.20b	1.53bc	1.23c	7.67a	2.73	0.58
Combined	*Celosia*	NI	2.84a	3.62a	2.30ab	1.00b	1.95	0.54
	Tete	NI	2.48a	1.62a	1.82a	2.52a	1.69	0.79
	NH-48	NI	2.10a	1.37a	2.20a	2.30a	1.59	0.39
	L. Black	NI	2.48a	2.27a	2.42a	3.20a	2.07	0.58
	NH-452	NI	3.30a	2.22a	2.25a	2.24a	2.00	0.16
	NH-493	NI	2.68ab	1.60b	1.12b	4.33a	1.95	0.89

Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan multiple range-test (DMRT).
NI: No *Alectra*-Infected Plants
L. Black: Local Black

The combined ANOVA of the data from the two trials showed that, cowpea plants sampled from the high population treatment produced the highest number of attached *Alectra* shoots which was comparable with that of the other treatments (Table 12).

Local Black: In Trial 1, cowpea plants sampled from the positive and medium population treatment produced the highest number of attached *Alectra* shoots which were comparable with that of the other treatments (Table 12).

In Trial 2, cowpea plants from the high population treatment produced the highest number of *Alectra* shoots which was significantly higher than that of the other treatments that are in turn comparable (Table 12).

The combined ANOVA of the data from the two trials showed that, cowpea plants sampled from the high population treatment produced the highest number of attached *Alectra* shoots which was comparable with that of the other treatments (Table 12).

NH-452 line: In Trial 1, cowpea plants from the positive control treatment produced the highest number of *Alectra* which was significantly higher than the lowest due to high population treatment. None of the sampled plants from the other treatments were infected with *Alectra* (Table 12).

In Trial 2, cowpea plants from the medium population treatment produced the highest number of *Alectra* shoots which was only significantly higher than the lowest due to positive control and low population treatments (Table 12).

The combined ANOVA of the data from the two trials showed that, cowpea plants sampled from the positive control treatment produced the highest number of attached *Alectra* shoots which was comparable with that of the other treatments (Table 12).

NH 493: In Trial 1, cowpea plants from the positive control treatment produced the higher number of *Alectra* which was only significantly higher than the lowest due to medium and high population treatments (Table 12).

In Trial 2, cowpea plants under the high population treatment produced the highest number of *Alectra* shoots which was significantly higher than the other treatments. The lowest number of *Alectra* due to medium population treatments was lower than that of the other treatments (Table 12).

The combined ANOVA of the data from the two trials showed that, cowpea plants sampled from the high population treatment produced the highest number of attached *Alectra* shoots which was only significantly higher than the lowest due to low and medium population treatments (Table 12).

Weight of *Alectra* attached to sampled cowpea plants in trial 2

The data obtained in Trial 2 from the weight of *Alectra* shoots attached to sampled cowpea plants showed higher weight of *Alectra* with those from the low population treatment, whereas positive control treatment produced lowest weight of *Alectra*.

Trial 2:

***Celosia*:** Cowpea plants from the low population treatment produced the highest weight of *Alectra* which was only significantly higher than the lowest due to high and medium population treatments that were comparable (Table 13).

Tete: Cowpea plants from the positive control treatment produced the lowest weight of *Alectra* which was significantly lower than the highest due to high population treatment (Table 13).

NH-48 line: Cowpea plants from the high population treatment produced the highest weight of *Alectra* which was comparable with that of the other treatments (Table 13).

Local Black: Cowpea plants from the low population treatment produced the highest weight of *Alectra* which was comparable with that of the other treatments (Table 13).

NH-452 line: Cowpea plants from the medium population treatment produced the highest weight of *Alectra* which was comparable with that of the other treatments (Table 13).

NH-493 line: Cowpea plants from the low population treatment produced the lowest weight of *Alectra* which was only significantly lower than the highest due to the high population treatment (Table 13).

Number of emerged *Alectra* shoots in cowpea pots

Generally, the data showed that, cowpea plants from the positive control and high population treatments of most *Amaranthus* lines produced the highest number of emerged *Alectra* shoots in both trials, than the other treatments. However, more *Amaranthus* line from the positive, low, medium and high population shows no *Alectra* infected plants in Trial 1. There was higher number of emerged *Alectra* shoots associated with all the treatments in Trial 2.

***Celosia*:** In Trial 1, at 7 WAP, cowpea plants from the high population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the medium population treatment. No emerged *Alectra* shoots was found with cowpea plants under the other treatments (Table 14).

Table 13. Effect of *Amaranthus* population levels on the weight of *Alectra* attached to sampled cowpea plants

Trial	Variety	*Alectra* weight (g)						
		Control		*Amaranthus* population level.				
		Negative	Positive	Low	Medium	High	Mean	SE±
	Celosia	NI	6.15ab	10.43a	2.57b	1.13b	4.06	1.49
	Tete	NI	0.96b	3.30ab	2.22b	6.31a	2.56	0.82
	NH-48	NI	3.80a	2.50a	4.27a	4.43a	3.00	0.06
	Local Black	NI	3.20a	10.15a	1.97a	6.03a	4.27	2.06
	NH-452	NI	4.57a	2.68a	10.10a	5.23a	4.52	2.03
	NH-493	NI	3.43b	1.73b	2.77b	7.17a	3.02	0.59

Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple Range-Test (DMRT).
NI: No *Alectra*-Infected Plants

In Trial 2, at 7 WAP cowpea plants from the high population treatment produced the highest number of emerged *Alectra* shoots which was only significantly than the lowest due to positive control treatment (Table 14).

The combined ANOVA of the data showed that, in both trials at 7 WAP, cowpea plants from the high population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

Tete: In Trial 1, no emerged *Alectra* shoots was found on cowpea plants, at 7 WAP (Table 14).

