Evaluation of Botanicals on the Control of *Alectra vogelii* on Groundnut (*Arachis hypogaea* L.) Varieties in Sudan Savannah of Nigeria

BY

ISAH MURTALA

(SPS/16/MAG/00011)

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DECLARATION

I hereby declare that this work is the product of my own research efforts undertaken under the supervision of DR. ABDULRAHAMAN LADO and has not been presented anywhere for the award of Msc degree certificate. All sources have been duly acknowledged.

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Isah Murtala Date

(SPS/16/MAG/00011)

CERTIFICATION

This is to certify that the research work for this dissertation and the subsequent write-up of this dissertation by ISAH MURTALA (SPS/16/MAG/00011) were carried out under our supervision.

________________________ ________________________

Dr. A. Lado Date
Supervisor

________________________ ________________________

Prof. I. B. Mohammed Date
Head of Department

APPROVAL

This dissertation entitled "Evaluation of Botanicals on the Control of *Alectra vogelii* on Groundnut (*Arachis hypogaea* L.) Varieties in Sudan Savannah of Nigeria" by Isah Murtala(SPS/16/MAG/00011) has been examined and approved for the award of Masters Degree in Agronomy

Date
(External Examiner)

Prof. A.A. MangaDate
(Internal Examiner)

Dr. A. Lado Date
(Major supervisor)

Prof. I.B. Mohammed Date
(Head of Department)

Dr. S. RufaiDate
(SPS Board Representative)

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DEDICATION

This work is dedicated to my father late Malam Murtala Haruna (My his soul rest in perfect peace Amin).

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ABSTRACT

A field experiment was conducted during 2018 rainy season at Bayero University Research Farm(11^0 57'N, $8^0$24'E) and Garko, in Garko local Government area, Kano state($22^0$11'N, $68^0$008'E). The objective was to evaluate the effectof botanicals on the control of *Alectra vogelii* on groundnut (*Arachis hypogaea* L.) varieties in Sudan Savannah of Nigeria. The experiment consisted of four (4) groundnut varieties (Kwankwaso, Maibargo, Sabaiya and Samnut 24) and five (5) plant botanicals (*Azadirachta* leaf powder, *Tamarind* leaf powder, *Ficus* spp leaf powder, *Parkia* fruit powder and control). These were factorially combine and laid out in a Randomized Complete Block Design (RCBD) replicated three (3) times. The gross plot was $9m^2$ while net plot size was $2.4m^2$. Data were taken on *Alectra* parameter (days to *Alectra* emergence, Number of *Alectra* infected stand , Number of *Alectra* per stand and *Alectra* dry weight) and crop parameters (establishment count, CGR, canopy height and spread, number of branches $plant^{-1}$, pod yield, kernel yield and 100 kernel weight). The results showed *Azadirachta* leaf powder significantly reduced number of Alectra infected by 71.4% in BUK and 59.5% in Garko compared to control plot. The varieties Sabaiya recorded the highest kernel yield per hectare in BUK (1253 kg ha^{-1}) and Garko (1284 kg ha^{-1}) while Sabaiya, Maibargo and Samnut 24 recorded the lowest number of Alectra per stand in both locations. Kwankwaso recorded the highest defoliation percentage at maturity. Ficus species leaf powder recorded the highest haulm yield while *Parkia* fruit powder and *Tamarind*leaf powder recorded the highest pod yield, kernel yield per hectare and 100 kernel weight respectively. Application of plant botanicals significantly reduced the *Alectra* infestation level. Thus the use of *Tamarind* leaf powder on Sabaiya was found to be effective on *Alectra* control and produced higher pod and kernel yield and can therefore be recommended in the study area for *Alectra* control.

CHAPTER ONE

1.0 INTRODUCTION

1.1BACKGROUND OF THE STUDY

Groundnut (*Arachis hypogaea* L.) is a leguminous oilseed crop cultivated in the semi-arid and subtropical regions of the world. It is grown in nearly 100 countries on six continents between 40^{o} N and S of the equator on nearly 24.6m ha, with a production of 41.3 m.t. and average yield of 1676 kg ha^{-1} in 2012(FAOSTAT 2014).China, India, Nigeria, USA and Myanmar are the leading groundnut producing countries in the world (Ajeigbe *et al.*, 2014). Asia, with 11.6 m ha (47.15%), and Africa, with 11.7 m ha (47.56%), had maximum global area under groundnut. Developing countries in Asia, Africa and South America account for over 97% of world groundnut area and 95% of total production. However, the yield ha^{-1} of Asia (2217 kg ha^{-1}) and Africa (929 kg ha^{-1}) are very poor as compared to Americans (3632 kg ha^{-1}) (Ajeigbe *et al.*, 2014).

Groundnut is usually grown as a smallholder crop in the semi-arid tropics under rainfed conditions. It is an important crop in many countries, especially in sub-Saharan Africa (SSA), where it is a good source of protein (25%-34%), cooking oil (48%-50%) and vitamins. The haulms are a good source of feed for livestock, especially during the dry season when fresh green grasses are not available. This serves as an additional source of income for farmers in the dry season when the fodder is in high demand. Groundnut improves soil fertility through nitrogen fixation, thereby increasing the productivity of other crops when used in rotation or in a cereal cropping system(Ajeigbe *et al*., 2014).The chemical composition of shelled groundnut is 11.7% CHO,30.4% protein, 47.7% oil, 2.5% fiber, 2.3% ash and 5.4% water (Hussain, 2011).

Groundnut or Peanut (*Arachis hypogaea*) is a major crop grown in the arid and semi-arid zone of Nigeria. It is grown for its nut, oil or its vegetative residue (haulms) and was recognized not only as a dietary supplement for children on protein poor cereals-based diets but also as effective treatment for children with protein related malnutrition(FAO,1994).It is the 13th most important food crop of the world and the 4th most important source of edible oil. Its seeds contain high quality edible oil (50%), easily digestible protein (25%) and carbohydrates (20%)(FAO,1994).In many countries groundnuts are consumed as peanut butter or crushed and used for the groundnut oil or simply consumed as a confectionary snack roasted, salted or in sweets. In other parts of the world they are boiled, either in the shell or unshelled (FAO,1994).

A botanical is a plant or plant part valued for its medicinal or therapeutic properties and used for a long time for pest control (U.S, 2011). The use of plant botanicals on pest control offer many environmental advantages. However, their uses during the 20th century have been rather marginal compared with other biocontrol methods of pests and pathogens. Improvement in our understanding of plant allelochemical mechanisms of activity offer new prospects for using these substances in crop protection. We examine the reasons behind their limited use and the actual crop protection developments involving plant allelochemicals, namely: (i) formulations including bio pesticides of plant origin for organic or traditional agricultures, and (ii) improvement of plant resistance to pathogens through identification of genes coding for allelochemicals and stimulation of natural passive and active defenses of the plant (Pau France and Bernard, 2008).

Treating the planting holes with *Azadiractha indica* seeds powder,*Azadiractha indica* leaf powder *Eucalyptus* spp leaf powder, *Anacadium occidentale* leaf powder, *Tamarindus indica* leaf powder and *Carica papaya* leaf powder delayed Alectra emergence, reduced number of Alectra shoot and number of plants infested, reduced injury score, delayed flowering and gave higher cowpea seed yield. (Shinggu, 2015).Use of sorghum, sunflower and sugar beet water extract has been reported for weed control in wheat. These extracts increased wheat height, ear number, seed number, biological and grain yield. Application 10 L/ha plant extract solely increased grain yield of wheat by 17.8% in comparison to weedy check (Hamid and Mohammed, 2013) The botanical family of Asteraceae (*Artemisia annua* and *Xanthium strumarium*) are source of natural herbicides(Stefano *et. al*,. 2017).

1.2 PROBLEM STATEMENT

The low productivity of groundnut in African countries may be attributed to use of low-yielding varieties, weed competition, poor adoption of agronomic practices and limited extension services (Ajeigbe *et al*., 2014) Compared to 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 *Alectra* control measures that can be accepted and used by subsistence farmers. (Parker and Riches,1993)

Alectra vogelii, is the major constrains to the production of groundnut, cowpea and other leguminous crops in sub-Saharan region of Africa, and its presence can result into total crop failure (Shinggu, 2015).Yield losses of 15% are reported for peanut production in Nigeria and up to 30 to 50% reduction in Bambara nut yields in south Africa (CABI, 2019). *Alectra vogelii* imposes an additional stress to groundnut farmers who have little capacity for investment in crop production (Karanja *et al.*, 2013). It is intimately involved with the host and have so much metabolic overlap with the host that differential treatments are very difficult to develop and make its control difficult. In some cases, the A. *vogelii* are closely associated to the host root, concealed underground, and undiagnosed until they irreversibly damage the crop (Neeraj, 2014).

1.3 JUSTIFICATION OF THE STUDY

The use of synthetic herbicides has negative environmental effect on soil properties, chemistry, and a microbial population. Herbicides can have direct toxic effects on soil fauna, herbicides typically affect these organisms indirectly via removal of aboveground vegetation and through changes to soil decomposer community structure and reductions in nutrient cycling. The use of herbicide in weed control reduce the growth and function of *mycorrhizal*, which increase the ability of plants to absorb and translocate nutrients. The herbicides and application equipment's are much cost and unavailable (Bill Freedman, 2011).Therefore, the use of botanicals may become environmentally friendly, more affordable and cost-effective method for the control of these parasitic weeds, since the plant materials used are widely available and at no or minimum cost. This method will not only eliminate the need of application equipment, but will also reduce the cost of production and increase yield (Shinggu, 2015). Most of the groundnut varieties are susceptible to *Alectra* inversion. Therefore, identifying the tolerant variety will increase yield and information obtain will also useful for breeders in developing the *Alectra* resistance variety (Justine *et al.*, 2009).

1.4 OBJECTIVE OF THE STUDY

The objectives of the study are:-

1. To evaluate the efficacy of plant botanicals (Plant materials) on *Alectra vogelii* control.
2. To evaluate the effect of botanicals on growth, yield component and yield of groundnut.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ALECTRA BIOLOGY

Alectra vogelii is a parasitic plant belonging to the family *Orobanche*, is a hemi parasite that derives its water and nutrients from roots of its host plant (Magani *et al*., 2008). it is an Annual herb, 20–50 cm high; stems erect, simple or with several branches arising from the base or above (Ghazanfar *et al.*, 2008). Base of stem and roots are orange-yellow. , bright orange stems attached to host roots. Leaves: 1.5- 3.5 cm long, 0.3 to 1.5 cm wide, very hairy with variable shape (Visser, 1978). Flowers are solitary in the axils of leaf-like bracts; flowers bell-shaped, pale yellow, sometimes with three deep red veins. Fruits: Withered flowers covering developing round capsule (5 mm when mature).Seeds: Tiny and dust-like; high seed production and long lived seed (CABI. 2016). Corollas are yellow with purple veins (Ghazanfar *et al.*, 2008) produces up to 600,000 seeds per plant (Visser, 1978), its seed is extremely small and remains viable for more than 10 years (Mwaipopo, 2014; Visser, 1978). It is spread in livestock forage (Berner et al., 1994), and it is likely to be spread in contaminated crop seed, on agricultural equipment and vehicles, and in mud on livestock (Parker and Riches, 1993).

So far *A. vogelii* has been the major constraint known to attack leguminous species (Parker and Riches, 1993). Cowpea is the major crop host of *A. vogelii* throughout its range, Bambara, groundnuts, common bean, soyabean, mung bean, and tepary beans are also common hosts. There have been occasional reports of infestation of chickpea and runner bean. Pigeon pea is the only widely grown grain legume which is not parasitized (Parker and Riches, 1993). Host range tests by Riches *et al*.

(1992), indicate that populations from Mali, Nigeria and Cameroon can attack groundnut and cowpea.

A. vogelii is always associated with the cultivation of leguminous crops, on which it is parasitic, in semi-arid savannah areas of sub-Saharan Africa (CABI, 2012). *A.vogelii* 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 hypogea* L.) and common bean (*Phaseolus vulgaris* L.). *A. vogelii* is distributed throughout semi-arid areas of tropical and sub-tropical Africa. (Parker and Riches 1993).

