AN EVALUATION OF HERBICIDE TREATMENTS FOR THE CONTROL OF *Aleclra Vogelii* Benth and *Striga gesnerioides* (Wild) Vatke IN COWPEA *(Vigna unguiculata (Li WALP)*

BY

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of Science in Agronomy

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DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.

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The above declaration is confirmed

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CERTIFICATION

This thesis entitled "An Evaluation of Herbicide Treatments for the Control of *Alectra vogelii* Benth and *Striga gesnerioides* (Wild) Vatke in Cowpea (*Vigna unguiculata* (L) Walp)" by CHIBIYA PAUL SHINGGU meets the regulations of Ahmadu Bello University, Zaria, Nigeria and is approved for its contribution to Scientific Knowledge and literary Presentation.

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DEDICATION

This work is dedicated to my Mother Mrs. Calvin Alahira and My Late Father Catchiest Calvin S. Alahira

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ABSTRACT

Seed treatment of acetolactate synthase (ALS) inhibitor herbicides, cinosulfuron and CGA152005 were evaluated for the control of parasitic weeds, *Alectra vogelii* Benth and *Striga gesnerioides* (Wild.) Vatke in cowpea *(Vigna unguiculata* (L.) Walp) at the Institute for Agricultural Research, Ahmadu Bello University, Samaru during the 1994 dry and 1995 wet seasons. The treatments consisted of five cowpea varieties (IT81D-985, SAMPEA 7, SAMPEA 6, IT90K-102-6 and IT89KD-245-1) and 10 herbicide seed treatment, cinosulfuron at 0.05, 0.1, 0.2 and 0.4 and CGA152005 at 0.008, 0.016, 0.032 and 0.064 g/1 including the water soaking and dry planting no herbicide controls. The treatments were laid out in in completely ramdomized design (CRD). In the laboratory and screen house and split plot design in the field varieties were the main plot treatment while the seed treatments were allocated to the sub-plots. The cowpea varieties IT90K-102-6 and IT81D-985 were susceptible to the herbicide seed treatments evaluated as reflected in depression in seed germination, poor stand establishment as well as high injury and low crop vigour score with and without parasitic weed infestation in the screen house. The nodulation of the cowpea varieties was also lower than the maximum obtained with IT89KD-245-1 with and without parasitic weed infestation in the field. Variety IT90K-102-6 also produced lower leaf dry matter than the maximum produced by SAMPEA 6 in the trials. The variety SAMPEA 6 produced higher cowpea grain yield than SAMPEA 7 and IT81D-985 inspite of high parasitic weed infestation and incidence. Cowpea variety SAMPEA 7 produced the least 1000-grain weight with and without

parasitic infestation while IT89KD-245-1 produced the heaviest seeds. Both SAMPEA-7 and SAMPEA 6 supported the highest infestation and incidence of *Striga* and *Alectra* in the study. IT89KD-245-1 and IT90K-102-6 however supported lower number *of Alectra* and incidence than the varieties and IT81D-985. *Striga* emergence was also delayed on varieties IT81D-985, IT89KD-245-1 and IT90K-102-6 compared with SAMPEA 6 and SAMPEA-7.

The seed treatments differentially affected parasitic weed infestation and incidence as well as the vigour, growth and yield of cowpea. CGA152005 at 0.064g/l with *Alectra* infestation and at 0.032 and 0.064g/l with infestation caused significantly higher injury score of cowpea compared with the lower concentrations and no-herbicide controls. Similarly, the highest rates *of* the two herbicides CGA152005 at 0.064g/l and cinosulfuron at 0.04g/l resulted in lower vigour score than their corresponding low concentrations in the screen house with and without Alectra inoculation. CGA152005 at 0.032 and 0.064g/l also reduced shoot dry weight of cowpea significantly compared with the no-herbicide controls. Similarly the nodulation of cowpea was depressed by cinosulfuron at 0.2 and 0.4g/l and CGA152005 at 0.016 to 0.064g/l with parasitic weed infestation. Under parasitic weed infestation, CGA 152005 at 0.032 and 0.064g/l however produced significantly higher cowpea grain yield than cinosulfuron at 0.05 and 0.1g/l, CGA152005 at 0.008g/l and dry planting control as a result of effective reduction of parasitic weed infestation. Cinosulfuroin at 0.04g/l and the planting of water-soaked seeds also resulted in higher cowpea grain yield than dry planting no-herbicide control. Cinosulfuron at 0.2