In Trial 2 at 7 WAP, cowpea plants from the high population treatment produced the highest number of emerged *Alectra* which was comparable with that of the other treatments (Table 14).

The combined ANOVA of the data showed that, in both trials at 7 WAP, cowpea plants from the high population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

Table 14. Effect of *Amaranthus* population levels on the number of emerged *Alectra* shoots on cowpea innoculated with *Alectra*

Trial	Age (WAP)	Variety	Emerged *Alectra* shoots						
			Control		*Amaranthus* population level.				
			Negative	Positive	Low	Medium	High	Mean	SE±
I	7	*Celosia*	NI	NI	NI	1.33a	3.33a	0.93	0.69
		Tete	NI	NI	NI	NI	NI	0.00	0.00
		NH-48	NI	NI	NI	NI	NI	0.00	0.00
		L. Black	NI	NI	0.33a	0.33a	0.33a	0.20	0.20
		NH-452	NI	NI	NI	NI	NI	0.00	0.00
		NH-493	NI	NI	NI	NI	10.33a	0.07	0.12
	9	*Celosia*	NI	2.00a	1.67a	2.33a	1.33a	1.47	0.54
		Tete	NI	3.00a	NI	NINI	NI	0.60	0.20
		NH-48	NI	3.67a	NI	0.66a	NI	0.73	0.42
		L. Black	NI	4.00a	3.66a	NI	2.67a	2.20	1.42
		NH-452	NI	5.33a	NI	1.00ab	NI	1.07	0.31
		NH-493	NI	2.67a	NI		0.67b	0.87	0.44
II	7	*Celosia*	NI	6.33b	13.67ab	12.00ab	17.67a	9.93	2.36
		Tete	NI	0.67a	1.33a	2.67a	4.67a	1.87	1.17
		NH-48	NI	NI	NI	1.33a	2.33a	0.73	0.75
		L. Black	NI	NI	NI	1.67a	0.67a	0.47	0.57
		NH-452	NI	3.67a	NI	NI	NI	0.73	0.81
		NH-493	NI	1.33a	NI	0.33a	2.67a	0.87	0.89
	9	*Celosia*	NI	16.67c	26.67b	31.67ab	42.33a	23.47	2.99
		Tete	NI	9.67a	21.33a	17.67a	14.00a	12.53	3.23
		NH-48	NI	12.00a	19.33a	15.00a	14.33a	12.13	3.47
		L. Black	NI	12.33a	8.67a	8.00a	8.33a	7.47	2.98
		NH-452	NI	10.67a	14.33a	5.67a	2.33a	6.60	3.17
		NH-493	NI	16.00a	17.00a	16.67a	13.00a	12.52	1.81
Combined	7	*Celosia*	NI	3.17ab	6.83a	6.67a	10.50a	5.43	3.04
		Tete	NI	0.33a	0.67a	1.33a	2.33a	0.93	1.05
		NH-48	NI	NI	NI	0.67a	1.17a	0.36	0.55
		L. Black	NI	NI	0.17a	1.00a	0.50a	0.33	0.41
		NH-452	NI	1.83a	NI	NI	NI	0.37	0.66
		NH-493	NI	0.67a	NI	0.17a	1.50a	0.47	0.69
Combined	9	*Celosia*	NI	9.33a	14.17a	17.00a	21.83a	13.27	6.92
		Tete	NI	6.33a	10.67a	8.83a	7.00a	6.57	4.50
		NH-48	NI	7.83a	9.67a	7.50a	7.17a	6.43	4.30
		L. Black	NI	8.17a	6.17a	4.33a	5.50a	4.83	3.43
		NH-452	NI	8.00a	7.17a	2.83a	1.17a	3.83	3.03
		NH-493	NI	9.33a	8.50a	8.33a	6.83a	6.60	3.57

Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple Range-Test (DMRT).
NI: No *Alectra*-Infected Plants L. Black: Local Black

NH-48: In Trial 1, no emerged *Alectra* shoot was found on cowpea plants, at 7 WAP (Table 14).

In Trial 2 at 7 WAP, high population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the medium population treatment. No emerged *Alectra* shoot from compea plants under the other treatments (Table 14).

The combined ANOVA of the data showed that, in both trials, at 7 WAP, cowpea plants from the high population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the medium population treatment. No emerged *Alectra* shoot from cowpea plants under the other treatments (Table 14).

Local Black: In Trial 1, cowpea plants from the low, medium and high population were found with the same number of emerged *Alectra* at 7WAP. No emerged *Alectra* shoot from positive control treatment (Table 14).

In Trial 2 at 7 WAP, cowpea plants from the medium population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of high population treatment. No emerged *Alectra* shoots from the other treatments (Table 14).

The combined ANOVA of the data showed that, in both trials at 7 WAP, cowpea plants from the medium population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments. No emerged *Alectra* shoot from cowpea plants under the two control treatments (Table 14).

NH-452: In Trial 1, no emerged *Alectra* shoots was found at 7 WAP (Table14).

In Trial 2 at 7 WAP, only cowpea plants from the positive control treatment was found to have emerged *Alectra* shoot. The other treatments were found to have no emerged *Alectra* shoots (Table 14).

The combined ANOVA of the data showed that, in both trials at 7 WAP, only cowpea plants under positive control treatment was found to have emerged *Alectra* shoots. None of the plants from the other treatments was found to have emerged *Alectra* shoots (Table 14).

NH-493: In Trial 1, only cowpea plants from high population treatment was found to have emerged *Alectra* shoots. None of the cowpea plants from the other treatments was found to have emerged *Alectra* shoots, at 7 WAP (Table 14).

In Trial 2 at 7 WAP, cowpea plants from the high population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments. None of the plants from the low population treatment was found to have emerged *Alectra* shoots (Table 14).