A. vogelii is largely dependent on annual cropping and environmental requirements mirror. The parasite is most commonly found in areas of mono-modal rainfall with a long dry season (CABI, 2012). Host crops are largely associated with free-draining sands and sandy-loams. (Caps, 2009)

2.2 METHOD OF ALECTRA CONTROL

Compare with non parasitic weeds, Elzein and Kroschel (2001) reported that, the control of parasitic weed such as *Striga* and *Alectra* has proved to have exceptional difficulty. However, several control method have been tried for control of parasitic weed such as *striga* and *Alectra* including cultural and mechanical such as crop rotation, trap crop and catch cropping, fallowing, hand-pulling, nitrogen fertilization, time and method of planting, intercropping and mixed cropping, other control method include chemical (herbicides, artificial seed germination stimulants), use of resistance varieties and biological control (Parker and Riches, 1993).

2.2.1. Cultural method of Alectra Control

A number of cultural practices including delayed sowing, hand weeding, no-tillage, nitrogen fertilization, intercropping, or rotations can contribute to seed bank demise (Diego and Monica, 2012). Two options, catch and trap-cropping are available for reducing the size of the *Alectra vogelii* seed bank in the soil. Catch-crops are susceptible species which are ploughed in or harvested after parasite attachment but before emergence and seed production (Hattingh, 1954). The use of trap crops offers the advantage of stimulating parasitic weed seed germination without being parasitized, contributing to seed bank depletion (Rubiales and Fernández-Aparicio, 2012). Groundnut and pearl millet genotypes caused effective suicidal germination of A. vogelii seeds and therefore can be used as trap crops in Integrated Weed Management Program (Clivan *et al.*, 2017).

However, (Parker and Riches, 1993). Reported that, in a season of good rainfall, a quick-maturing crop of sunflower could then be grown with cowpea planted again the following season, similarly. Trap-crops produce the Alectra germination stimulant in their root exudates but are not susceptible to attack by the parasite seedlings. Therefore, grain or fodder cultivars of peal millet and bambara, which is not attacked by the local biotype of the parasite, are potent stimulators of A. vogelii germination. These can be used in rotation to cause suicidal germination of the parasite and hence reduce the number of seed in the soil. Grenz *et al.*, (2005) reported that, rotation may have direct and indirect impacts on parasitic weed in infested areas. While trap- and catch-crops in rotation may reduce to some extent the parasite seed bank in soil, other rotation crops may have allelopathic effects on parasitic weed seeds.

Crop rotation with trap crops has long proposed and practiced as control measures for parasitic weeds (Kroschel, 2001). Similarly, delay in the sowing, soil solarization and sterilization can be use to control parasitic weed (Joachim *et.al.*, 2005). Audu, (2003), reported that *Celosia /Amaranthus* lines can be use as trap crops to control *Alectra vogelii* (Benth) on cowpea. This is because *Celosia* and the *Amaranthus* lines caused suicidal germination of Alectra seeds and therefore could serve as trap crop for *Alectra vogelii.*

Nitrogen in ammonium form affects negatively root parasitic weed germination (Van Hezewijk and Verkleij, 1996) and/or elongation of the seedling radicle (Westwood and Foy, 1999). Karanja et al., 2012 reported the use of Farm yard manure to reduce the virulence of *Alectra vogelii* (Benth) on cowpea (*Vigna unguiculata*). Therefore, farm yard manure application is advantageous in reducing the effect of *Alectra* parasitism on cowpea.

Nitrogen fertilization and poultry droppings ameliorating the effect of *Alectra vogelii* on the performance of groundnut (*Arachis hypogaea* L.). Applications of 25 and 50 kg Nha^{-1} reduced incidence significantly, while application of 5.0 tonnes of poultry droppings ameliorated parasitism in groundnut by increasing groundnut kernel yield (Yohanna, 2014). He further reported the effectiveness of nitrogen and phosphorus in reducing the virulence of *Alectra* parasitism on groundnut (*Arachis hypogaea* L.). A number of cultural practices including delayed sowing, hand weeding, no-tillage, nitrogen fertilization, intercropping, or rotations can contribute to seed bank demise (Diego and Monica, 2012).

Cultivation of the soil can strongly affect the parasitic weed seed bank. Minimum tillage can contribute to parasitic weed control by reducing the amount of viable seeds incorporated into the soil (Ghersa and Martínez- Ghersa 2000). On the other hand, deep-ploughing has been recommended to bring the seeds into a depth, where they cannot germinate due to the lack of oxygen (Van Delft *et al.*, 2000),

2.2.2 Preventive method of Alectra control.

Both sanitation and quarantine are required in order to prevent the dispersal of seeds (Panetta and Lawes 2005). Diego and Monica (2012) reported that, hand pulling and destruction of emerged stems before flowering may be useful where infestations are limited in extent, to prevent seed production and an expansion of area infested. However, Beck (1987) noted that, prompt ploughing of crop residues after harvest will prevent continue seed production as host plants continue to grow on residual moisture.

Preventing the movement of weed seeds into uninfested areas is a crucial component of control. Seed bank demise can be achieved by fumigation and solarization. However, this method is not economically feasible for low-value and low-input legume crops (Diego and Monica 2012). Extermination of seeds before their spread to new fields and regions is a crucial component in parasitic weed prevention program (Panetta and Lawes, 2005). Quaternary ammonium salts have been found effective in seed eradication with complete seed kill achieved under commercial conditions at 0.5% a.i. of the disinfectant didecyl dimethyl ammonium bromide (Rubiales and Fernández-Aparicio, 2012).

2.2.3. Biological Method of Alectra Control

Biological control of weeds with insects and microbial agents means the utilization of living organism to reduce weed densities. Biological control especially using insect and fungal antagonists against parasitic weed, has gained considerable attention in recent years and appear to be promising as viable supplement to other weed control method (Kambou *et al.,* 1997). Because of close interconnection between the parasitic weed and its host, herbicidal control is difficult the herbicides cannot selectively distinguish between the species. The high specificity of many organism (fungi, bacteria, arthropods), feeding exclusively on selected hosts, in our case parasitic weeds, can be considered an advantage because these organism may work as bio control agents where other weed control option have not work (Joachim *et. al*., 2005).

Numerous microorganisms that might be useful for bio-control of parasitic weeds have been isolated and reported (Diego and Monica, 2012). The fungal isolates reported to be pathogenic to parasitic weeds are for the most part *Fusarium* spp., prevailing especially strains of F. *oxysporum Schlecht*.: Fr.. Advantages of *Fusarium* spp. relate to their host specificity and longevity in soil (Amsellem *et al*., 2001; Boari and Vurro, 2004; Sauerborn et al., 2007; Zermane *et al*., 2007).

Some compatible *Rhizobium* strains have been reported to decrease O. *crenata* infections in pea by activation of oxidative process, LOX pathway and production of possible toxic compounds, including phenolics and pisatin, inhibiting germination of O. *crenata s*eeds and causing a browning reaction in germinated seeds (Mabrouk *et. al.,* 2007). Colonisation by the nitrogen-fixing bacterium *Azospirillum brasilense* has also been reported to inhibit germination and radicle growth of P. *aegyptiaca* (Dadon *et al.,* 2004). Also colonization by *Arbuscular mycorrhizal* fungi can provide protection against parasitic weeds as reported in cowpea reducing germination of S. *gesnerioides* (Lendzemo *et al.,* 2009) or in pea reducing 15 germination of various *Orobanche* and *Phelipanche* species (Fernández-Aparicio *et al.,* 2010).

Most of the insects reported to occur on root parasitic weed species are polyphagous without any host specificity and thus, damage to these parasitic weeds is limited (Klein and Kroschel, 2002). However, for biological control only oligo- and mono-phagous herbivorous Smicronyx spp. has potential for *Striga* seed reduction (Kroschel *et al*., 1999). *Phytomyza orobanchia* Kalt. is a fly monophagous on broomrape. The feeding of the larvae within the capsules markedly diminishes seed multiplication of the parasite (Klein and Kroschel, 2002). P. *orobanchia* is widely distributed in the broomrape infected area, eating a substantial number of seeds (Rubiales *et al*., 2001),

2.2.4 Chemical Method of Alectra Control

Agrochemicals have been conventionally used to manage agricultural fields and continue to be valid today. Extensive efforts are being made to develop novel methods for selective control of root parasitic weeds. In present review, strategies to control root parasitic weeds by using conventional herbicides and natural growth inhibitors, the so called suicidal germination stimulant (Atsushi and Takatoshi, 2015).

Herbicides for the control of root parasitic weeds, which are characterized by long underground developmental stages, may be applied pre – or post – emergence to the crop but should always be pre-emergence to the parasites (Garcia *et. al.*, 1992). However, lack of application technology, marginal crop selectivity, low persistence and availability as well as affordability are the major constraints that limit the successful usage of herbicide in developing countries where subsistence farmers constitutes the majority (Odhiambo and Ransom, 1997).

In the control of *Orobanche crenata*, Garcia *et al.*, (1992) reported effective control of the parasitic weed with imazaquin at 0.80 kg a.i/ha. The potentials of controlling of *Alectra vogelii* by treating the seed of cowpea with the herbicide imazaquin before planting has been demonstrated but this practice has not been commercialized (Berner *et al*,. 1994).

According to Magani and Lagoke (2008), several pre and post–emergence herbicides were evaluated for the control of Alectra vogelii. Pre–emergence herbicide application of the mixtures containing (metazachlor + antidote), followed by imazaquin at 0.18kg a.i/ha resulted in significantly lower number of infected plants, pendimethalin plus imazaquin at 0.87+0.15 and 1.09 + 0.19 kg a.i/ha and pendimethalin plus imazethaphyr at 1.58+0.12kg a.i/ha, followed by imazaquin at 0.18kg a.i/ha, resulted in lower number of cowpea plants infected by Alectra compared with the weedy check.

As reported by Magani and Lagoke, (2008), that in a repeated trial, all pre-emergence herbicide mixtures containing pre (metazachlor + antidote) as well as pendimethalin plus imazaquin at 0.87 + 0.15 kg a.i/ha and 1.09 + 0.19 kg a.i/ha; Pendimethalin plus imazethapyr at 1.58 + 0.12 kg a.i/ha all followed by imazaquin at 0.18 kg a.i/ha resulted in low number of plants infected and Alectra shoot count and number of plants infected with consequent increase in cowpea grain yield. So also, in the control of *Orobanche crenata,* Garcia *et al.* (1998) reported effective control of the parasitic weed with imazaquin at 0.80 kg a.i/kg. However, early sowing coupled with high yield cropping systems, which are normally subject to heavy and lasting parasite infestations, would require a combination of pre- emergence and post-emergence treatments.

In a study to develop cowpea seed treatment for control of both *Striga gesnerioides* and *Alectra vogelii,* a five minute seed soak in solutions of 3.6 - 7.2ml/g of imazaquin reduced parasite attachment by 90% in comparison to untreated controls (Berner *et al.,* 1993). The highest pod weight and consequently cowpea grain yield were obtained with pendimethalin plus imazaquin at 1.09 + 0.19 kg a.i/ha followed by SHW and pendimethalin plus imazethapyr at 1.58 + 0.12 kg a.i/ha followed by SHW in 2003 and 2004. The yields of pree (Metazachlor + antidote) and imazaquin treatments for Alectra control were generally lower than those of pendimethalin containing mixtures of pendimethalin plus imazethapyr at 1.58 + 0.12 kg a.i/ha followed by SHW, although the former had fewer plants infected and less Alectra shoot count (Berner *et al.,* 1993).

The use of pre-emergence and post- emergence herbicides was to act as both barriers to prevent Alectra emergence and Alectra seed production respectively (Magani and Lagoke, 2008). Pree (Metazachlor + antidote) had lower number of plants infected and Alectra shoot count, (Magani and Lagoke, 2008). Seed treatments with Imidazolinone have proven to be effective controlling O. crenata in faba bean and lentil (Jurado-Expósito *et al*., 1997) and S. *gesnerioides* and A. *vogelii* in cowpea (Berner *et al*., 1994).

Application of germination stimulants to induced suicidal seed germination of parasitic weed (such as *Alectra)* appears attractive way of managing parasitic weed. However, the result achieved in Kenya was only 50-60 percent reduction of the seed bank (Egley et al., 1990). Alectra seeds require chemical stimulation from the host root to germinate. This suggests that the artificial use of suitable chemicals may reduce the parasitic weed seed bank by stimulating seeds germination in the absence of a suitable host, which should lead to their demise due to their inability to survive without nutritional supply by a host (Johnson *et al.* 1976). Several classes of plant secondary metabolites are known to induce seed germination of root parasitic weeds (Yoneyama *et al.,* 2008).