and 0.4g/l and CGA152005 at 0.032 and 0.064g/l significantly delayed the emergence of the parasitic weeds in the screen house and field. Alectra/Striga emergence was also delayed by cinosulfuron at 0.4g/l and CGA152005 at 0.064g/l compared with the lower rates while cinosulfuron at 0.2g/l and CGA152005 at 0.032g/l delayed Striga emergence only. The herbicide seed treatments reduced the number of emerged and unemerged Alectra in the screen house and Alectra/Striga shoot infestation and incidence on cowpea in the field. CGA152005 at 0.032 and 0.064g/l caused more effective reduction of infestation than the other herbicide treatments.

Yield loss due to the parasitic infestation was 12.7% for SAMPEA 6 to 34.7% for SAMPEA 7. The interactions of varieties and herbicide seed treatments on number of days to 50% flowering without parasitic weed infestation was significant in the trial.

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CHAPTER ONE

INTRODUCTION

1.1 Production and Uses of Cowpea

Cowpea *(Vigna unguiculata (L.)* Walp.) is an important food crop which provides supplementary plant protein to human diets and livestock feeds. The cotyledons contains 17 - 40% protein (Bressani and Elias, 1980). Cowpea is cultivated on 12.5 million hectares cultivated in many tropical and sub tropical countries with an annual production of over 3 million tonnes of grains world wide (Singh *et al.*, 1997). Out of this, Africa produced 64% while the annual production of cowpea in Nigeria is estimated at about 1.7 million tonnes on 4 million hectares (Singh *et al.*, 1997).

In Nigeria, cowpea is used both as vegetable and as pulse. According to Purseglove (1974), it is also used as green manure and for animal feed; the ash from the burnt herbage is also used as potash for cooking. The young succulent leaves are eaten as vegetable containing about 25% protein (Oyenuga, 1959). Cowpea seeds form a major source of storable and transportable protein in the tropics (Purseglove, 1974; Rachie and Rawal, 1976).

Despite the importance of cowpea in the Nigerian diet and economy, its production has remained in the hands of peasant farmers whose traditional methods do not sufficiently meet the challenges of the fast growing population of the country (Ezedinma,

1961). The grain yield of cowpea is generally low in Nigeria (Anon., 1975). Hartmans (1983) reported an average grain yield of 250kg ha^{-1} for Nigeria compared with 3,103kg ha^{-1} and 651kg ha^{-1} reported for Egypt and Malawi, respectively (Anon., 1975). The low yield in Nigeria has been attributed to the fact that the crop is rarely planted sole unreliable distribution of rainfall in northern Guinea and Sudan ecological zones, pests, diseases and weeds, especilly parasitic weeds such as *Striga* and *Alectra*.

It has been reported that 50 - 69% of cowpea yield loss resulted from weed competition (Moody, 1973; Medrano, 1973; Akobundu, 1980; Lagoke *et al.*, 1982). Weeds also act as host for insects, diseases and nematodes whose infection might increase yield losses (Lagoke *et al.*, 1981).