The combined ANOVA of the data showed that, in both trials at 7 WAP, cowpea plants from the high population treatment produced the highest number of emerged *Alectra* shoots which *Alectra* which was comparable with that of the other treatments. No emerged *Alectra* shoots from cowpea plants under the low population treatments (Table 14).

***Celosia*:** In Trial 1, at 9 WAP, cowpea plants in pots pre-treated with medium population treatment of *Celosia* produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

In Trial 2 at 9 WAP, cowpea plants from the high population treatment produced the highest number of emerged *Alectra* shoots which was only comparable with that of the medium population treatment. The lowest due to positive control treatment was significantly lower than that of the other treatments (Table 14).

The combined ANOVA of the data showed that, in both trials at 9 WAP, cowpea plants from the high population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatment (Table 14).

Tete: In Trial 1, at 9 WAP, only cowpea plants of positive control treatment of Tete was found to have emrged *Alectra* shoots. No emerged *Alectra* shoots from cowpea plants under the other treatments (Table 14).

In Trial 2 at 9 WAP, Cowpea plants from the low population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

The combined ANOVA of the data showed that, in both trials at 9 WAP, cowpea plants from the low population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

NH-48 line: In Trial 1, at 9WAP, only cowpea plants under positive control treatment was found to have emerged *Alectra* shoots (Table 14).

In Trial 2 at 9 WAP, cowpea plants under the low population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

The combined ANOVA of the data showed that, in both trials at 9 WAP, cowpea plants from the low population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

Local Black: In Trial 1, at 9 WAP, cowpea plants from the positive control treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

In Trial 2 at 9 WAP, cowpea plants from the positive control treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

The combined ANOVA of the data showed that, in both trials at 9 WAP, the cowpea plants from the positive control treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

NH-452 line: In Trial 1, at 9 WAP, only cowpea plants under positive control treatment was found to have emerged *Alectra* shoots (Table 14).

In Trial 2 at 9 WAP, cowpea plants from the low population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

The combined ANOVA of the data showed that, in both trials, cowpea plants from the positive control treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

NH-493 line: In Trial 1, at 9 WAP, cowpea plants under positive control treatment producedthe highest number of emerged *Alectra* shoots which was only significantly higher than the lowest due to high population treatment. No emerged *Alectra* shoots from cowpea plants under the low population treatment (Table 14).

In Trial 2 at 9 WAP, cowpea plants from the low population treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

The combined ANOVA of the data showed that, in both trials at 9 WAP, cowpea plants from the positive control treatment produced the highest number of emerged *Alectra* shoots which was comparable with that of the other treatments (Table 14).

Yield parameters of cowpea plants

Generally, the pretreatment of pot soil with *Celosia* and *Amaranthus* lines at the various population levels tended to produce higher number of flower, pod numbers, pod weight, total grain, yields, and 100-seed weight.

Flowers number

There was a tendency toward higher flower number in cowpea plants under the *Amaranthus* population treatments than the two controls (except under *Celosia*).

Celosia :Cowpea plants from the negative *Celosia* control treatment produced the highest number of flowers, which was comparable with that of the other treatments (Table 15).

Tete : Cowpea plants from the low Tete population treatment produced the highest number of flowers which was comparable with that observed from the other treatments (Table 15).

NH-48 line: Cowpea plants from the medium NH-48 population treatment produced the highest number of flowers, which was comparable with that of the other treatments (Table 15).

Local Black: Cowpea plants from the low Local black population treatment produced the highest number of flowers, which was comparable with that of the other treatments (Table 15).

NH-452 line: Cowpea plants from the medium NH- 452 population treatment produced the highest flowers number, which was only significantly higher than the lowest flower number due to negative NH-452 control treatment (Table 15).

NH-493 line: Cowpea plants from the medium NH-493 population treatment produced the highest number of flower which was comparable with that observed from the other treatments (Table 15).

Pod number

There was a tendency toward higher pod number under the *Amaranthus* population treatments than the two controls (except under *Celosia*).

Table 15. Effect of *Amaranthus* population levels on the number of flowers produced by cowpea inoculated with *Alectra* .

	Number of Flowers Produced						
	Control		*Amaranthus* population level				
Variety	Negative	Positive	Low	Medium	High	Mean	SE±
Celosia	43.67a	41.67a	34.67a	28.00a	29.00a	35.40	4.66
Tete	20.67a	33.00a	40.67a	39.33a	32.67a	33.27	4.79
NH-48	24.00a	25.00a	28.33a	36.00a	25.00a	27.67	3.67
Local Black	31.00a	27.33a	31.67a	29.67a	27.67a	29.47	3.06
NH-452	21.00b	23.00ab	34.67ab	41.33a	37.00b	31.4	4.44
NH-493	22.00a	29.00a	26.67a	35.67a	34.33a	29.53	5.10

Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple Range Test (DMRT)

Celosia:Cowpea plants from the low population and positive control treatments produced the highest pod number which was comparable with that observed from the other treatments (Table 16).

Tete: Cowpea plants from the low Tete population treatment produced the highest pod number, which was comparable with that observed from the medium and high populations of Tete treatments. The lowest pod number observed from the negative Tete control treatment was comparable with that observed from the positive control and high population of Tete treatments (Table 16).

NH-48 line: Cowpea plants from the medium NH-48 population treatment produced the highest pods number which was comparable with that of positive control and low population treatments. The lowest pods number observed from the high population treatment was only comparable with that due to negative control treatments (Table 16).

Table 16. Effect of *Amaranthus* Population levels on the number of pods produced by cowpea inoculated with *Alectra* .