2.2.5 Use of Resistance Varieties to Control Alectra

Host plant resistance would probably be the most feasible and potential method for parasitic weed control. Using biotechnological approaches significant progress has been made in developing screening methodologies and new laboratory assays, leading to the identification of better sources of parasitic weed host resistance (Ejeta *et al.,* 2000; Haussmann *et al.,* 2000; Omanya, 2001). Using resistance varieties is potentially an easy, effective and economical method of controlling Alectra vogelii. (Ngwako and Mashungwa, 2011).

Resistance to *Alectra* was discovered after screening more than 650 cowpea accessions. Landraces B301 and B359 appeared to be particularly useful (Riches, 1987). It is important to notice that landrace B301 is resistant to both S. *gesnerioides* and A. *voguel*ii, being resistance to each weed conferred by independent non-allelic genes (Atokple *et al*., 1993). Lack of Alectra emergence was observed in the variety B301 and IT97K-499-35 and the earlier was prove to be resistance and the later was the tolerant varieties (Kutama *et al.,* 2014).

The genetic basis of resistance to S. gesnerioides and A. *vogelii* parasitism has been examined by a few laboratories. Single genes conferring resistance to S. gesnerioides named Rsg genes (Ouédraogo *et al*., 2001; Li *et al*., 2009) or to A. vogelii named Rav genes. Atokple *et al.,* (1993) have been reported molecular markers linked to Rsg1-1, Rsg2-1, Rsg3-1, Rsg 4-3 and Rsg994-1 genes for S. gesnerioides resistance have been identified and several sequence-confirmed amplified regions (SCARs) have been developed 24 for use in marker-assisted selection (Ouédraogo et al., 2002; Li *et al*., 2009). Markers linked to A. vogelii resistances are being sought (Kouakou *et al*., 2009)

Field and screen house trials were conducted at Samaru in the northern Guinea savanna ecological zone of Nigeria to evaluate the reaction of 36 groundnut (*Arachis hypogaea* L.) genotypes to artificial inoculation with *Alectra vogelii* (Benth.). Two out of the 36 groundnut genotypes screened ISG NIG 701 and SAMNUT-18, exhibited low pod yield reduction in the screen house and hosted low to moderate *Alectra* shoot number in both the field and screen house. These genotypes therefore appeared to be moderately resistant to Alectra.(Yohanna *et al.,* 2010).

Two other genotypes, ISG NIG 174 and SAMNUT-11 which had very low pod yield reduction in the screen house and moderate to high Alectra shoot population in the screen house as well as the field could be regarded as being tolerant to *Alectra* (Yohanna *et al.,* 2010). Groundnut genotypes, ISN NIG 858, ISG NIG 251, ISG NIG 826, ISG NIG 200B and ISG NIG 222 which had less pod yield reduction than ISG NIG 174 and SAMNUT-11 and supported moderate to high number of *Alectra* shoots both in the field and screen house were considered to be moderately tolerant to *Alectra* (Yohanna *et al.,* 2010). Other groundnut genotypes supported high Alectra shoots in both the field and screen house and had high pod yield reduction in the screen house and were therefore highly susceptible to Alectra parasitism (Yohanna *et al.,* 2010). Kureh *et al.,* (1996) reported the response of 22 soybean genotypes to Alectra infestation. Result revealed that SAMSOY2 and TGX1485-1D that significantly supported high numbers of Alectra recorded grain yields similar to those of genotypes that supported few or no Alectra.

Cowpea varieties (IT97K-499-35, IT98K573-1-1, IT03K-338-1, IT98K-205-8 and UAM 11D, 24-55-3) were confirmed resistant to *Alectra,* while The Gazum, Banjar, Borno brown, and TVX3236 were found to be very susceptible to *Alectra* ; while IT84S-246-4 and IT98KD-391 recorded moderate infestation of *Alectra* (Itta *et al.,* 2014). Karanja *et al.*, (2013) reported significant differences observed amongst cowpea genotypes on days to first Alectra emergence, number of Alectra shoots emerged at 6, 8, 10 and 12 week after planting and grain yield. Cowpea genotypes Kir/Nya-005 and Mbe/Mach-022 showed complete resistance to Alectra while Ken-Kunde, M66 and K80 supported the highest number of Alectra shoots.

Phiri *et al.* (2018) reported that IT82E-16 and Sudan 1 shared Alectra earlier infested while late on IT99K-7-21-2-2XIT82E-16 (38 days) which correlated to the number of Alectra attachments. Mkanakaufiti shared no Aletra while the IT99K-7-21-2-2XIT82E-16 had Alectra shoots infestation. So also Phiri *et al.* (2018) reported that number of pods, grain weight (g) and harvest index per pot were significantly affected by inoculation protocol with lower yield on infested cowpea genotypes. The same trend was observed on cowpea varieties where Mkanakaufiti (21.9 g/pot) shown higher yield followed by IT82E-16 (12.5 g/pot) which is susceptible but with tolerance ability to the parasitic weed (Phiri *et al.* 2018) .

MBwando (2015), identify the type of gene action controlling the trait for resistance to Alectra *vogelii* in cowpeas and its heritability. Seven genotypes of cowpea were mated in half diallel and their F2 progeny including parents were evaluated for reaction to *Alectra vogelii* infection. Thus indicating that both additive and non-additive gene actions influenced the trait for resistance to *Alectra* emergency and infestation with additivity being predominant. Narrow sense heritability estimates were found to be 0.41 and 0.44 respectively.

Indirect breeding for resistance or tolerance to *Alectra* infestation can endeavor to screen or breed for cultivars with high number of pod. The finding on Baker's ratio means crossing carefully selected genotypes with resistance gene followed by selection at early segregating generation is the best method for improving this trait for resistance to *Alectra vogelii* in cowpea (MBwando, 2015).

2.2.6 Organic Method of Alectra

The use of plant products especially *Azadiractha indica* seed powder, *azadiractha indica* leaf powder, Eucalyptus spp. Leaf powder, *Anacadium occidentale* leaf powder, *Tamarindus indica* leaf powder and *Carica papaya* leaf powder have been reported to significantly control parasitic weeds such as Alectra vogelii (Shinggu, 2015). Kambou *et al.*, (1997) reported the use of parkia products (*Parkia biglobosa*) powder to control S. *hermonthica*. Germination inhibition of 97 – 100% and 92% when untreated powder extract and decorticated powder of parkia were used respectively. 29.1 and 38.8% reduction of striga emergence under a field and screen house conditions when fruit and fruit powder of parkia were used, respectively. (Marley *et al*., 2004). Yonli et al., (2010) concluded a study to evaluate the allelophathic properties of endogenous plant species against S. *hermonthica* (Del) Benth and reported that parkia biglobosa peels completely inhibited striga seed germination. Magani et al., (2010) reported great advantages in using *Parkia* based products as pre-sowing treatments and there after followed post emergence application of 2-4 D or Triclopyr (herbicides) at the rate of 0.3kg ai/ha to control S. *hermonthica*.

Use of plant extract solely of sorghum, sunflower, sugar beet and safflower reduced weeds number and dry weight in wheat (Hamid and Mohammed, 2013) further more Hamid and Mohammed (2013) added that application of 10L/ha plant extract also, increased wheat height, ear number, seed number, biological and grain yield by 17.8%. The botanical family of Asteraceae (*Artemisia annua* and *Xanthium strumarium*) are source of natural herbicides (Stefano *et. al,.* 2017). Twenty Asteraceae species were collected during flowering time and evaluated in terms of the yield and quality of essential oils (germination inhibition and growth of weeds). Half the species showed a sufficient yield of essential oil (from about 0.1% to 1.43%) when testing these phytochemicals in vitro as germination inhibitors of two typical weeds, *Amaranthus retroflexus* and *Setaria viridis.* Despite the higher tolerance of S. viridis, the concentration of 100 mg L^{-1} of essential oils of the two Artemisia species and *Xanthium strumarium* could totally inhibit germination. After spraying the weeds at different concentrations (10, 100 and 1000 mg L^{-1}) during two different phenological stages of weed seedlings (cotyledons and the third true leaf), the essential oils of Artemisia annua and X. strumarium showed the best performance (Stefano *et al.,* 2017).

2.2.7 Integrated Method of Alectra Control

Once a field is infested with parasitic weeds such as Striga and Alectra, controlling its seed production is very difficult. The only effective way to cope with parasitic weeds is to apply an integrated approach (Diego and Monica, 2012). bio-control with P. *orobanchia* can be helpful to slow down further dissemination and infestation in weakly infested areas, and can be part of an integrated control approach to reduce the seed bank in heavily infested soils. This effect could be substantially increased by massive propagation and inundative release of this insect (Klein and Kroschel, 2002). However, Garcia *et al.* (1992) reported that, early sowing coupled with high yield cropping systems, which are normally subject to heavy and lasting parasite infestations, would require a combination of pre- emergence and post-emergence treatments. Manure application(16 t/ha), hand pulling and trap crop upon control Alectra vogelii using susceptible cowpea variety K80A (Bagnaii – Oakeley, *et al.*, 1991).

2.3 EFFECT OF PLANT BOTANICALS ON WEED CONTROL

A botanical is a plant or plant part valued for its medicinal or therapeutic properties; botanicals have been in use for a long time for pest control (U.S, 2011). Clivan *et al.,* (2017), reported that, study was conducted to evaluate the effect of root exudates from cowpea, groundnut, maize, sorghum and pearl millet genotypes on the germination and attachment of *Alectra vogelii. Parkia* fruit powder reduce the number of S. *gesnerioides* parasitizing cowpea and this implies that there will be depletion of striga seed bank build up for future infestation, thereby ensuring control of striga over time (Fatima, 2017).

The use of aqueous extract of botanicals (*Cyperus rotundus*, *Echinochloa colona leaf, Bambusa vulgaris leaf* and shoot, *Cucumis sativus l*eaf, *Xanthium strumarium* leaf extract) at @ 100ml per 1 lit water as a pre-emergence application alone with mechanical weeding at 30 DAT(days after transplanting) of rice had significant influence on weed control efficiency, weed control index, (Gayati and Mahadev, 2019). Suitable botanicals having weed suppression characters under puddled condition. Six botanies viz ., *Abutilon indicum, Trichoderma indicum, Cassia auriculata*, *Parthenium hysterophorus, Jatropha gossypifolia, Lantana camara* were incorporated a three application rates viz ., 5, 7.5 and 10 t ha^{-1}. The study revealed that *Lantana camara*, *Parthenium hysterophorus* and *Cassia auriculata* incorporation each at 10tha-^{1} significantly reduced the weed density and weed dry matter production and showed better weed control efficiency over other treatments (Prabukumar and Athayakumar, 2006).

Treating the planting holes with *Azadiractha indica* seeds powder, *Azadiractha indica* leaf powder *Eucalyptus* spp leaf powder, *Anacadium occidentale* leaf powder, *Tamarindus indica* leaf powder and *Carica papaya* leaf powder delayed Alectra emergence, reduced number of Alectra shoot and number of plants infested, reduced injury score, delayed flowering and gave higher cowpea seed yield. The results show that using botanicals for the control of Alectra in cowpea reduce negative impact on the crop. (Shinggu, 2015). The botanical family of Asteraceae (*Artemisia annua* and *Xanthium strumarium*) are source of natural herbicides (Stefano *et. al.,* 2017).

Twenty Asteraceae species were collected during flowering time and evaluated in terms of the yield and quality of essential oils (germination inhibition and growth of weeds). Half the species showed a sufficient yield of essential oil (from about 0.1% to 1.43%) when testing these phytochemicals in vitro as germination inhibitors of two typical weeds, *Amaranthus retroflexus* and *Setaria viridis* (Stefano *et al.,* 2017). Despite the higher tolerance of S. viridis, the concentration of 100 mg L^{-1} of essential oils of the two Artemisia species and *Xanthium strumarium* could totally inhibit germination. After spraying the weeds at different concentrations (10, 100 and 1000 mg L^{-1}) during two different phenological stages of weed seedlings (cotyledons and the third true leaf), the essential oils of Artemisia annua and X. strumarium showed the best performance (Stefano *et al.,* 2017).

The use of aqueous sorghum extract solely reduced number and dry weight of weeds and increased wheat yield and yield components. While application of 10 L/ha aqueous extract solely causes 17.8% increase in wheat yield in comparison to weedy control (Hamid and Muhammad, 2013).