1.2 Parasitic Weed Problems in Cowpea

In addition to pests and diseases, two distinct root parasitc weeds *Striga gesnerioides* (Wild) vatke and *Alectra vogelii* Benth both of the family Scrophulariaceae have devastating effects on cowpea while *Striga* is more wide spread in the sahel, sudan and southern Guinea savanna of the sub saharan Africa, *Alectra* appears to be more destructive in the northern Guinea and Sudan savannas (Aggarwal, 1985; Emechebe *et al.*, 1991). Although attack by *Alectra* is less dramatic than that by *Striga*, total yield loss is not uncommon in fields heavily infested by these parasites when susceptible varieties of cowpea are planted (Emechebe, 1981; Emechebe *et al.*, 1983). *Alectra* has been reported to cause yield losses of up to 100% in a susceptible varieties of cowpea and groundnut

(Emechebe *et al.,* 1983; Lagoke, 1989). Atokple *et al.* (1991) reported yield loss of up to 100% in a susceptible, and up to 90% in moderately resistant cowpea varieties when *Striga gesnerioides* population was over ten per plant. Fields infested with the parasites are difficult to clean due to the high prolificity of the plants and the longevity of the seeds. The dormancy mechanisms of the seeds makes it possible for tthem to stay in the soil for several years (Uttaman, 1950; Emechebe *et al.,* 1983). Several cultivable lands have been abandoned as a result of high infestation of these noxious weeds.

1.3. **Control of Parasitic Weeds in Cowpea**

Considerable work has been done on various control methods for parasitic flowering plant species, although *Striga gesnerioides* and *Alectra vogelii* have received relatively less attention. Cultural practices recommended to limit *Striga* infestation include trap cropping, hand pulling, crop rotation and tillage operations (Timson, 1929; Andrew, 1947; Dogget, 1954).

Handpulling and cultivation are labour intensive and increasingly expensive for farmers. Control of the cereal - parasitizing species of *Striga* by trap crops or false hosts that stimulate the germination of seeds of the parasites show promise but no trap crop have been identified for *Striga gesnerioides* and *Alectra vogelii.*

The use of high nitrogen fertilizer has proved effective in reducing the number of plants infected and *Alectra* shoot count but resulted in cowpea grain yield depression (Magani, 1994). However the results have been inconsistent and inconclusive with cowpea *Striga*

(Adu *et al.*, 1989; Emechebe *et al.*, 1991), Preliminary studies in sand culture, however showed that 140ppm N applied as Sodium nitrate solution drastically reduced the incidence of *Striga gesnerioides* infection in potted cowpea (Emechebe et al., 1988). The constant weeding advocated as a control measure by Olunuga and Akobundu (1980) has been found ineffective. This is because of intensive labour requirements, re-emergence of *Striga* and *Alectra* (Emechebe *et al.*, 1983) and the severe crop damage done by the subterranean *Striga* prior to its emergence (Press and Stewart, 1987). Emphasis on control of *Striga* and *Alectra* in cowpea has been placed mainly on host plant resistance (Aggarwal, 1985; 1989). However, complete reliance on host plant resistance is not advisable, rather a strategy that combines *Striga* - resistant cultivars with appropriate complementary agronomic practices has been advocated (Ramaiah, 1984; 1990). Resistant cultivars of cowpea acceptable to farmers are not widely available, and recent research indicates the possibility of races of *Striga gesnerioides* (Parker and Polniaszek, 1990) making control through host plant resistance more difficult.

The pre-emergence and post-emergence application of imadazolinone and imazaquin herbicides were found to be effective in controlling the parasitic plants *Orobanche crenata* Forsk in broad bean (Garcia-Torres *et al.*, 1991) and *Cuscuta* spp in Soyabean (Liu and Lecocq, 1991). Berner *et al.* (1992) developed a method using imazaquin that was effective in controlling soil borne fungi, which in many aspects are similar to flowering root parasites. However, herbicides are not widely used in Africa because of the high cost and the attendant application equipment problems. Seed

treatment would be a cost effective method of herbicde application for the control of root parasites, as it would eliminate the need for application equipment and reduce the amount of active ingredient required for control. Cinosulfuron and CGA 152'005 are taken up mainly by roots and shoot. Seed treatment might prove non-injurious to the host while providing protection against the parasites (Ciba-Geigy handbook).