	Pod Number Produced						
	Control		*Amaranthus* population level				
Variety	Negative	Positive	Low	Medium	High	Mean	SE±
Celosia	15.00a	26.33a	26.33a	20.67a	24.00a	22.40	2.85
Tete	10.33b	14.00b	36.00a	32.00a	24.33ab	23.33	2.47
NH-48	11.67bc	16.67ab	18.67ab	20.00a	11.33c	15.67	1.68
Local Black	10.33b	16.00ab	24.00a	20.67ab	17.33ab	17.67	2.42
NH-452	10.67b	10.67b	22.33a	30.00a	24.00a	19.53	2.71
NH-493	11.00b	10.33b	18.00ab	20.67ab	23.00a	16.60	2.55

Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple Range-Test (DMRT).

Local Black: Cowpea plants from the low Local black population treatment produced the highest pod number which was only significantly higher than the lowest pod number due to negative Local black control treatment (Table 16).

NH-452 line: Cowpea plants from the medium NH-452 population treatment produced the highest pod number which was comparable with that of the high and low population treatments. The lowest pod number due to negative and positive NH-452 control treatments were comparable and significantly lower than that of the other treatments (Table 16).

NH-493 line: Cowpea plants from the high NH-493 population treatment produced the highest pod number which was significantly higher than that of the negative and positive control treatments. The lowest pod number due to positive NH-493 control treatment was only comparable with that of the negative control treatment (Table 16).

Pod weight

Generally, higher pod weight was observed from cowpea plants under the *Amaranthus* population treatments than the two controls (except under *Celosia*).

Celosia: Cowpea plants from the low *Celosia* population treatment produced the highest pod weight which was comparable with that observed from the other treatments (Table 17).

Table 17. Effect of *Amaranthus* population levels on the pod weight of cowpea inoculated with *Alectra* .

	Pod weight (g)						
	Control		*Amaranthus* population level				
Variety	Negative	Positive	Low	Medium	High	Mean	SE±
Celosia	24.00a	27.00a	29.00a	20.33a	26.33a	25.33	3.40
Tete	16.00b	14.33b	38.67a	38.33a	29.67ab	27.40	4.22
NH-48	15.00b	21.33a	22.67a	24.00a	12.67b	19.27	1.52
Local	16.33a	18.33a	25.67a	22.00a	21.67a	20.80	3.30
Black	15.33b	10.33b	30.33a	36.67a	28.33a	24.20	2.68
NH-452	15.00ab	10.66b	20.33ab	24.67a	24.67a	18.73	5.88
NH-493							

N.B: Means followed by the same letter(s) in each row, are not significantly different (P=0.05), using Duncan Multiple Range-Test (DMRT).

Tete: Cowpea plants from the low Tete population treatment produced the highest pod weight which was only comparable with that of the medium and high Tete population treatments (Table 4.30). The lowest pod weight due to positive Tete control treatment was only comparable with that of the negative Tete control treatment (Table 17).

NH-48 line: Cowpea plants from the medium NH-48 population treatment produced the highest pod weight which was only comparable with that of the low population

and positive NH-48 control treatments. The lowest pod weight due to high population treatment was comparable only with that of the negative control treatment (Table 17).

Local Black: Cowpea plants from the low Local black population treatment produced the highest pod weight, which was comparable with that of the other treatments (Table 17).

NH-452 line: Cowpea plants from the medium NH-452 population treatment produced the highest pod weight which was only comparable with that observed from the low and high NH-452 population treatments. The lowest pod weight due to positive NH-452 population treatment was only comparable with that of the negative control treatment (Table 17).

NH-493 line: Cowpea plants from the high and medium NH-493 population treatments produced the highest pod weight which was only significantly higher than the lowest pod weight, due to positive NH-493 control treatment (Table 17).

Total grain yield

There was a tendency toward higher total grain yield/plant in cowpea plants under the *Amaranthus* population treatments than the two controls.

Celosia: Cowpea plants from low *Celosia* population treatment produced the highest total grain yield at yield which was comparable with that of the other treatments (Table 18).

Tete*:* Cowpea plants from the medium Tete population treatment produced the highest total grain yield, which was comparable with that of the low and high population treatments. The lowest total grain yield due to positive Tete control treatment was comparable with that of the negative control and high population treatments (Table 18).

NH-48 line: Cowpea plants from the medium population treatment produced the highest total grain yield which was comparable with that of the low population treatment. The lowest total grain yield due to high NH-48 population treatment was comparable only with that of the negative control treatment (Table 18).

Local Black: Cowpea plants from the low Local black population treatment produced the highest total grain yield, which was comparable with that of the other treatments (Table 18).

NH-452 line: Cowpea plants from the medium NH-452 population treatment produced the highest total grain yield, which was only comparable with that of the high and low population treatments. The lowest total grain yield due to positive NH-452 control treatment was only comparable with that of the negative control treatment (Table 18).

NH-493: The lowest total grain yield due to positive NH-493 control treatment was only significantly lower than the highest due to medium and high population treatments (Table 18).

Table 18. Effect of *Amaranthus* population levels on the total grain yield of cowpea inoculated with *Alectra*.

	Total Grain Yield (g)/Plant						
	Control		*Amaranthus* population level				
Variety	Negative	Positive	Low	Medium	High	Mean	SE±
Celosia	1.64a	1.33a	1.97a	1.39a	1.84a	1.63	0.30
Tete	1.11b	0.97b	2.50a	2.58a	1.97ab	1.83	0.40
NH-48	0.97cd	1.25bc	1.54ab	1.67a	0.86d	1.26	0.29
Local Black	1.09a	1.25a	1.72a	1.52a	1.47a	1.49	0.28
NH-452	1.10b	0.67b	1.83a	2.42a	1.83a	1.57	0.20
NH-493	1.06ab	0.72b	1.11ab	1.61a	1.58a	1.22	0.19

N.B: Means followed by the same letter(s) in each row, are not significantly different (P=0.05), using Duncan Multiple Range-Test (DMRT).