2.4. EFFECT OF PLANT BOTANICALS ON GROUNDNUT YIELD.

Investigation was conducted to examine the 8 treatments along with control to study about their effect of seed treatments with botanical, chemical, on seed yield and quality traits in groundnut (*Arachis hypogea* L.) Highest per plant yield was also recorded from individual application the Neem leaf extract solution (5%) with soaking duration six hours and calcium chloride (CaCl2) 2% solution on soaking duration 12 hours gave best performance respectively in decreasing order (Sanoj, *et al.*,2017). Bamsida, *et al.,* (2016) reported that the use of leaf powder of *Cassia fistula, Azadirachta indica, Cassia siamea*, particularly their mixtures have significant control on the population of *Meloidogyne incognita* and results to better growth of groundnut. The findings indicate that controlling root knot nematode (*Meloidogyne incognita*) with leaf powder is a potential variable venture. The efficacy of powders of plant parts from *Azadirachta indica, Lawsonia inermis, Annona senegalensis* and *Hyptis suaveolens* at 10 , 15 and 20g/250g seed was tested against the storage pest *Tribolium castaneum* (Herbst) in groundnut in the laboratory. (Sriniyas *et al.,* 1997).

The influence of *Aspergillus flavus* on groundnut seed quality was evaluated by artificial inoculation. The fungal infection reduced protein by 1.35% but increased fat and carbohydrate content of groundnut seeds by 0.62% and 0.86% respectively (Caroline, 2011). Shinggu *et al.,* (2015) reported that treating planting hole with *Azidiractha indica* seed and leaf powder, *Eucarlyptus* spp. Leaf powder, *Tamarindus* indica leaf powder*, Anacadium occidentale* leaf powder and *Carica papaya* leaf powder reduce cowpea reaction score to *Alectra*, took longer days to 50% flowering and give higher cowpea seed yield.

2.5 EFFECT OF VARIETY ON METHOD OF ALECTRA CONTROL.

Two out of the 36 groundnut genotypes screened on *Alectra* parasitism, ISG NIG 701 and SAMNUT 18, exhibited low pod yield reduction in the screen house and hosted low to moderate *Alectra* shoot number in both the field and screen house. These genotypes therefore appeared to be moderately resistant to *Alectra*. Two other genotypes, ISG NIG 174 and SAMNUT 11 which had very low pod yield reduction in the screen house and moderate to high *Alectra* shoot population in the screen house as well as the field could be regarded as being tolerant to *Alectra*. Groundnut genotypes, ISN NIG 858, ISG NIG 251, ISG NIG 826, ISG NIG 200B and ISG NIG 222 which had less pod yield reduction than ISG NIG 174 and SAMNUT 11 and supported moderate to high number of *Alectra* shoots both in the field and screen house were considered to be moderately tolerant to *Alectra* (Yohanna *et al.,* 2010).

Alectra emergence showed that Gazum local, TVX3236, Banjar and Borno brown supported significantly the earliest emergence of *Alectra* ; while the genotypes IT89KD-373-1- 1 and IT84S-246-4 delayed the emergence of Alectra by 6 and 4 days , (Itta *et al.,* 2014) . Kernel yield had positive correlation with vegetative characters; which were plant height, crop vigour and haulm yield. This shows that the vegetative performance of groundnut has great effect on its kernel yield. (Yohanna, 2014).

22 soybean genotypes evaluated on *Alectra* infestation revealed that Sixteen soybean genotypes supported few or no *Alectra* shoots while six were susceptible. (Kureh *et al.,* 1996) Itta *et al.,* (2014). Evaluate the reactions of cowpea genotypes to *Alectra* infestations. The treatments consisted of eleven cowpea genotypes five

varieties (IT97K-499-35, IT98K573-1-1, IT03K-338-1, IT98K-205-8 and UAM 11D, 24-55-3) were confirmed resistant to *Alectra* in the study area. The Gazum local variety, Banjar, Borno brown, and TVX3236 were found to be very susceptible to *Alectra*; while IT84S-246-4 and IT98KD-391 recorded moderate infestation of *Alectra.*

2.6. EFFECT OF VARIETY ON GROWTH AND YIELD OF GROUNDNUT.

Hussain, (2011), reported that, all the cultivated varieties can be classified in to two groups; those from an erect plant and the crawling type, almost all the commercial varieties belong to the first group (Media,1999). In Nigeria, also there are main growth from, bunch and runner. Bunch types grow upright, while the runner types grow near the ground. Ajeigbe *et al.,* (2014). Reported that bunch types cultivars grow erect, pod are clustered around the base of the plant and mature at almost the same time, the pod and kernel are small and individual plants are not productive, thus, harvesting is easier and better suited for inter row cultivation. Samnut 24 an bunch type is an early-maturing (80-90 days), good haulm yield (2.5-3 t ha-1), vigorous plant growth, good yield (2-2.5 t ha-1) and high oil content (53%).

While the runner or spreading type as reported by Hussain (2011) that cultivars belonging to the group that pegs are distributed to the basal to the terminal region of the branches or occur in cluster along these branches, up to 40cm from the base of the plant and are generally very reproductive and have large kernels

2.7 EFFECT OF INTERACTION BETWEEN VARIETY AND PLANT BOTANICALS IN GROWTH AND YIELD OF GROUNDNUT.

Highest per plant yield was also recorded from individual application the Neem leaf extract solution (5%) with soaking duration six hours and calcium chloride (CaCl2) 2% solution on soaking duration 12 hours were gave best performance respectively in decreasing order. All of the treatment found were significantly increased the yield and yield attributing traits of groundnut variety (amber) under field condition as compared to control plot (Sanoj, *et al.,*2017). Bamsida, *et al.,* (2016) reported that the use of leaf powder of *Cassia fistula*, *Azadirachta indica*, *Cassia siamea*, particularly their mixtures have significant control on the population of *Meloidogyne incognita* and results to better growth of Kampala and Ex Dakar groundnut varieties.

The efficacy of *Azadirachta indica* (Neem leaf extract foliar spray 25%) showed better performance in controlling leaf spot and increasing pod yield of groundnut variety (Dhaka-1) by 53.61% as compared to control in the field. (Hasan *et. al.,*2016). Effect of botanicals and chemicals individually and in combinationfor the management of tikka leaf sport disease of groundnut result indicated thatsprying 5% leaf extracts of *calotropis procera* or combination of 2.5 g and 1.0 g of mamcozeb and carbendazin prove significantly effective in controlling the leaf sort and increasing the yield (Sriniyas *et. al.,* 1997).

2.8 EFFECT OF INTERACTION BETWEEN VARIETY AND PLANT BOTANICALS ON ALECTRA CONTROL.

Shinggu (2015), reported delay of *Alectra* emergence, reduce the number of *Alectra* count and number of Alectra infected plant in cowpea when plant botanicals such as *Azadirachta indica* seed and leaf powder, *Anacadium occidentale* leaf powder, *Tamarind indica* leaf powder, *Eucalyptus* spp. Leaf powder ad *Carica papaya* leaf powder. Fatima (2017) where she reported the application of *Parkia* fruit powder by basal method reduced significantly the number of Striga gesnerioides infested stand and striga metre^{-2} in cowpea IT90K-277-2 and IT97K-208-8 varieties. Hamid and Muhammad (2013) who said, tha use of aqueous extract of sorghum, sunflower, sugar beet and safflower for weed management in wheat reduced number and dry weight of weeds.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 EXPERIMENTAL SITES

The experiment was conducted during the wet season of 2018 at two locations in the Research and Teaching farm of Faculty of Agriculture, Bayero University Kano (latitude $11^{0}57'$N and longitude $8^{0}24'$E) and Garko, (Latitude 22^{0} 11'N, longitude $68^{0}008'$E). Garko local government area of Kano state.

3.2 TREATMENTS AND EXPERIMENTAL DESIGN

The experiment consisted of two (2) factors i.e. groundnut varieties and plant botanicals. The varieties used were Kwankwaso, Maibargo, Sabaiya (obtained at local market) and Samnut 24 (obtained from ICRISAT) .The plant botanicals used include *Azadirachta indica* leaf powder, *Tamarindus indica* leaf powder, *Ficus* spp. leaf powder, *Pakia biglobosa* fruit powder and control (plot inoculated with Alectra vogelii seed not treated with Botanicals) These were Factorially combined and laid out in Randomized Complete Block Design (RCBD), replicated three times. Each plot size was measured 4.5m broad x 2m long ($9m^2$); while the net plot size was 1.5m x 1.6m ($2.4m^2$)

3.3 PREPARATION AND ANALYSIS OF PLANTS BOTANICALS

The leaf powder of the plant botanicals were obtained by collecting fresh leaf and drying the leaves under shade. The dried leaves were ground into powder using pestle and mortar later sieve with fine mesh. The phytochemical analysis of the pant botanicals was determined in chemistry analytical laboratory, Department of chemistry, Yobe State University Damaturu. The analysis was done with Gas

Chromatography- Mass Spectroscopy (GCMS), using high performance thin layer chromatography method as reported by Sahira and Catherine (2015).

3.4 CULTURAL PRACTICES

3.4.1 Land Preparation

The land was ploughed, harrowed and made in to ridges at 75m apart. The field was marked in to plots of $9m^2$ and replicated three times. An alley of 0.5 m and 1.0m were left between plots and replication respectively.

3.4.2 Inoculation of Planting Hole

Alectra inoculums stock was prepared by thoroughly mixing 30 g of Alectra seeds with 500 g of sieved sand as reported by Karanja.*et al. (*2013). 0.3g of the above mixture was measured and placed in to the planting hole during planting.

3. 4.3 Treating Plots with Botanicals

The plant botanicals where applied at the rate of 3g per hole on top of the *Alectra* soil mixture on sowing date.

3.4.4 Sowing

The groundnut Seeds were manually placed in a planting hole (on top of the Alectra and plant botanicals) at spacing of 75 X 20 cm using 2 seed per hole

3.4.5 Fertilizer Application

Fertilizer was applied at the rate of 20 kg N,54 kg P_2O_5 and 20 kg K_2O ha^{-1} using NPK (15 – 15 – 15) and single superphosphate (18% P_2O_5).at two week after sowing using side dressing method.

3.4.6 Weed Control

Weed other than A. *vogelii* were controlled manually using manual hoe weeding at 3-6 week after sowing (WAS).

3.4.7 Pest and Disease Control

Pest and disease incidences were not observed during the experiment at both locations.

3.4.8 Harvesting

Harvesting was done manually after the crop have reached physiological maturity, by digging and lifting the crop and allow to dry. The pods were handpicked manually.

3.5 DATA COLLECTION

3.5.1 *Alectra* Parameter

Days to *Alectra* emergence

Days to *Alectra* emergence from sowing were recorded from each plots.

Number of *Alectra* infected stand

The number of *Alectra* affected stand were counted and recorded from each plots

Number of *Alectra* per stand

Number of emerged *Alectra* plant per plot were counted and divided by the number of stand per plot, to obtain number of Alectra per stand.

Alectra Dry Weight

At physiological maturity, the *Alectra* plants from each plot were manually uprooted together with root and oven dried at 75^0c to constant and weight using electronic weighing scale.(model TH 1000 PEC MEDICAL USA)

3.5. 2 Crop Parameters

Stand Count

Emergence count was taken at two weeks after sowing from each plot.

Crop Growth Rate (CGR)

CGR is the increase in plant material per unit time. The dried weight of the sampled plant from each plot was used to determine CGR per plant at 8 and 10 WAS. This was determined using the following relationship:

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \qquad \frac{g}{wk} = \text{grams per week}$$

Where W_1 and W_2 equal to the values of the total dry weight at time T_1 and T_2

Leaf Chlorophyll Content

The chlorophyll content from each plot at 11weeks after sowing were determined using chlorophyll meter (Apogee - CCM -200 PLUS) on five leaves from five randomly selected plants and average recorded.

Plant height

Five plants were randomly selected and their height were measured from the ground level to the tallest branch at maturity using ruler graduated in centimeter and average height was recorded.

Number of branches plant^{-1}

Number of branches per plant were determined by counting the number of branches at maturity from five randomly selected plants and average recorded.

Leaf Area Index

The leaf area index from each net plot was determined using Bio leaf foliar analysis. (A professional mobile phone application soft- ware) At 11 weeks after sowing

Defoliation Percentage (%)

The rate of defoliation were determined at maturity using Bioleaf foliar analysis (a professional mobile application soft-ware).