The study was conducted with the following objective

(1) To evaluate the effect of seed treatments with Sulphonylurea herbicides, Cinosulfuron and CGA 152'005 on the reaction of cowpea varieties to *Alectra vogelii* Benth and *Striga gesnerioides* (Willd.) Vatke.

CHAPTER TWO

LITERATURE REVIEW

2.1 Biology of Parasitic Weeds of Cowpea

Alectra vogelii Benth. has large yellow flower which distinguishes it from *Striga gesnerioides* which usually has purple flowers. Some features common to *Alectra* and *Striga* are the herbaceous shoot habit and tiny dust-like seed which are produced in large numbers. The seeds are about 0.25mm to 0.35mm long and 0.12mm to 0.20mm broad. *Alectra* is alleged to produce from 40,000 to 450,000 seeds per plant with an average of 431 to 1,761 seed per capsule (Kust, 1963). Longevity of seeds in the soil vary between six months and 20 years depending on climatic conditions (Babawi *et al.*, 1984). *Alectra* seed germination occurs in response to the stimulus of root exudates of potential host. Root exudates from various members of the Leguminoseae induced *Alectra* seed to germinate (Botha, 1948). *Alectra* seeds are well protected by thick seed coats and usually remain dormant until they are induced to germinate by exudates from the roots of the hosts (Okonkwo and Nwoke, 1975; Visser, 1975). The majority of the seeds within 2mm of the host root receive sufficient stimulant to germinate, such that few seeds are wasted through being distant from the host root. Many of the seeds which imbibe water and fail to germinate enter a period of "wet dormancy" (Reid and Parker, 1979).

Growth occurs largely at the meristem during the germination of the seeds of both *Alectra vogelii* and *Striga gesnerioides*, resulting in seedlings with elongated radicles

(Okonkwo and Raghavan, 1982). The radicles of two parasitic weeds grow to a maximum of 3mm and 2mm respectively, and penetrate a compatible host root within 8 to 10 days to survive. The radicle of the parasite first penetrates the host cortex, and induces lateral root formation by the host. In the case of *Alectra*, general dilation of the host root progresses into stele and then xylem, thereby completing the connection between the host and the parasite. A complex tuberous structure is then formed by the haustorium of the parasite and the host root.

2.2. Ecology and Distribution of *Alectra Vogelii*

Alectra, as a weed shows great phenotypic plasticity, and wide environmental tolerance. *Alectra* is known to parasitize cultivated legumes in many parts of Africa, from Swaziland to the Transvaal in Southern Africa. The distribution of this purely African species extends through Central Africa to Burkina Faso and Mali in the West and Kenya, Uganda, Tanzania and Ethiopia in the east of the continent (Richie, 1987; Lagoke *et al.*, 1992).

Striga gesnerioides is widely distributed in Africa as range extends from Morocco and Sudan to around 30°S in South Africa. Although *Striga gesnerioides* is known to infest cowpea fields in the dry sahelian and savanna zones of West and Central Africa, streching from Senegal to Chad in the Sahel and the coastal savannas of Southern Togo and Benin (Agbobli, 1991; Gbehounou, 1994).

The seeds of most parasitic weed plants can be disseminated by a combination of wind and water. Seeds of *Alectra* are also soil borne. Emechebe *et al.* (1983) and Lagoke (1989) reported that the seeds are spread by contaminated agricultural equipment and seeds of host crop like cowpea, groundnut and bambara groundnut. Seeds of this parasitic weed fed to animals may pass through the gut undigested in animals when ingested during feeding or medication alone or in combination with other herbs. Berner *et al.* (1995) have however indicated that the spread by animals is insignificant compared with that of the crop seed.