1000 Seed weight

Generally, higher 1000 seed weight was observed from cowpea plants under the *Amaranthus* population treatments than the two controls.

Celosia line: Cowpea plants from high *Celosia* population treatment produced the highest 1000 seed weight, which was comparable with the lowest that was observed from the medium population treatment (Table 19).

Tete: The lowest 1000 seed weight observed from the positive Tete control treatment was only significantly lower than the highest due to low population treatment (Table 19).

NH-48 line: Cowpea plants from the medium NH-48 population treatment produced the highest 1000 seed weight which was only comparable with that of the low population and positive NH-48 control treatments. The lowest 1000 seed weight due

to high population treatment was only comparable with that of the negative control treatment, (Table 19).

Local Black: Cowpea plants from the low Local black population treatment produced the highest seed weight, which was comparable with that of the other treatments (Table 19).

NH-452 line: Cowpea plants from the medium NH-452 population treatment produced the highest 1000 seed weight, which was only comparable with that of the high and low NH-452 population treatments. The lowest 1000 seed weight observed from the positive NH-452 control treatment was only comparable with the negative control treatment (Table 19).

NH-493 line: Cowpea plants from the high NH-493 population treatment produced the highest 1000 seed weight which was only significantly higher than the lowest 100 seed weight due to positive control treatment (Table 19).

Correlation

Celosia:There was a highly positive and significant correlation between the shoot fresh weight of infected *Celosia* plant with root fresh weight and plant height of infected *Celosia* plants, whereas it had negative correlation with the shoot fresh weight and plant height of uninfected *Celosia* plants (Table 20).

The correlation between shoot fresh weight of uninfected *Celosia* with root fresh weight and plant height of uninfected *Celosia* was also highly positive and significant, but it had a negative correlation with infected *Celosia* shoot fresh weight, plant height and root nodule number (Table 20).

Table 19. Effect of *Amaranthus* population levels on the 1000 seed weight of cowpea inoculated with *Alectra*.

	1000 Seed Weight (g)						
	Control		*Amaranthus* population level				
Variety	Negative	Positive	Low	Medium	High	Mean	SE±
Celosia	110.33a	107.67a	126.00a	100.67a	136.67a	116.27	20.71
Tete	77.00b	75.00b	197.00a	161.67ab	155.00ab	133.13	27.32
NH-48	71.33b	102.62a	114.67a	128.00a	68.67b	97.07	7.32
Local	79.67a	98.33a	130.33a	117.67a	115.67a	108.33	17.27
Black	77.00b	50.33b	148.67a	176.33a	146.00a	119.67	14.04
NH-452	76.00ab	58.67b	101.67ab	115.33a	122.67a	94.87	12.99
NH-493							

Means followed by the same letter(s) in each row, in each trial are not significantly different (P=0.05), using Duncan Multiple Range-Test (DMRT).

plants. Thus, there was no negative correlation between the parameters and NH-452 (Table 24).

NH-493 line: There was a highly positive correlation between shoot fresh weight of infected NH-493 plant with root fresh weight, plant height of infected and uninfected NH-493 plants (Table 25).

There was also a highly positive correlation between the shoot fresh weight of uninfected NH-493 with plant height of infected and uninfected plants.

Generally, the correlation between root nodule of uninfected NH-493 plant was negative with most of the parameters (Table 25).

However, there is generally a highly and positive correlation between shoot fresh weight infected with root fresh infected and root nodule number infected.

Table 20. Simple correlation matrix table between the growth parameters of *Alectra* infected and uninfected Cowpea plants on soil pre-treated with *Celosia* plants

	CELOSIASFWI	CELOSIASFWUN	CELOSIARFWI	CELOSIARFWUN	CELOSIAPLHI	CELOSIAPLHUN	CELOSIARNDI	CELOSIARNDUN
CELOSIA SFWI	1.0000							
CELOSIASFWUN	-0.1529	1.0000						
CELOSIARFWI	0.7806**	-0.1725	1.0000					
CELOSIARFWUN	0.0435	0.7785**	0.0026	1.0000				
CELOSIAPLHI	0.8833**	-0.1676	0.7438**	0.0363	1.0000			
CELOSIAPLHUN	-0.2802*	0.6987**	-0.2564*	0.7646**	-0.2330*	1.0000		
CELOSIARNDI	0.1677	-0.2981*	-0.0060	0.3459*	0.1298	-0.2354*	1.0000	
CELOSIARNDUN	0.0894	0.3460*	-0.3455*	0.3067*	-0.3645*	0.5785**	-0.0951	1.0000

Keys:

SFW - Shoot fresh weight
RFW - Root fresh weight
PLH - Plant height
RND - Root nodule number
I - Infected
UN - Uninfected
* - Significant
** - Highly significant

Table 21. Simple correlation matrix table between the growth parameters of *Alectra* infected and uninfected cowpea plants on soil pre-treated with *Amaranthus* line Tete plants

	TETESFWI	TETESFWUN	TETERFWI	TETERFWUN	TETEPLHI	TETEPLHUN	TETERNDI	TETERNDUN
TETESFWI	1.0000							
TETESFWUN	-0.0207	1.0000						
TETERFWI	0.6742**	0.0038	1.0000					
TETERFWUN	0.1529	0.3945*	0.1311	1.0000				
TETEPLHI	0.3897*	-0.0103	0.3877*	0.9448**	1.0000			
TETEPLHUN	0.2801*	0.3431*	0.2791*	0.9185**	0.2232*	1.0000		
TETERNDI	0.6337**	-0.0753	0.2639*	0.0233	0.1962	0.0627	1.0000	
TETERNDUN	-0.9860**	-0.0362	0.0370	0.3290*	0.0737	0.3030*	-0.3327*	1.0000