Number of stand at Harvest

Number of stand from each net plot were counted during harvesting and recorded

Fodder Yield

Fodder yield from each plot harvested was dried and using weighing balance in kg /ha (model CAMRY)

Number of Pod per Plant

Number of Pods from each net plot were counted and divided by number of plant per net plot

Pod yield per plant

Pod Yield from net plot were weighed after drying and divided by number of plants per plot

Pod yield per hectare (kg/ha)

Pod yield per net plot after harvesting and drying the pods were weighed in kg and extrapolated to kg ha^{-1}.using electronic scale.(model TH 1000 PEC MEDICAL USA)

$$\text{Pod Yield (kg/ha)} = \frac{\text{pod Yield (kg)}}{\text{Harvested Area } (m^2)} \times 10000\ m^2$$

Shelling percentage (%)

This was calculated using the following relationship: Shelling percentage = kernel weight/ pod weight x 100

Number of kernel per plant

This was obtained by counting the number of kernels from each net plot and divided by the number of stands per net plot.

Kernel Yield per Plant

This was obtained by weighing the kernel from each net plot and divided by number of plant per plot.

Kernel yield per hectare

This was obtained by weighing the kernel from each net plot after shelling and extrapolated to kg ha^{-1} using the following fomular:

$$\text{Kernel Yield per/ha (kg)} = \frac{\text{Yield per net plot (kg)}}{\text{Net plot Area}(m^2)} \times 10000m^2$$

100 kernel weight (g)

The weight of 100 randomly selected kernels were taken from each plot using electronic weighing scale (model TH 1000 PEC MEDICAL USA)

3.6 DATA ANALYSIS

Data generated were subjected to analysis of variance (ANOVA) using GenStat discovery Edition version 7. Significantly treatments means were separated using SNK (student-neuman-keuls'test)

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 RESULTS

4.1.1 Phytochemical composition of Plant Botanicals.

Table 1 shows the result of phytochemical composition of the plant botanicals used. Approximately ten (10) phytochemical compounds (Flavonoids, Alkaloids, Glycossides, Coumarins, Terpenoids, Phenols, Tannins, Anthraquinones and Saponins) were detected in the plant botanicals sample. *Azadirachta* leaf powder and *Parkia* fruit powder had all the nine (9) phytochemical compounds (Flavonoids, Alkaloids, Glycossides, Coumarins, Terpenoids, Phenols, Tannins, Anthraquinones and Saponins). *Tamarind* leaf powder had seven (7) phytochemical compounds (Flavonoids, Alkaloids, Coumarins, Terpenoids, Phenols, Anthraquinones and Saponins). While Glycossides and Tannins are absent in *Tamarinds.* However *Ficus* species leaf powder had eight phytochemical compounds they include Flavonoids, Alkaloids, Glycossides, Coumarins, Terpenoids, Phenols, Tannins and Saponins. Anthraquinones are absent in *Ficus* spp leaf powder.

Table 1. Phytochemical composition of Plant Botanicals

S/No	Phytochemical Constituents	*Ficus*	*Tamarind*	*Parkia*	*Azadirachta*
1	Flavonoids	+	+	+	+
2	Alkaloids	+	+	+	+
3	Glycossides	+	-	+	+
4	Coumarins	+	+	+	+
5	Terpenoids	+	+	+	+
6	Phenols	+	+	+	+
7	Tannins	+	-	+	+
8	Anthraquinones	-	+	+	+
9	Steroids	-	-	-	-
10	Saponins	+	+	+	+

+ = present of phytochemical constituent, - = absent of the phytochemical constituent

4.1.2 Days to *Alectra* Emergence and Number of *Alectra* Infected Stand.

Table 2, shows the effect of groundnut varieties and plant botanicals on days to Alectra emergence and number of *Alectra* infected stands. Varieties and plant botanicals had no significant effect on days to *Alectra* emergence in both locations. The interaction between varieties and plant botanicals on days to *Alectra* emergence was not significant in both locations.

Effect of groundnut varieties and plant botanicals on number of *Alectra* infected stand at BUK and Garko was presented in Table 2.Varieties had no significant effect on number of *Alectra* infected stand in both locations. Number of *Alectra* infected stands were significantly influenced by plant botanicals in both locations. All the plant botanicals recorded the lowest *Alectra* infected stands which were significantly different from the control which recorded the highest number of Alectra infected stands in both locations. The interaction between varieties and plant botanicals on number of *Alectra* infected stand was not significant in both locations.

Table 2: Effect of Groundnut Varieties and Plant Botanicals on Days to *Alectra* Emergence and Number of *Alectra* Affected stand per plot at BUK and Garko.

Treatments	Locations			
	Days to *Alectra* emergence	Number of *Alectra* infected stand	Days to *Alectra* emergence	Number of *Alectra* infected stand
Varieties (V)				
Kwankwaso	54.4	6.47	86.7	4.87
Maibargo	55.9	6.13	89.3	6.20
Sabaiya	58.3	6.53	85.7	5.47
Samnut 24	53.3	7.73	89.0	5.33
Level of probability	0.133	0.650	0.124	0.544
S E ±	12.36	1.332	5.81	0.649
Plant botanicals (P)				
Azadirachta Leaf powder	33.7	4.08 b	87.67	4.08 b
Tamarind Leaf powder	62.0	4.50 b	69.00	5.08 b
Ficus spp. Leaf powder	54.3	5.00 b	78.83	3.33 b
Parkia fruit powder	62.5	5.83 b	73.08	4.75 b
Control	64.7	14.16 a	69.33	10.08 a
Level of probability	0.571	0.0470	9.236	<.001
S E ±	13.82	1.489	6.49	0.726
Interaction				
V x P	0.571	0.689	0.862	0.490
	BUK		Garko	

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test.

4.1.3 Number of *Alectra* per Stand and *Alectra* Dry Weight per Plot at.

Effect of groundnut varieties and plants botanicals on number of *Alectra* per stand at BUK and Garko is presented in Table 3. Groundnut varieties had no significant effect on number of *Alectra* per stand at BUK. However, varieties significantly influenced number of Alectra per stand at Garko. Kwankwaso recorded high number of *Alectra* per stand which was significantly similar to Maibargo and Sabaiya but different from Samnut – 24 which had the lowest.

Plant botanicals significantly affected number of *Alectra* per stands at BUK while non significant effect was observed at Garko. The *Azadirachta* leaf powder treated plots recorded the lowest number of *Alectra* per stand than all other plant botanicals, while the control had the highest. The interaction between groundnut varieties and plant botanicals on number of *Alectra* per stand was non significant in both location.

Effect of groundnut varieties and plant botanicals on *Alectra* dry weight per plot at BUK and Garko was presented in Table 3. Groundnut varieties had no significant effect on *Alectra* dry weight at BUK and Garko. Plant botanicals significantly affected *Alectra* dry weight in both locations. The control treated plot recorded higher *Alectra* dry weight which was significantly different from all other plant botanicals. The interaction between groundnut varieties and plant botanicals on Alectra dry weight was not significant in both locations.

Table 3: Effect of groundnut varieties and plant botanicals on Number of *Alectra* per stand and *Alectra* dry weight per plot at BUK and Garko.

Treatments	Locations			
	BUK		Garko	
	No of Alectra per stand	Alectra dry weight per plot	No of Alectra per stand	Alectra dry weight per plot
Varieties (V)				
Kwankwaso	1.70	6.59	1.97 a	9.4
Maibargo	1.3	6.46	1.72 ab	10.4
Sabaiya	1.22	5.90	1.68 ab	11.0
Samnut 24	1.44	7.85	1.10 b	7.0
Level of probability	0.081	0.837	0.041	0.588
S E ±	0.18	2.19	0.21	2.21
Plant botanicals (P)				
Azadirachta Leaf powder	1.00 b	2.02 b	1.76	0.41 b
Tamarind Leaf powder	1.41 ab	5.24 b	1.21	8.03 b
Ficus spp. Leaf powder	1.36 ab	3.83 b	1.37	5.26 b
Parkia fruit powder	1.71 a	6.07 b	1.86	7.51 b
Control	1.68 a	16.33 a	1.89	20.06 a
Level of probability	0.007	<.001	0.170	2.47
S E ±	0.20	2.44	0.24	2.47
Interaction				
V x P	0.356	0.542	0.312	0.882

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test.

4.1.4 Stand Count, Crop Growth Rate and Leaf Chlorophyll content.

Table 4 shows the effect of groundnut varieties and plant botanicals on stand count, crop growth rate and leaf chlorophyll content. The effect of groundnut varieties on stand count was not significant in both locations. The effect of Plant botanicals as well as the interaction between groundnut varieties and plant botanicals on stand count was not significant in both locations.

The effect of groundnut varieties and plant botanicals on crop growth rate at BUK and Garko was presented on Table 4. Varieties had no significant on crop growth rate in both locations. Plant botanicals as well as interaction between groundnut varieties and plant botanicals on crop growth rate were not significant in both locations.

Effect of groundnut varieties and plant botanicals on Leaf chlorophyll content at BUK and Garko was presented in Table 4. Groundnut varieties have no significant on chlorophyll at Garko but significance effect was observed at BUK. Sabaiya, Kwankwaso and Maibargo had recorded the highest leaf chlorophyll content than Samnut 24 which had the lowest. The effects of Plant botanicals on leaf chlorophyll content was not significant in both locations. The interaction between groundnut varieties and plant botanicals on Leaf Chlorophyll Content was not significant in both locations.

Table 4: Effect of groundnut varieties and plant botanicals on stand count, crop growth rate and chlorophyll content at BUK and Garko.

Treatment	Locations					
	BUK			Garko		
	Stand count.	Crop growth rate (g/wk)	Chlorophyll content	Stand count.	Crop growth rate (g/wk)	Chlorophyll content
Variety (V)						
Kwankwaso	9.73	50.3	20.41 a	10.87	48.8	27.50
Maibargo	10.13	54.9	24.95 ab	11.13	30.0	26.80
Sabaiya	10.20	57.3	28.87 a	11.47	39.7	28.04
Samnut 24	9.13	49.8	23.51 b	10.40	30.9	28.57
Level of probability	0.236	0.700	0.002	0.086	0.031	0.746
S E ±	0.570	7.46	2.022	0.292	5.30	1.184
Plant botanicals (P)						
Azadirachta leaf powder	9.67	62.23	23.78	11.42	37.45	26.44
Tamarind leaf powder	9.50	46.82	22.33	10.75	35.29	27.36
Ficus spp. Leaf powder	10.25	60.04	27.27	10.42	32.31	27.32
Parkia fruit powder	9.58	49.16	24.49	11.42	35.89	28.53
Control	10.00	47.12	24.28	10.83	45.62	28.99
Level of probability	0,744	0.195	0.302	0.148	0.587	0.665
S E ±	0.637	8.34	2.260	0.327	5.92	1.324
Interaction						
V x P	0.884	0.411	0.931	0.908	0.881	0.292

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test. g/wk =gram per week.

4.1.5 Canopy Height, Canopy Spread and Number of Branches per Plant.

Table 5 shows the effect of groundnut varieties and plant botanicals on canopy height, canopy spread and number of branches per plant at BUK and Garko. The result revealed that groundnut varieties had significant effect on canopy height in both locations. Samnut 24 significantly observed to be taller than other varieties in both locations.

Plant botanicals had no effect on canopy height in both locations. The interaction between groundnut varieties and plant botanicals on height was not significant at BUK but significant effect was observed at Garko. Samnut 24 appears to be taller than all other varieties in this location.

The Interaction between Groundnut varieties and plant botanicals on plant height at Garko was presented in Table 6. Treating Kwankwaso, maibargo and sabaiya with plant botanicals recorded statistically similar height with control. However, treating Samnut 24 with Azadirachta leaf powder recorded the tallest plant which was statistically similar with treating the same variety with Parkia fruit powder but different from those treated with *Tamarind*, Ficus leaf powder and control.

Groundnut varieties had significant effect on canopy spread in both locations. Kwankwaso, Maibargo and Sabaiya were observed to have wider canopy than Samnut 24 in both locations. Plant botanicals had no effect on canopy spread in both locations. The interaction between groundnut varieties and plant botanicals on canopy spread in all locations was not significant.

The effect of groundnut varieties and plant botanicals on number of branches per plant was presented in Table 5.. The results showed that groundnut varieties had significant effect on number of branches per plant in both locations .Kwankwaso, Maibargo and Sabaiya were observed to have more number of branches per plant than samnut 24 in both locations. Plant botanicals had no effect on number of branches per plant in both locations. The interaction between groundnut varieties and plant botanicals on number of branches in all locations was not significant

Table 5: Effect of groundnut varieties and plant botanicals on canopy height (cm), canopy spread (cm) and Number of branches per plant at BUK and Garko.