2.3. Effect of Parasitic Weeds on Cowpea

A considerable damage is inflicted on food and fodder plant by wide-spread occurence of parasitic flowering plants. *Striga* is presently the most important biological constraint to food production in Africa (Sauerborn, 1991; Emechebe *et al.*, 1991). Visser (1978) earlier predicted that although *Alectra* was not yet considered very important agriculturally, it was a potential danger in all areas where leguminous crops were being cultivated throughout the African continent South of the Sahara. *Alectra* has been reported to cause yield loss of up to 100% in susceptible cowpea varieties and 90% in moderately susceptible varieties when the level of attack was up to ten *Alectra* plants per cowpea plant. Aggarwal and Ouedraogo (1989) reported that yield loss of cowpea due to *Striga gesnerioides* were 56% in a susceptible variety with 83% plants infected and 30% in less susceptible varieties with 40 to 50% plants infected. Magani (1994) and Lagoke *et al.* (1994, 1996a, 1997) reported yield loss in cowpea as a result of parasitic

weeds infestation.

2.4. Symptoms of Parasitic Weed Infection in Host Crop

The extent of the physiological disorder caused by *Striga gesnerioides* in cowpea which include drastic and extensive loss of carbohydrates from the host cowpea plant, correlated with the size of the robust haustoria of the parasite which consists of phloem and other transport cells (Ba, 1983). The removal of organic compounds mainly carbohydrates in large quantities results in extensive damage to the cowpea plant, despite the relative small size of the parasite.

The most common above ground symptom observed on cowpea infested by *Striga gesnerioides* in the field and screen house is interveinal chlorosis (Emechebe *et al.*, 1988; Aigbokhan and Hussain, 1991). On a heavily infected plant, an important symptom is foliar desiccation which may be preceeded by interveinal rusty brown to purplish spots; a few days later the areas around spots suddenly desiccate to produce straw-coloured necrotic spot with water-soaked margins. Coalescence of several spots result in blighting of the lamina (Aigbokhan and Hussain, 1991). A leaflet may be completely desiccated before the blight spreads to the rachis resulting in necrosis in which consequently results in the desiccation of other leaflets. Desication later spread from the petioles to their points of attachment to the stem which then dries up downwards, rarely upwards. However, pre-mature abscission of the leaf or leaflet prevents internode desiccation. In addition, a less severely infected plant may be stunted while mild chlorosis is symptomatic

of even light infection. The effect of *Alectra* on cowpea is invariably the same as that of *Striga gesnerioides* although less dramatic (Emechebe *et al.*, 1983).

2.5. Sources of Resistance to *Striga* and *Alectra* in Cowpea

Although no absolute resistance to *Striga* has been found in cereals, several sources of true resistance to *Striga gesnerioides* and *Alectra vogelii* have been identified in cowpea. Field screening of 54 varieties at Kamboinse Burkina Faso in 1981 indicated two *Striga* resistant varieties: SUVITA-2 from Burkina faso amd 58-57 from Senegal (IITA/SAFGRAD, 1981; IITA, 1982). These two varieties supported little or no *Striga* emergence compared to a large number of emerged *Striga* on susceptible check varieties. From 1983 to 1986, systematic field testing programmes were conducted in Niger, Nigeria, Burkina Faso and Mali (IITA/SAFGRAD, 1983). The screening involved these resistant varieties and derivatives of cross from SUVITA-2 to ascertain the stability of *Striga* resistance across the West African savanna. The result showed that SUVITA-2 and 58-57 maintained their high level of resistance only in Burkina Faso and Mali, but low to very low level of resistance or complete susceptibility in other countries, giving credence to the presence of different strains of *Striga gesnerioides* (Aggarwal, 1986; IAR 1986; 1987; Muleba *et al.*, 1996). Screen house studies conducted at Weed Research Organization (WRO) in UK using seeds of these cowpea varieties and *Striga* from various countries in West Africa, confirmed the previous field observations that there were at least two strains of *Striga gesnerioides* in West Africa (IITA, 1984; 1985 Aggarwal, 1985). The search for additional sources of resistance resulting in the