Keys:

SFW - Shoot fresh weight
RFW - Root fresh weight
PLH - Plant height
RND - Root nodule number
I - Infected
UN - Uninfected
* - Significant
** - Highly significant

Table 22. Simple correlation matrix table between the growth parameters of *Alectra* infected and uninfected cowpea plants on Soil pre-treated with *Amaranthus* line NH-48 plants

	NH-48SFWI	NH-48SFUN	NH-48RFWI	NH-48RFWUN	NH-48PLHI	NH-48PLHUN	NH-48RNDI	NH-48RNDUN
NH-48SFWI	1.0000							
NH-48SFUN	-0.0745	1.0000						
NH-48RFWI	0.7462**	-0.1605	1.0000					
NH-48RFWUN	0.0463	0.8712**	0.0393	1.0000				
NH-48PLHI	0.3770*	-0.1533	0.3905*	-0.1022	1.0000			
NH-48PLHUN	-0.1844	0.8639**	-0.3864*	0.7519**	-0.2526*	1.0000		
NH-48RNDI	0.4060**	-0.2382*	0.2728*	-0.1092	0.1029	-0.2680*	1.0000	
NH-48RNDUN	-0.3246*	0.4044**	0.2780*	0.4021**	-0.2230*	0.4917**	-0.2959*	1.0000

Keys:

SFW - Shoot fresh weight
RFW - Root fresh weight
PLH - Plant height
RND - Root nodule number
I - Infected
UN - Uninfected
* - Significant
** - Highly significant

Table 23. Simple correlation matrix table between the growth parameters of *Alectra* infected and uninfected cowpea *plants* on soil pre-treated with *Amaranthus* line local Black plants

	L.BSFWI	L.BSFWUN	L.BRFWI	L.BRFWUN	L.BPLHI	L.BPLHUN	L.BRNDI	L.BRNDUN
L.BSFWI	1.0000							
L.BSFWUN	-0.1470	1.0000						
L.BRFWI	0.3447**	-0.1279	1.0000					
L.BRFWUN	0.1449	0.3382*	0.7130*	1.0000				
L.BPLHI	0.8304**	-0.2997*	0.5357**	0.1439	1.0000			
L.BPLHUN	0.09129	0.2434*	0.0978	0.2144*	-0.0014	1.0000		
L.BRNDI	0.3904**	-0.2681*	0.2334*	0.0868	0.7103**	-0.0142	1.0000	
L.BRNDUN	-0.2364*	0.4640**	-0.1840*	0.2261*	-0.3373*	0.1468	-0.2366*	1.0000

Keys:

SFW - Shoot fresh weight
RFW - Root fresh weight
PLH - Plant height
RND - Root nodule number
LB - Local Black
I - Infected
UN - Uninfected
* - Significant
** - Highly significant

Table 24. Simple correlation matrix table between the growth parameters of *Alectra* infected and uninfected cowpea plants on soil pre-treated with *Amaranthus* line NH-452 plants

	NH-452SFWI	NH-452SFWUN	NH-452RFWI	NH-452RFWUN	NH-452PLHI	NH-452PLHUN	NH-452RNDI	NH-452RNDUN
NH-452SFWI	1.0000							
NH-452SFWUN	0.0900	1.0000						
NH-452RFWI	0.8514**	0.8514**	1.0000					
NH-452RFWUN	0.8514**	0.8514**	0.8000**	1.0000				
NH-452PLHI	0.9648**	0.9648**	0.4926**	0.8493**	1.0000			
NH-452PLHUN	0.4775**	0.4775**	0.4162**	0.4162*	0.4236**	1.0000		
NH-452RNDI	0.8003**	0.8003**	0.6589**	0.6589**	0.7518**	0.3342*	1.0000	
NH-452RNDUN	0.0636	0.6356**	0.5726**	0.0572	0.0010	0.5582**	0.0009	1.0000

Keys:

SFW - Shoot fresh weight
RFW - Root fresh weight
PLH - Plant height
RND - Root nodule number
I - Infected
UN - Uninfected
* - Significant
** - Highly significant

Table 25. Simple correlation matrix table between the growth parameters of *Alectra* infected and uninfected cowpea plants on soil pre-treated with *Amaranthus* line NH-493 plants

	NH-493SFWI	NH-493SFUN	NH-493RFWI	NH-493RFWUN	NH-493PLHI	NH-493PLHUN	NH-493RNDI	NH-493RNDUN
NH-493SFWI	1.0000							
NH-493SFWUN	0.0802	1.0000						
NH-493RFWI	0.8396**	0.8396**	1.0000					
NH-493RFWUN	-0.0200	-0.0250	-0.0134	1.0000				
NH-493PLHI	0.8835**	0.8835**	0.6370**	0.7062**	1.0000			
NH-493PLHUN	0.8835**	0.8835**	0.6370**	-0.7062**	0.0900	1.0000		
NH-493RNDI	0.2842*	0.2842*	0.2000	-0.1395	0.3839*	0.3839*	1.0000	
NH-493RNDUN	-0.2274*	-0.2276*	-0.1303	0.5220**	-0.1459	-0.1459	-0.2187	1.0000

Keys:

SFW - Shoot fresh weight
RFW - Root fresh weight
PLH - Plant height
RND - Root nodule number
I - Infected
UN - Uninfected
* - Significant
** - Highly significant

Table 26. Simple correlation matrix table of the growth parameters (combined data) of *Alectra* infected and uninfected cowpea on soil pre-trated with *Celosia/Amaranthus* line plants