Treatment	Location					
	BUK			Garko		
	Canopy height (cm).	Canopy spread (cm)	Number of branches per plant.	Canopy height (cm)	Canopy spread (cm)	Number of branches per plant.
Variety (V)						
Kwankwaso	34.35 b	61.44 a	15.55 a	33.73 c	63.52 a	18.17 a
Maibargo	33.29 b	53.84 b	16.29 a	39.77 b	63.36 a	19.53 a
Sabaiya	28.01 c	57.59 ab	17.85 a	30.23 d	61.73 a	19.49 a
Samnut 24	60.44 a	53.52 b	9.78 b	58.44 a	55.76 b	10.64 b
Level of probability	< .001	0.015	< . 001	< . 001	0.031	< . 001
S E ±	1.505	2.640	1.086	0.885	2.01	0.617
Plant botanicals (P)						
Azadirachta leaf powder	37.72	54.53	14.18	42.33	63.20	16.25
Tamarind leaf powder	38.07	59.07	15.09	38.98	59.67	16.92
Ficus spp. Leaf powder	39.03	56.38	15.69	41.20	59.97	18.07
Parkia fruit powder	40.28	55.90	15.66	39.47	61.03	16.72
Control	40.02	57.10	13.70	40.73	61.60	16.84
Level of probability	0.463	0.638	0.380	0.138	0.811	0.448
S E ±	1.632	2.952	0.215	0.989	2.25	0.690
Interaction						
V x P	0.689	0.166	0.602	0.018	0.312	0.226

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test. Cm =centimeter.

Table 6. Interaction between groundnut varieties and plant botanicals on canopy height (cm) at Garko.

Plant botanicals	Groundnut Varieties			
	kwankwaso	Maibargo	Sabaiya	Samnut 24
Azadiracthaleaf powder	34.80 def	37.40 cde	32.80 def	64.33 a
Tamarind leaf powder	32.80 def	40.60 cd	26.40 f	56.13 b
Ficus spp. Leaf powder	31.33 def	44.73 c	33.00 def	55.73 b
Parkia fruit powder	33.47 def	35.53 def	30.00 ef	58.87 ab
Control	36.27 de	40.60 cd	28.93 ef	57.13 b
S E ± 1.978				

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test.

4.1.6 Leaf Area Index, Defoliation percentage (%) and Stand Count at Harvest.

Effect of groundnut varieties and plant botanicals on leaf area index, defoliation percentage (%) and Stand Count at Harvest were presented in Table 7. Varieties had no significant effect on leaf area index in both locations. Plant botanicals had no significant effect on leaf area index, in both locations. Similarly the interaction between the groundnut varieties and plant botanicals on leaf area index was found to be non - significant in both locations.

The effect of Groundnut varieties and plant botanicals on defoliation percentage at BUK and Garko was also presented in Table 7. Groundnut varieties had no significant effect on defoliation percentage at BUK. However varieties had significant effect on defoliation percentage at Garko. Kwankwaso had the highest defoliation percentage which was statistically similar to Sabaiya and Samnut 24 but different from Maibargo. Plant botanicals had no significant effect on defoliation percentage in both locations. Similarly the interaction between the groundnut varieties and plant botanicals on defoliation percentage was not significant in both locations.

Groundnut varieties had no significant effect on Stand Count at Harvest at BUK. However varieties significantly affected stand count at Garko. Samnut 24 had the lowest stand count at harvest than all other varieties used. Plant botanicals had no significant effect on stand count at harvest in both locations. The interaction between the groundnut varieties and plant botanicals on stand count at harvest was not significant in both locations.

Table 7: Effect of Groundnut Varieties and Plant Botanicals on Leaf Area Index, Defoliation Percentage (%) and Number of Plant at Harvest at BUK and Garko.

Treatments	Location					
	BUK			Garko		
	Leaf Area index (LAI)	Defoliation percentage (%)	Number of plant at harvest.	Leaf Area index (LAI)	Defoliation percentage (%)	Number of plant at harvest.
Variety (V)						
Kwankwaso	0.96	23.86	14.40	0.96	22.90 a	15.93 a
Maibargo	1.12	21.00	15.53	1.08	17.48 b	17.27 a
Sabaiya	1,16	21.06	14.93	0.95	20.63 ab	16.67 a
Samnut 24	0.93	23.87	12.93	1.12	19.95 ab	12.93 b
Level of probability	0.333	0.188	0.139	0.439	0.032	0. 001
S E ±	0.1489	1.788	1.128	0.0870	1.238	0.750
Plant botanicals (P)						
Azadirachta Leaf powder	1.00	23.44	14.58	1.05	19.29	15.67
Tamarind Leaf powder	0.88	24.32	13.83	1.09	20.58	16.25
Ficus spp. Leaf powder	1.06	22.05	14.58	1.06	19.90	15.00
Parkia fruit powder	1.16	20.47	14.58	1.07	18.94	14.83
Control	1.12	21.97	14.67	0.867	22.48	16.75
Level of probability	0.499	0.370	0.961	0.473	0.409	0.450
S E ±	0.1665	1.999	1.216	0.0973	1.384	0.838
Interaction						
V x P	0.513	0.507	0.904	0.502	0.293	0.841

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test. %= percentage.

4.1.7 Haulm Yield (kg ha^{-1}) and Number of Pod $Plant^{-1}$.

Table 8 shows the effect of groundnut varieties and plant botanicals on haulm yield (kg ha^{-1}) and number of pod $plant^{-1}$ at BUK and Garko. Groundnut Varieties had no significant effect on haulm yield per hectare at BUK. However, significant varietal effect was observed on haulm yield per hectare at Garko. Maibargo recorded the highest haulm yield per hectare which was statistically similar with Sabaiya. Plant botanicals significantly affected haulm yield at BUK. Treating planting hole with *Ficus* Leaf powder recorded the highest haulm yield per hectare which was statistically similar with other plant botanicals. The interaction between the groundnut varieties and plant botanicals on haulm yield per hectare were not significant in both locations.

The effect of groundnut varieties and plant botanicals on number of pod $plant^{-1}$ at BUK and Garko was presented in Table 8. Varieties had no significant effect on number of pod per plant at BUK. However, significant varietal effect was observed at Garko. Kwankwaso recorded the highest number of pod per plant which is statistically similar with Sabaiya and Samnut – 24 but different from Maibargo which recorded the lowest. Plant botanicals significantly affected number of pod per plant at both locations. *Tamarind* leaf powder consistently recorded the highest number of pod $plant^{-1}$ while the control recorded the lowest in both locations. The interaction between the groundnut varieties and plant botanicals on number of pod per plant were not significant in both locations.

Table 8. Effect of Groundnut Varieties and Plant Botanicals on Days to Maturity, Haulm Yield (kg hectare^{-1}) and Number of Pod per Plant at BUK and Garko.

Treatment	Location			
	BUK		Garko	
	Haulm yield per hectare(Kg)	Number of pod per plant.	Haulm yield per hectare (Kg)	Number of pod per plant.
Variety (V)				
Kwankwaso	3519	20.01	3815 b	20.63 a
Maibargo	3889	18.90	4481 a	16.04 b
Sabaiya	4037	22.65	4185 ab	17.52 ab
Samnut 24	4259	21.07	2407 c	19.28 ab
Level of probability	0.201	0.313	< .001	0. 023
S E ±	345.8	2.040	183.8	1.066
Plant botanicals (P)				
Azadirachta leaf powder	3700 ab	20.35 b	3843	17.70 ab
Tamarind leaf powder	3519 b	27.47 a	3704	20.97 a
Ficus spp. Leaf powder	4676 a	19.37 b	3565	19.02ab
Parkia fruit powder	3704 ab	18.24 b	3796	19.14ab
Control	3981 ab	17.85 b	3704	15.01b
Level of probability	0.044	0.001	0.896	0.017
S E ±	386.6	2.280	205.5	1.192
Interaction				
V x P	0.177	0.804	0.329	0.090

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test. Kg=kilogram.

4.1.8 Pod Yield Plant^{-1} (g), Pod Yield kg ha^{-1} and Shelling Percentage.

Effect of Groundnut varieties and plant botanicals on pod yield plant^{-1}, pod yield kg ha^{-1} and shelling Percentage at BUK and Garko was presented in Table 9. Varieties had no significant effect on pod yield per plant in both locations Plant botanicals significantly affected pod yield per plant in both locations. *Tamarind* leaf powder consistently recorded higher pod yield per plant than other plant botanicals used in both locations. The control treated plot recorded lower pod yield per plant in both locations. The interaction between groundnut varieties and plant botanicals on pod yield per plant was not significant at BUK and Garko.

Varieties had significant effect on pod yield kg ha^{-1} in both locations (Table 9). Sabaiya consistently recorded the highest pod yield ha^{-1} in both locations. Kwankwaso and Samnut 24 recorded the lowest pod kg ha^{-1} yield at BUK. At Garko, Kwankwaso and Sabaiya had the highest pod yield than Maibargo and Samnut 24. Plant botanicals had significant effect on pod yield per hectare in both locations. *Tamarind* leaf powder consistently recorded highest pod yield per hectare than other plant botanicals used in both locations. The control treated plots recorded lower pod yield per hectare in both locations. The interaction between groundnut varieties and plant botanicals on pod yield per hectare was found to be non significant at BUK but significant at Garko. The response of Kwankwaso, Maibargo and Sabaiya to plant botanicals on pod yield ha^{-1} was statistically similar (Table 10). However Samnut 24 responded differently to plant botanicals on pod yield ha^{-1} . Treating Samnut 24 with *Tamarind* leaf powder had higher pod yield than treating the same variety with *Azadirachta* and control.

Groundnut varieties had significant effect on shelling percentage in both location. Sabaiya consistently recorded the highest shelling percentage in both locations .Kwankwaso
and Samnut 24 recorded the lowest shelling percentage at BUK. At Garko, Kwankwaso, Sabaiya and Samnut 24 had highest shelling percentage. Maibargo recorded the lowest shelling percentage which is statistically different from other varieties. Plant botanicals had no significant effect on shelling percentage in both locations. So also, the interaction between groundnut varieties and plant botanicals on shelling percentage was not significant in both locations.

Table 9: Effect of Groundnut Varieties and Plant Botanicals on Pod Yield $plant^{-1}$, pod yield $hectare^{-1}$ and shelling percentage at BUK and Garko.

Treatments	Location					
	BUK			Garko		
	Pod yield per plant (g)	Pod yield per hectare (kg)	Shelling %	Pod yield per plant (g)	Pod yield per hectare (kg)	Shelling %.
Variety (V)						
Kwankwaso	18.49	1466c	61.53b	19.14	1753a	66.20a
Maibargo	20.66	1661b	63.93ab	17.23	1562b	63.17b
Sabaiya	23.56	1865a	67.22a	21.03	1892a	67.87a
Samnut 24	19.03	1367c	62.67b	20.18	1403b	67.35a
Level of probability	0.096	< .001	0.023	0.155	< .001	< .001
S E ±	2.140	95.9	1.843	1.194	61.0	0.790
Plant botanicals (P)						
Azadirachta leaf powder	18.95b	1509	64.78	19.71ab	1703ab	67.02
Tamarind leaf powder	27.82a	2064	63.81	21.41a	1772a	65.29
Ficus spp. Leaf powder	18.85b	1506	62.48	18.58ab	1635ab	67.24
Parkia fruit powder	18.65b	1469	54.69	22.19a	1678ab	65.75
Control	17.70b	1400	63.48	15.45b	1473b	65.45
Level of probability	< . 001	< . 001	0.791	0.009	0.045	0.386
S E ±	2.393	107.2	2.060	1.334	68.2	0.886
Interaction						
V x P	0.668	0.302	0.700	0.168	0.041	0.501

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test. Kg=kilogram, g=gram,%=percentage.

Table 10: Interaction between groundnut varieties and plant botanicals on Pod yield hectare^{-1} (kg) at Garko.

Plant botanicals	Groundnut Varieties			
	Kwankwaso	Maibargo	Sabaiya	Samnut 24
Azadirachta leaf powder	1935ab	1510abc	2051a	1316bc
Tamarind leaf powder	1570abc	1761ab	1901ab	1853ab
Ficus spp. Leaf powder	1809ab	1573abc	1793ab	1364abc
Parkia fruit powder	1786ab	1378abc	2066a	1483abc
Control	1663ab	1586abc	1650ab	993c
S E ± 136.4				

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test.

4.1.9: Number of Kernel Pod^{-1}, Number of Kernel Plant^{-1} and Kernel Yield plant^{-1} (g).