discovery of two new sources of resistance to *S. gesnerioides*, B301 and IT 82D-849 in 1997. They showed stable resistance to *Striga* across Burkina Faso, Mali, Republic of Niger and Nigeria (Aggarwal, 1988; Emechebe *et al.*, 1991). B301, a landrace from Botswana was initially identified to be resistant to *Alectra vogelii* in Botswana (IITA/SAFGRAD, 1981). IT82D-849 is an improved breeding line developed at IITA whose source of resistance is from Emma 60, a variety from Uganda. Parker and Polniaszek (1990), and Bailey and Terry (1990) independently reported the combined resistance of B301 to *Striga* and *Alectra* in and confirmed the stable resistance of IT82D-849 to *S. gesnerioides* and its susceptibility to *Alectra*. Singh and Emechebe (1979) and Lagoke *et al.* (1996a) reported that IT81D-994 and IT8ID-985 exhibited resistance by combining support for low emergence of *Striga* and *Alectra* with the production of high cowpea grain yields. Systematic genetic studies have revealed a single dominant gene for *Striga* and independent duplicate dominant genes for *Alectra* resistance in B301 (Singh and Emechebe, 1990a, 1990b; Singh *et al.*, 1993; Atokple *et al.*, 1993). Also studies have shown that resistance in IT 82D-849 to *Striga* is controlled by a single dominant gene which is different from that of B301 (Atokple *et al.*, 1993). In addition to these sources of resistance to *Striga* and *Alectra*, a number of moderately resistant lines have been identified. These improved breeding lines includes IT81D-994, IT86D-472, IT84D-666, IT86D-534 and IT86D-371 which were developed at IITA and showed delayed emergence of smaller number of *Striga* and *Alectra* which rarely grow to maturity (Singh and Emechebe, 1990b).

2.6. Chemical Control of Parasitic Weeds in Cowpea

Chemicals are generally applied pre-emergence or post-emergence in various crops (Ayensu, *et al.*, 1984; Doggett, 1988). Pre-emergence herbicides capable of controlling these parasites include the dinitroanilines (DNAs) and Diphenyl ethers (Eplee *et al.*, 1991). Among the DNA's trifluralin, benefin, fluchloralin and pendimethalin have been found effective. Another promising chemical in the group is formesafen (Eplee *et al.*, 1991). All these herbicides reduce the emergence of *Striga* and *Alectra* to various degree in host crop plants.

Pre-emergence and post-emergence herbicides most commonly used to stop the reproduction of *Striga* in cereals are the salt formulations of 2, 4-D (Choudhari et al., 1980; Yaduraju and Hosmani, 1979; Lagoke *et al.*, 1993a; 1996b). They are applied to *Striga* foliage about the time of flowering at the rate of 0.5 - 1.0kg a.i/ha. The herbicides are also effective in preventing *Striga* seed production (Yaduraju and Hosmani, 1979). However, these treatments do not prevent the irreversible damage inflicted between the time of parasite attachment to and emergence on the crop.

Currently the use of systemic herbicides to control *Striga* at incipient attachment being investigated (Eplee *et al.*, 1991). Schmitt *et al.* (1991) demonstrated the effectiveness of the systemic non-selective herbicide, glyphosphate, in killing broomrape (Orobanche spp.) on broad beans (*Vicia faba*) and other crops at or soon after parasite attachment. Metalachlor has recently been found in field trials to provide sufficient

suppression of *Striga* attachment (Eplee *et al.*, 1991). Pendimethalin is a pre-emergence herbicide that was observed to provide sufficient suppression of *Striga* attachment in field trials. When applied at 1.7kg a.i/ha it gave a 100% reduction of early *Striga* emergence (Eplee *et al.*, 1991). Imazaquin which is absorbed by the roots and foliage is translocated to other parts in both the xylem and phloem (Shaner *et al.*, 1983). although it has been suggested that the chemical is to be mainly obsorbed through the root (Orwick *et al.*, 1983).