	SFWI	SFWUN	RFWI	RFWUN	PLHI	PLHUN	RNDI	RNDUN
SFWI	1.0000							
SFWUN	0.0142	1.0000						
RFWI	0.6237**	0.0418	1.0000					
RFWUN	0.1155*	0.3729**	0.0641	1.0000				
PLHI	0.4624**	0.0179	0.0359	0.0359	1.0000			
PLHUN	0.0804	0.2928**	0.0723**	0.4703**	0.0278	1.0000		
RNDI	0.5664**	0.0811	0.2532**	0.0178	0.2498**	-0.0158*	1.0000	
RNDUN	0.1628	0.1719*	0.0978	0.3687**	0.3687**	0.2975**	-0.2189*	1.0000

Keys:

SFW - Shoot fresh weight
RFW - Root fresh weight
PLH - Plant height
RND - Root nodule number
I - Infected
UN - Uninfected
* - Significant
** - Highly significant

Tete: There is a highly positive and significant correlation between the shoot fresh weight of infected Tete plant with root fresh weight and root nodule number, but had a negative correlation with shoot fresh weight and root nodule number (Table 21).

NH-48 line: The shoot fresh weight , root fresh weight and root nodule number of infected NH-48 plant had highly positive and significant correlation, whereas it had a negative correlation with the root fresh weight, plant height and root nodule number of uninfected NH-48 plants (Table 22).

However, there was a highly positive and significant correlation between the uninfected NH-48 shoot fresh weight with root fresh weight and plant height of uninfected NH-48 plants, but a negative correlation with uninfected NH-48 root nodule (Table 22)

Local Black: There was a highly positive and significant correlation between the shoot fresh weight of infected local black plant with root fresh weight,plant heigt and root nodule number of infected local black plants, whereas it had a negative correlation with shoot fresh weight and root nodule of uninfected plants (Table 23).

There was also negative correlation between shoot fresh weight of uninfected local black with root fresh, plant height and root nodule of infected plants.

However, there was a negative correlation between root nodule of uninfected local black with shoot fresh weight, root fresh weight and root nodule of infected local black plants (Table 23)

NH-452 line: Generally, there was a highly positive correlation between the shoot fresh weight of NH-452 and all the growth parameters in infected and uninfected

Also there was a highly and positive correlation between the plant uninfected, root nodule number infected with the various parameters within all the *Amaranthus/Celocia* lines. (Table.26)

CHAPTER FIVE

5.0 DISCUSSIONS

5.1 Laboratory Experiment

5.1.1 Percentage germination

Different *Amaranthus* lines and *Celosia* tested in the laboratory stimulated the germination of *Alectra* seeds. The relative effectiveness of the lines to induce the germination of the *Alectra* seeds proved that the lines had chemical stimulants which are capable of stimulating the germination of *Alectra* seeds. Germination of *Alectra* seeds was strongly stimulated by the root exudates of the various crops, thus in the absence of a specific germination stimulant, germination does not occur, even under favourable condition. This is in line with the findings of Musselman (1987) and Parker and Riches (1993a) who reported that the life cycle of parasitic weeds is closely adapted to that of their host plant. The seeds of the parasite germinate only if they are exposed to stimulant molecules, which are present in the root exudates of a suitable host plant.

The percentage germination of *Alectra* seeds was not significant between the various crop lines except in Tete at 3 WAP in Trial 2 with lower percentage stimulation, which might be probably due to low germinating stimulants produced by the crop lines. However, *Amaranthus* line Tete stimulated significantly higher germination of *Alectra* seeds than the other crop lines at 5 and 7 WAP in Trial 2 which indicated that the line produced more germination stimulants than the other crop lines at these stages of growth.

However, the percentage stimulation of the crop lines was higher at 5WAP, therefore with increase in age more of the germination stimulants was probably produced between 3 and 5 WAP. This is similar to the findings of Alabi *et al.* (2007) who reported that higher stimulation of *Striga* seeds germination from the root content of *Celosia/Amaranthus* lines at 3WAP than that obtained at 5 and 7 WAP. This is in conformity with Botanga *et al*. (2003) who reported that S. *hermonthica* seeds germination by trap crops was recorded with the roots of cotton obtained from three weeks old plant with precondition seeds of S. *hermonthica* for the same period.

SAMPEA 7 a susceptible cowpea variety that served as the positive control stimulated *Alectra vogelii* seeds germination significantly more than all the other *Amaranthus* lines tested, except in Tete and NH-493 with higher percent stimulation at 3 WAP in Trial 1 and 2 respectively than that of the control treatment. This can be an indication of the potential in these crop lines to serve as trap crop, particularly at that age.

Amaranthus line Tete and NH-48 were the two *Amaranthus* lines that closely followed SAMPEA 7 (shown clearly in combined ANOVA of the data) in stimulating *Alectra vogelii* seeds germination particularly at 5 and 7WAP. Along with these, all the *Amaranthus/Celosia* lines stimulated *Alectra* seeds germination significantly much more than the negative control (i.e. distilled water). Thus, this signify that, all the lines had the ability to stimulate the germination of *Alectra* seeds, and this prove that, the lines had chemical exudates in their root, which can enable them serve as trap crop and reduce the parasitic weed seeds in the soil.

The percentage germination of *Alectra* seeds by the tested lines at 3WAP, was between 11.66-12.00 (SAMPEA 7), 7.00-14.00 (*Amaranthus*/*Celosia*). And 1.13-1.38 Negative control (Distilled water). And at 5 WAP, 24.00-29.00 (SAMPEA 7), 6.66-17.66 (*Amaranthus/Celosia*) and 1.12-1.20 Negative control (Distilled water) and at 7 WAP, 13.00-20.00 (SAMPEA), 7.33-15.00 (*Amaranthus/Celosia*), and 1.11-1.22 (Distilled water) negative control. This is also similar to the findings of Alabi *et al*. (2007).