Table 11 shows the effect of groundnut varieties and plant botanicals on number of kernel per pod, number of kernel plant^{-1} and kernel yield plant^{-1} (g) at BUK and Garko. The effect of groundnut varieties on a number of kernel per pod were found to be non significant at BUK, but significant at Garko. Sabaiya produced the highest number of kernel per pod which was statistically similar to Kwankwaso and Samnut 24 but different from maibargo which recorded the lowest.

Plant botanicals significantly affected number of kernel per pod at BUK, while non-significant effect was observed at Garko. *Parkia* fruit powder recorded the highest number of kernel per pod at BUK. The control plot recorded the lowest (1.60) which is statistically similar with *Tamarind* leaf powder and *Ficus* spp. leaf powder. The interaction between groundnut varieties and plant botanicals on number of kernel per pod was found to be non significant in both locations.

Effect of groundnut varieties and plant botanicals on Number of kernel per plant at BUK and Garko is presented in Table 11. The effect of groundnut varieties on number of kernel per plant was found to be non significant at BUK, but significant at Garko. Kwankwaso, Sabaiya and Samnut 24 recorded statistically similar and higher number of kernel plant^{-1}, while Maibargo had the lowest.

Plant botanicals significantly affected number of kernel per plant in both locations. *Tamarind* leaf powder recorded highest number of kernel per plant in both locations which was similar to all the plant botanicals at Garko. The control plot recorded the lowest in both locations. The interaction between groundnut varieties and plant botanicals on number of kernel per plant was not significant in both locations.

The effect of groundnut varieties on kernel yield per plant was found to be non significant at BUK, but significant at Garko. Kwankwaso, Sabaiya and Samnut – 24 recorded statistically similar and higher number of kernel plant^{-1}, while Maibargo had the lowest.

Plant botanicals significantly affected number of kernel yield per plant in both locations *Tamarind* leaf powder recorded the highest kernel yield plant^{-1} which is statistically different from all the botanical used at BUK. However, at Garko *Parkia* fruit powder had higher kernel yield plant^{-1} which was statistically similar to other plant botanicals but different from the control.

The interaction between groundnut varieties and plant botanicals on kernel yield per plant was not significant at BUK How ever significant interaction was observed on kernel yield per plant at Garko (Table 12). All the four varieties recorded statistically similar kernel yield plant^{-1} across the plant botanicals. However *Azadirachta* leaf powder on sabaiya recorded the highest kernel yield plant$^{-1.}$.

Table 11: Effect of Groundnut Varieties and plant Botanicals on Number of Kernel pod^{-1}, Number of Kernel Plant^{-1} and Kernel Yield per Plant at BUK and Garko.

Treatments	Location					
	BUK			Garko		
	Number of kernel per pod	Number of kernel per plant	Kernel yield per plant (g)	Number of kernel per pod	Number of kernel per plant	Kernel yield per plant (g)
Variety (V)						
Kwankwaso	1.55	31.6	11.68b	1.54ab	31.37a	13.73a
Maibargo	1.53	28.9	12.91b	1.47b	21.87b	11.08b
Sabaiya	1.60	36.4	16.56a	1.61a	29.43a	14.66a
Samnut 24	1.54	34.4	12.28b	1.59ab	31.18a	13.56a
Level of probability	0.396	0.133	0.005	0.039	< .001	0.008
S E ±	0.07	3.33	1.37	0.04	1.46	0.72
Plant botanicals(P)						
Azadirachta Leaf powder	1.46b	29.90b	11.65b	1.59	29.62a	14.01ab
Tamarind Leaf powder	1.62ab	44.30a	18.82a	1.47	28.42a	13.80ab
Ficus spp. Leaf powder	1.51ab	29.03b	11.82b	1.60	30.05a	13.65ab
Parkia fruit powder	1.70a	32.28b	12.22b	1.60	31.98a	14.02a
Control	1.60ab	28.61b	12.22b	1.50	22.18b	10.82b
Level of probability	0.038	< . 001	< . 001	0.087	0.002	0.032
S E ±	0.08	3.72	1.53	0.04	1.63	0.80
Interaction						
V x P	0.376	0.571	0.528	0.328	0.183	0.013

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test. g=gram.

Table 12: Interaction between Groundnut Varieties and Plant Botanicals on Kernel Yield plant^{-1} at Garko.

Plant botanicals	Groundnut Varieties			
	Kwankwaso	Maibargo	Sabaiya	Samnut-24
Azadirachta Leaf powder	13.50abc	10.90abc	19.23a	12.40abc
Tamarind Leaf powder	12.13abc	13.60abc	11.80abc	17.67abc
Ficus spp. Leaf powder	15.67abc	11.23abc	13.73abc	13.97abc
Parkia fruit powder	14.87abc	10.03bc	15.10abc	16.07abc
Control	12.50abc	9.63bc	13.43abc	7.70c
S E ± 1.598				

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test.

4.1.10 Kernel Yield kg ha^{-1} and100 Kernel Weight.

The effect of groundnut varieties and plant botanicals on kernel yield per hectare and 100 kernel weight at BUK and Garko was presented in Table 13. Groundnut varieties had significant effect on kernel yield ha^{-1} in both locations. Sabaiya recorded the highest kernel yield per hectare in both locations, while Samnut 24 have the lowest.

Plant botanicals had significant effect on kernel yield ha^{-1} at both locations. *Tamarind* leaf powder recorded the highest kernel yield ha^{-1} in both locations. Control plot had lowest kernel yield per hectare which was statistically different from other botanicals in both locations. Interaction between groundnut varieties and plant botanicals on kernel yield per hectare was not significant at BUK. However, the interaction was significant at Garko. (Table 14). The kernel yield of all the varieties did not differ significantly with the change of plant botanicals, except Samnut 24. Treating Samnut 24 with *Tamarind* leaf powder recorded higher kernel yield ha^{-1} which was statistically similar to treating the same variety with *Ficus* leaf powder and *Parkia* fruit powder but different from the control and Azadirachta treated plot..

Groundnut varieties significantly influenced 100 kernel weight in both locations (Table 13). Sabaiya and Maibargo recorded the highest 100 kernel weight while Samnut 24 had the lowest in both locations. Plant botanicals had no significant effect on 100 kernel weight at both locations. Interaction between groundnut varieties and plant botanicals on kernel 100 kernel weight was not significant at BUK, but was significant at Garko. (Table 14). Treating Sabaiya with Azadirachta leaf powder had heavier kernel than treating Kwankwaso and Samnut 24 with either Azadirachta leaf powder, Ficus leaf powder or Parkia fruit powders.

Table 13: Effect of Groundnut Varieties and Plant Botanicals on Kernel Yield kg ha^{-1} and 100 kernel weight at BUK and Garko.

Treatments	Locations			
	BUK		Garko	
	Kernel yield per hectare (kg)	100 kernel weight (g)	Kernel yield per hectare (kg)	100 kernel weight (g)
Varieties (V)				
Kwankwaso	907bc	41.71b	1161b	48.72b
Maibargo	1028b	48.07a	987c	53.36a
Sabaiya	1253a	48.32a	1284a	55.12a
Samnut 24	856c	39.40c	944c	47.77b
Level of probability	< . 001	< . 001	< . 001	< .001
S E ±	68.8	0.998	40.8	0.928
Plant botanicals (P)				
Azadirachta leaf powder	937b	43.90	1145a	50.93
Tamarind leaf powder	1322a	45.72	1155a	51.12
Ficus spp. Leaf powder	946b	43.38	1102abc	50.70
Parkia fruit powder	953b	44.43	1104ab	50.38
Control	897b	44.45	965b	53.08
Level of probability	< .001	0.322	0.040	0.393
S E ±	76.9	1.116	45.6	1.037
Interaction				
V x P	0.522	0.687	0.036	0.029

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test. Kg=kilogram, g=gram.

Table 14: Interaction between Groundnut Varieties and Plant Botanicals on Kernel Yield plant^{-1} and 100 kernel weight at Garko.

Plant botanicals	Groundnut Varieties			
	kwankwaso	Maibargo	Sabaiya	Samnut 24
	kernel yield per plant			
Azadirachta leaf powder	1316ab	966abc	1416a	881c
Tamarind leaf powder	1029abc	1079abc	1265ab	1248ab
Ficus spp. Leaf powder	1231ab	1051abc	1235ab	891bc
Parkia fruit powder	1164ab	861bc	1369a	1019abc
Control	1063abc	978abc	1136ab	682c
S E ± 91.2				
	100 kernel weight			
Azadirachta leaf powder	48.53bcd	50.20abcd	59.73a	45.27d
Tamarind leaf powder	46.73cd	53.80abcd	53.47abcd	50.47abcd
Ficus spp. Leaf powder	48.87bcd	58.27ab	50.20abcd	45.47d
Parkia fruit powder	48.40bcd	51.13abcd	55.80abcd	46.20cd
Control	51.07abcd	53.40abcd	56.40abc	51.47abcd
S E ± 2.074				

Means followed by the same letter(s) in a column are not significantly different at 5% level of probability using student- Newman keuls Test

4.2 DISCUSSION

4.2.1 Effect of Groundnut Varieties on Alectra Control

All the varieties tested had no significant effect on days to Alectra emergence and Alectra infected stand in both locations. This indicate that the varieties are genetically alike and lack the ability to control the parasite. This study is contrary to the result observed by Karanja et al., (2013) which reported significant differences among cowpea genotype in first day to *Alectra* emergence and number of *Alectra* infected stand. This indicates the varieties had similar invasive ability to *Alectra*.

The variety Kwankwaso recorded the highest number of *Alectra* per stand at Garko. This indicates that this variety is highly susceptible to *Alectra* while Samnut-24 recorded the lowest. This implies that Samnut – 24 may have some resistant to the parasite and can be used in managing the parasite. Similar result is reported by Yohanna *et al,.*(2010) on the related strain Samnut-18 which has low *Alectra* shoot number in both field and screen house experiment.

4.2.2 Effect of Varieties on Growth and Yield of Groundnut.

Groundnut varieties Sabaiya, Kwankwaso and Maibargo recorded the highest leaf chlorophyll content than Samnut-24 at BUK. This reflects genetic variation between these varieties. Higher chlorophyll content result in higher assimilate which result in higher yield. Variety Samnut-24 where observed to be taller than the other varieties in both locations. This could be attributed to the upright growth habit as reported by Ajeigbe *et al.*, (2014).

Kwankwaso, Maibargo and Sabaiya were observed to have wider canopy spread with higher number of branches. This is because these varieties are runner type. This was in line with earlier reported by Hussain (2011) who reported that the runner or spreading type are cultivars belonging to the group whose peg were distributed 40cm from the base of the plant as the branches grow more or less prostrate on the ground. Maibargo recorded the highest haulm yield probably because of its lowest defoliation percentage. Muktar *et al* (2014) had earlier reported that level and intensity of defoliation could have diverse effect on the crop biological and economic yield. Samnut-24 had lowest stand count at harvest. Probably because of its poor emergence and establishment.

The higher number of pod recorded by Kwankwaso may be attributed to the varieties having the highest chlorophyll content which contributes to the higher assimilate which are contributing factor to higher yield. This variety is also a runner cultivar whose leaves had equal opportunity of trapping sunlight without mutual shading. Sing and Joshi (1993) had reported that the runner cultivars of groundnut showed higher chlorophyll production with more leaf and this contribute to the high assimilate production, biomass and yield.

Higher pod yield recorded by Sabaiya may be attributed to its high pod number and pod yield per plant. This is as a result of good adaptation to environment. The variety Sabaiya recorded the highest number of kernel per pod and kernel yield per plant. This could be probably due to its high pod number and pod yield per plant. May be due to its highest number of kernel per pod and kernel yield per plant

4.2.3 Effect of Plant Botanicals on *Alectra* Contro

Application of plant botanicals had significant effect on number of *Alectra* infested stand in both locations and number of *Alectra* per stand at BUK. Low number of stand infected by *Alectra* was observed when plant botanicals were applied. This indicates that all the botanicals can be used to suppressed *Alectra* infestation in groundnut. This could be possible due to allelopathic effect of the plant botanicals on *Alectra* germination. It implies that there will be depletion of *Alectra* seed bank and reduced future infestation, thereby ensuring control of *Alectra* over time. This is as a result of the presence of some phytochemical compounds present in most of the plant botanical used such as coumarins, phenols, Terpenoids and tannins which acts as defence mechanism against parasitism and predation from other organism including plant. This result obtained was similar to report of Shinggu (2015) who noted that treating planting hole with plant botanical powder delay *Alectra* emergence, reduce *Alectra* count and number of plant infested by *Alectra* in cowpea. So also, similar result obtained by Fatima (2017), who reported low *Striga gesnerioides* L. when *Parkia* fruit powder was applied basally in cowpea. Similarly Ibrahim *et al*,. (2011), reported that soaking maize seed for 20 minutes before planting in *Parkia* based products suspension significantly produce fewer number of maize plant infested by *Striga* shoot count as compare to those soaked in distilled water.