In Nigeria, Magani *et al.* (1992) reported that pre-emergence herbicide applications of the mixtures containing metazachlor + antidote, followed by imazaquin at 0.18kg a.i/ha significantly reduced the number of cowpea plants infected by *Alectra*. Similarly in 1991, pendimethalin plus imazaquin at 0.87 + 0.15 and 1.09 + 0.19kg a.i/ha and pendimethalin plus imazethapyr at 1.58 + 0.12kg a.i/ha, all followed by imazaquin at 0.18kg a.i/ha resulted in lower number of cowpea plants infected by *Alectra* compared with the weedy check. The author further observed that, post-emergence application of metazachlor plus imazethapyr at 1.0 + 0.075kg a.i/ha resulted in lower number of infected cowpea plants compared with the maximum obtained with pendimethalin plus imazaquin at 1.09 + 0.19 kg a.i./ha and pendimethalin plus imazethapyr at 1.58 + 0.12 kg a.i./ha, both followed by single hoe weeding.

Seed treatment for the control of parasitc weeds in cowpea

Seed treatment has also been used by some researchers for the control of *Alectra* spp. and *Striga* spp. Farmers in Sokoto state, Nigeria have claimed that soaking the seed in brine or extract of *Parkia filicoides* reduces *Striga* infestation while in Mali the use of Nere (*Parkia biglobosa*) powder has been shown to be ineffective (Konate, 1989). Researchers at National Cereals Research Institute, Badegi, Nigeria have claimed some degree of success with brine and locust bean extract (Olaniyan *et al.*, 1990). Berner *et al.* (1994) reported that using imazaquin at 1.8mg/ml gave good parasite control. Garcia-Torres and Lopez-Granados (1991) tried imazaquin on orobanche and obtained effective control of the parasitic weed. More recently imazethapyr was found to provide early season *Striga* control when applied to the maize seed at planting (Ransom *et al.*, 1995). Berner *et al.* (1994) also found that *Striga gesnerioides* could be controlled in cowpeas by soaking the seed before planting in an aqueous solutions of imazaquin.

Sulphonylurea herbicides

This is a sub-group of the substituted ureas consisting of herbicide molecules characterized by low mammalian toxicity and high phytotoxicity particularly on broadleaf weeds. They are applied either pre-emergence or post-emergence because they are taken up by plants through both the roots and foliage (Akobundu, 1987). Sulphonyl-urea herbicides are generally used at a very low rates for effective control of weeds. They are easily degraded by soil microbes and so not leave any residue in the soil and underground water. They are environmentally friendly especially when used effectively as seed

treatment.

CGA 152'005, a herbicide developed by CIBA-GEIGY provides selective pre-emergence and post-emergence control of annual dicotyledonous weeds in maize, sorghum and sugar cane. As pre-emergence herbicide it controls weeds very well at 10 - 40g a.i/ha. The herbicide has a solubility of 0.030g/l in water at pH 5.1, 3.580g/l in water at pH 6.8 (buffer solution) 6.4% w/v in acetonitril and 2.1% w/v in methanol at 20°C. It is formulated as wettable powder and granules. CGA 152'005 is absorbed via both the foliage and the plant roots. The ratio of foliar to root uptake may vary with environmental conditions. The uptake via the foliage is significantly enhanced by addition of a non-ionic surfactant or a crop oil concentrate to the spray solution. Lower residual activity is observed under dry soil conditions especially in late germinating or large-seeded weeds (Anon. 1993). The growth of the susceptible plant treated with CGA 152'005 stops rapidly. The plant becomes yellowish or reddish and begin to die. Death of these species take one to three weeks to occur. The primary site of action of CGA 152'005 is the inhibition of enzyme acetolactate synthase (ALS) responsible for protein synthesis. Ishaya (1997) reported that both maize and rice crops tolerate CGA 152005 at rates between 0.01 and 0.03 kg a.i/ha.