5.2 Pot Experiment

Pre-treating *Alectra* infected soil by growing *Amaranthus* lines before planting susceptible cowpea SAMPEA 7 reduced the emergence of *Alectra* in the soil infected with the parasitic weed seeds. The reduction of *Alectra* occurrence might probably be due to the root exudates from the *Amaranthus* lines earlier planted which could have caused suicidal germination of some of the seeds in the soil. Lagoke *et al*. (1997), Oswald *et al.* (1997) and Ariga *et al*. (1997), reported that, intercropping of maize with non-host crop improved soil productivity and reduction of *S. hermonthica* seed bank in the soil as a result of suicidal germination of *Striga* seeds by non-host. The soil pre-treated with medium *Amaranthus* population enhanced the good growth of the shoot fresh weight and root nodule number of cowpea plants. This probably might be as a result of the production of more stimulants that suppressed the emergence of *Alectra* seeds in the soil at this population than other *Amaranthus* populations. Girma *et al*. (2005) reported the potentiality of trap crop of maize (*Zea-mays*) and snap bean (*Phaseolus vulgare*) in reducing seed bank of *O. ramose and O. cernua* by 74% and 71% respectively.

High population of *Amaranthus* lines produced higher root fresh weight in cowpea plants in the pre-treated soil. This could probably be that the *Amaranthus* population produced higher germination stimulants which largely had reduced the *Alectra* seeds in the pre-treated soil. Olupot *et al*. (2001) reported the ability of trap crop *Celosia argentia (*Amaranthaceae) in reducing *Striga* emergence on *Sorghum* by 55%.

However, low population of *Amaranthus* lines gave a better growth of plant height of cowpea in the pre-treated soil of both trials. This might be as a result of both the effect of the germinating stimulants produced and the moderate number of *Amaranthus* plants in the pre-treated pots soils which reduced *Alectra* emergence. Parkinson *et al*. (1989) reported the effectiveness of soyabeans, cotton and bambara, groundnut, trapcrops in causing abortive germination of *Striga* seeds when grown in rotation with susceptible crop or as an intercrop. This will give way to the higher growth of the cowpea plant height.

Cowpea plants sampled from the negative control treatment (uninfected plants) generally produced better shoot fresh weight, root fresh weight, plant height and root nodule number than all the *Celosia/Amaranthus* population treatments among the uninfected cowpea plants. This indicates that in an *Alectra* free cowpea field, good growth of the cowpea variety and higher yield would be recorded as compared with that of the infected farm, which can seriously affect and reduce the growth of cowpea plants.

However, positive control treatment generally produced higher number of infected cowpea plants, indicating that the cowpea SAMPEA 7, is very susceptible to *Alectra*. The positive control treatment had the highest percentage number of attached and

emerged *Alectra* shoots. Dhanapal and Struik (2006), reported the effectiveness of trap crops in stimulating the seed germination of parasitic weeds, *O. cernua Loefl* in both the laboratory and glass-house experiment. The trap crops used strongly increased germination of the parasites.

Thus pre-treating soils by growing the *Amaranthus* lines in them before planting a susceptible cowpea variety SAMPEA 7 influenced the cowpea to produced higher yield than that observed from the untreated soils. Soil pre-treated with the low, medium and high populations of *Amaranthus* lines resulted in higher shoot fresh weight, root fresh weight, plant height and root nodule number when sampled.

However, the production of a good shoot fresh weight and root nodule number with medium population treatment and high population with better root fresh weight, while the low population that supported good plant height resulted in the production of higher grain yield which includes higher flower number, pod number, pod weight, total grain yield and 1000 seed weight.

The soil pre-treated with low and medium population of *Amaranthus* lines produced higher grain yield of cowpea variety SAMPEA 7, and this was probably because of the effectiveness of the crops lines in reducing *Alectra* seed bank in the soil. Kureh *et al.* (2000) reported the effectiveness of trap crop soyabeans to induce the germination of the parasite which lead to the production of higher head weight, 1000-seed weight of grain yield of *Sorghum* in a maize cultivated field infected with *Striga*.

CHAPTER SIX

6.0 Conclusion and Recommendations

6.1 Conclusions

1. In this study, it has been shown that *Amaranthus /Celosia lines* can induce *Alectra* seeds to germinate.
2. The SAMPEA7 had better germination% and growth than that of *Amaranthus* lines.
3. *Alectra* infected sampled cowpea plants from the high population treatment produced the lowest plant height, shoot fresh weight and root nodules number, but with the highest root fresh weight.
4. Cowpea plants under the negative control treatment generally produced higher higher shoot fresh weight, root fresh weight, plant height and root nodule number than the other treatments under the uninfected plants.
5. The cowpea plants from *Celosia/Amaranthus* pre-treated soil produced higher flower numbers, pod number, pod weight, total grain yield and 1000 seed weight than the controls, which indicates that the *Amaranthus* lines can be used as trap crop in the control of *Alectra vogelii*.
6. *Amaranthus/Celosia* lines caused suicidal germination of *Alectra* seeds and thereby could serve as trap crop for *Alectra vogelii*.

6.2 Recommendations

Farmers with serious infestation of *Alectra vogelii* on their farmland should use the low to medium population of *Celosia* and *Amaranthus* line Tete for the control of the parasitic weeds.

It is also recommended that more research work should be carried out to evaluate the mechanism of *Amaranthus* as trap crop in the control of parasitic weeds *Alectra.* parasitic weed.

6.3 Problems observed

- The growth of *Amaranthus* suffered in the absence adequate water supply.
- There was poor germination of cowpea seeds, when there was too much supply of water in the soil.
- Presence of insect (Aphids) on cowpea plants was observed.
- Presence of some birds and rodents was also observed at the germination and yield stages of cowpea plants.
- Disruption of electricity supply during the measurement of parameters in the Laboratory was often encountered.

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