Among the botanicals, used low number of *Alectra* infestation per stand was observed when *Azadirachta* leaf powder was applied. This may be as a result of the phytoxic compound present in it such as coumarine, terphenoids phenols and tannins which has biological function to plant against parasitism from other plant. Shinggu (2015), had earlier observed that the use of *Azadirachta indica* seed and leaf powder reduced *Alectra* count and number of *Alectra* infested plant in cowpea. Low *Alectra* dry weight was observed when plant botanicals were applied when compared with control plot. This could be attributed to the low *Alectra* count recorded, this implies that there was depletion of *Alectra* dry weight which was possible sign of reducing the *Alectra* parasitism. This result was similar to Hamid and Mohammad (2013), who noted that aqueous extract of sorghum, sunflower, sugar beet and safflower can be use in weed management in wheat, which reduced number and dry weight of weed. This result is also in line with the findings of Prabukumar and Athaya kumar (2006), who reported that the use of *Lantana camara*, *Cassia auriculata* and *perthenium hysterophorus* significantly reduced the weed density and weed dry matter production in rice.

4.2.4 Effect of Plant Botanicals on Growth and Yield of Groundnut.

Ficus spp leaf powder recorded the highest haulm yield than other plant botanicals, this could be as a result of the compound present in *Ficus* spp. such as phenolic, alkaloids, terpenoids, and tannins which stimulate growth as reported by Maria *et. al*. in (2015).. This indicates that use of *Ficus* spp enhance groundnut growth and increase haulm yield which is used as livestock feed. This result was in line with findings of Bamisida *et al.,* (2016) who reported that the use of *Cassia fistula, Azadirachta indica* and *Cassia siamoa* leaf powder significantly control population of *Meloidogyne incognita*, which resulted better growth of groundnut and yield compare to control.

Tamarind leaf powder recorded the highest number of pod plant^{-1}, pod yield plant^{-1}and pod yield ha^{-1} among all plant botanicals used. This is as a result higher phenols compound in *Tamarinds* leaf which is essential for reproduction and Flavonoids which stimulate root nodules formation as reported by Maria *et. al*. (2015).. . Increase in nodule implies increase supply of Nitrogen which increased growth and yield. Thus may results in more N for subsequent crops in rotation. Zubaida (2014) reported increase in maize grain yield when *Tamarind* leaf extract was spray on maize under reduced nitrogen rate by 50%. This result was in line with what Shinggu (2015) reported that *Tamarind* seed and leaf powder increase cowpea seed yield. Similarly Fatima (2017) reported that application of *Parkia* fruit powder basally increase pod yield, pod length and number of grain pod^{-1} of cowpea. Therefore the content of *Tamarind* are effective on control of *Alectra* which might have explained the reason of higher number of pod per plants and per hectare. Similar result was reported by Hassan *et al.,* (2016) Who highlighted the efficacy of *Azadirchta indica* neam leaf extract spray and *Polyacthia longifolia* leaf extract spray show better performance in controlling leaf spot and increasing pod yield and pod weight of groundnut.

Plant botanicals had significant effect on number of kernel pod^{-1}, kernel yield plant^{-1} and kernel yield per hectare in both locations. *Parkia* fruit powder recorded the highest number of kernel per pod. This is as a result of some compound (phenolics and alkaloids) that has biological function in reproduction present in *Parkia* fruit powder (Maria *et. al.,* 2015). This suggest that the application of *Parkia* fruit powder could be use to enhance groundnut production. This result is in line with finding of Fatima (2017) who reported that basal application of *Parkia* fruit powder increase pod yield, pod length and number of grain pod$^{1.}$

Tamarind leaf powder recorded the highest kernel yield plant^{-1}. This can be as a result of higher pod yield per plant produced by Tamarind. This could also be as a result of the present of Flavonoid and Alkaloid which are essential in reproduction and Alkaloid which are essential in root noodle formation and biological nitrogen fixation (Maria *et. al.,* 2015).. This result was similarly reported by shinggu (2015) where *Tamarind* belongs to one of the plant botanicals that increase cowpea seed yield.

Tamarind leaf powder application to planting hole significantly resulted in higher kernel yield ha^{-1}. This could be as a result of the phytochemical compound present in *Tamarind* (flavonoids, phenolics, alkaloids, Tannins, Terpenoids and caumarin) that has biological function in growth, reproduction, nutrient absorption, nodule formation/symbiotic nitrogen fixation and protect plant against parasitism from other organism in association as reported by Maria *et. al* (2015). This result was similar to Shinggu (2015) who reported that on treating the planting hole with *Tamarind* gives higher cowpea seed yield. So also, Zubaida (2014) reported on increase in maize grain yield per hectare when *Tamarind* leaf extract was apply at half dose of nitrogen requirement of maize. This indicates that *Tamarind* effect on *Alectra* control and some macronutrient content in it which stimulate growth and yield of groundnut.

4.2.5 Interaction Between Varieties and Plant Botanicals on *Alectra* Control.

Treating all varieties with no plant botanicals (control) significantly recorded highest number of *Alectra* infested stand than treating the varieties with plant botanicals. This indicates the effectiveness of plant botanicals in destroying *Alectra.* This result showed that plant botanicals have a depressive effect on the attachment and growth of *Alectra* to groundnut plant. Therefore combination of groundnut varieties and plant botanicals can play significant role in reducing the parasite and therefore should be encouraged. This confirms the report of shinggu (2015) who reported delay of *Alectra* emergence, reduced the number of *Alectra* count and number of *Alectra* infected plant in cowpea when *Azadirachta indica* leaf powder and seed powder, *Anacadium occidentale* leaf powder, *Tamarind indica* leaf powder and *Eucalyptus* spp. Leaf powder were added into planting hole. Treating planting hole with *Azadirachta* leaf powder recorded the lowest number of *Alectra* per stand

and number of *Alectra* infested plant. This indicate that all the plant botanicals can be used to suppressed *Alectra* infestation in groundnut considering the amount of seed inoculated at each planting hole.

Varieties Kwankwaso, Maibargo and Sabaiya recorded considerably lowest number of *Alectra* per stand statistically than Samnut-24, in all plant botanicals used. This implies that the three local varieties respond positively to the application of these plant botanicals to *Alectra* control than samnut-24. This suggests that plant botanicals used is more suitable on the three local varieties and could be recommended by the farmers. This result is also similarly reported by Fatima (2017) where she reported the application of *Parkia* fruit powder by basal method reduced significantly the number of *Striga gesnerioides* infested cowpea(IT90K -277-2 and IT97K – 205 -8) and *Striga* metre^{-2}.

Plant botanicals had significantly reduced the *Alectra* dry weight in all groundnut varieties used. This could be associated with lower *Alectra* count recorded. This implies that, there will be a reduced *Alectra* parasitism which improves the yield. This result was reported earlier by Hamid and Muhammad (2013) who noted, that the treatment combination use of aqueous extract of sorghum, sunflower and sugar beet for weed management in wheat reduced number and dry weight of weeds.

4.2.6 Interaction Between Plant Botanicals and Groundnut Varieties on Growth and Yield of Groundnut.

Increased in height of Samnut 24 with Azadirachta leaf powder could be attributed to the fact that the powders from *Azadirachta* and *Parkia* has beneficial substances (phenols, Tannins, alkaloids) to soil by adding nutrient which might have enhance the productivity of this variety as reported by Kambou et al.,(1997) in which *Parkia* products improve the soil agrochemicals.

Treating Samnut-24 with *Tamarind* leaf powder had higher pod the same variety with *Azadirachta* and control. This implies that the varieties were tolerant to *Tamarind* which effectively control the *Alectra* there by making more photosynthase available to support more pods. The phenolic compound in tamarind was earlier reported by Zubaida (2014) who noted the increase of maize grain yield by spraying *Tamarind* leaf extract at half dose of nitrogen requirement of maize.

Sabaiya treated with *Azadirachta* leaf powder recorded the highest kernel yield per plant then all other treatment combination. This could be attributed to the variety that is tolerant to the Azadirachta leaf powder which effectively controls the *Alectra.* The use of plant products significantly control some weed and increase growth and yield

The application of *Azadirachta* leaf powder and *Tamarind* leaf powder to Sabaiya recorded the highest kernel yield ha^{-1} and 100 kernel weight than all other treatment combinations. This could be attributed to the fact that this variety with *Azadirachta* leaf powder control *Alectra* leaf which might have reduced kernel size and weight. Similar observation was reported by shinggu (2015) who noted that *Azadirachta* seed and leaf powder increase cowpea grain yield. This collaborated with work of Fatima (2017) and Magani (2010) in which they reported that high yield of cowpea and maize respectively with application of Parkia based products.. This suggested that Sabaiya could be used to enhance the groundnut production and control of *Alectra*. *Parkia* fruit powder and *Azadirachta* leaf powder are cheap and easy to obtain at non cost or less cost. The used of these products are also environmentally friendly.

CHAPTER FIVE

5.1 SUMMARY

Experiments were conducted at. Research and Teaching Farm of the Faculty of Agriculture, Bayero university Kano (latitude11^0 57' N and Longitude 8^0 24' E) and Garko in Garko local Government area Kano state (latitude 22^0 11' N and longitude 63^0 008' E) in 2018 wet season. The aim of the experiment was to evaluate the effects of plant botanicals on the control of *Alectra* vogelii on groundnut varieties in Sudan savanna of Nigeria. The experiment consisted of two factors (four groundnut varieties and four plant botanicals including control). The experiment was laid out in Randomized Complete Block Design (RCBD) and of replicated three times. The gross and net plot sizes were 9m^2 and 2.4m^2.

Data were collected on *Alectra*, growth and yield characters of the groundnut varieties. Data collected ware subjected to analysis of variance (ANOVA). Using GENSTAT and significant treatment were separated using SNK. Result obtained showed that Groundnut varieties had no significant effect on days to *Alectra* emergence and *Alectra* infected stand at both locations but significant on number of *Alectra* per stand. Kwankwaso variety recorded the highest number of *Alectra* per stand while samnut 24 recorded the lowest number of *Alectra* per stand. Treating planting hole with plant botanicals recorded the lowest *Alectra* infected stand and Alectra dry weight in both location. Samnut 24 treated with *Azadirachta* and *Parkia* fruit powder recorded the taller canopies than all other plant botanicals. The variety Kwankwaso recorded the highest defoliation percentage which was statistically similar with Sabaiya and Samnut 24 but different from Maibargo. Sabaiya had higher pod yield, shelling percentage and kernel yield in both locations. *Tamarind* leaf powder recorded the highest pod yield per hectare at Garko, so also *Tamarind* leaf powder had highest kernel yield and 100 kernel weight in both locations.

5.2 CONCLUSION

Based on the result obtained from this study it can be concluded that treating planting hole with plant botanicals significantly reduced the number of *Alectra* per stand and reduced the infestation level. This implies that there will be depletion of *Alectra* seed bank since the germination is reduced which in turn ensured control of *Alectra* control and reduced future infestation. Application of *Azadirachta* leaf powder and *Parkia* fruit powder resulted in the production of taller canopies of Samnut 24 while *Ficus* Spp. leaf powder had higher haulm yield than all other botanicals used. *Tamarind* leaf powder was found to be effective on pod and kernel yield. Sabaiya performed better than other varieties used on all yield parameters tested. Samnut 24 treated with *Azadirachta* leaf powder and *Parkia* fruit powder appear to be taller than all other varieties this could be possible due to the presence of phenols, alkaloids that stimulate growth. Sabaiya treated with *Parkia* fruit powder had higher pod yield per plant. The same variety treated with *Tamarind* leaf powder recorded the highest kernel yield per hectare in both locations. Therefore the use of plant botanicals increased groundnut production and reduced *Alectra* infestation levels.

5.3 RECOMMENDATION

The use of Tamarind leaf powder and *Parkia* fruit powder on Sabaiya and Samnut – 24 are recommended in Sudan savanna of Nigeria for the control of Alectra and increase the productivity. Further research with different rates and method of the botanicals application need to be investigated and the genes responsible for resistance to the parasite in Sabaiya needs further investigation.

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