Cinosulfuron (3-C4, 6 - dimethoxy)phenyl-sulfuron urea (setoff) is a selective herbicide used mainly for the control of weeds in rice. Lagoke *et al.* (1993; 1994)

reported the selectivity of the herbicde in other cereals including maize, sorghum and millet. The herbicide is absorbed through the roots and shoot. After transportation via the xylem and phloem it inhibits the division in meristematic plant tissues. Guerra *et al.* (1989) reported that cinosulfuron controlled a broad range of weeds of rice including the members of *Alismateceae*, *Cyperaceae*, *Potanogetonaceae*, *Elatinaceae*, and *Lythraceae* family without injuring rice at a rate of 80g a.i/ha. Burhan *et al.* (1989) reported greater than 80% control of *Monochoria vaginalis*, *Marsiloa crerata*, *Cyperus*, *Scirpus juncoides* and *Fimbrystyle miliacea*, but only 50 - 60% control of *Echinochloa Cirus-galli* - in transplanted rice cultivar IR - 64 and IR - 36, in Indonesia. The results of greenhouse and field trials on tranplanted and direct sown rice in Indonesia and Thailand showed the broad spectrum activity and low dose requirements of cinosulfuron (Quadranti *et al.*, 1987). Crop tolerance and flexibility of application date are considered the major advantages of the herbicide (Quadranti et al., 1987). In trials conducted in Malaysia and Thailand, 10 - 20g a.i/ha of cinosulfuron, applied alone provided 76 - 99 and 25 - 27% control, especially of grasses mainly *Echinochloa crus-galli* and *Leptochloa chinensis* and 29 - 68 and 91 - 94% control especially of broadleaved weedes mainly dorminated by *Limnocharis flava*, *Sagittaria guyanensia* and *Sphenoclea zeylanica* (Here *et al.*, 1989). Achilderon *et al.* (1987) recommended the application of cinosulfuron at 20g a.i/ha, 3 to 15 days after sowing or transplanting for optimum efficiency in weed control.

2.7 Acetolactate Synthase Inhibitors

The site of action of this group of herbicides is acetolactate synthase (ALS). They

are the sulfonylureas, imidazolinones and the triazolopyrimidine sulfonanilides (DeVine *et al.*, 1993a, Hawkes *et al.*, 1989). These herbicides act on the acetohydroxy acid synthase or AHAS which is the first enzyme in the branched chain amino acid pathway that produces valine, leucine and isoleucine (DeVine *et al.*, 1993a). This enzyme and others in the pathway are found only in the plastid. It is nuclear encoded and, thus requires a transit sequence to be properly imported and processed. The ALS inhibitor herbicide stops the growth and then kill the plant relatively slowly compared to some of the older contact herbicides. ALS appears to be a particularly good molecular target site for herbicides considering how little of the best inhibitors is needed to kill plants. Only a few grams per hectare of certain sulfonylureas are needed to kill target weeds. Crops that are naturally unaffected by the ALS inhibitor compounds are resistant due to rapid metabolic degradation of the herbicide (Beyer *et al.*, 1988; Shaner and Millipudi, 1991). However, weeds that have evolved resistance to ALS inhibitors almost always have evolved an ALS that is resistant to the herbicide (DeVine *et al.*, 1993; Schmitzer *et al.*, 1993).

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CHAPTER THREE

MATERIALS AND METHODS

3.1 Laboratory Experiment

The effect of CGA152'005 at 0.008, 0.016, 0.032, 0.064g/l and cinosulfuron at 0.05, 0.1,0.2 and 0.4g/l on the germinability of the seeds of five varieties of cowpea (IT 81D-985, SAMPEA 7, SAMPEA 6, IT 90K-102-1 and IT 89KD-245-1) used in the study was evaluated in the Weed Science Laboratory of the department of Agronomy, Institute for Agricultural Research, Ahmadu Bello University, Samaru, Nigeria. One hundred seeds each of the five cowpea varieties were weighed dry before soaking either in distilled water or herbicide solutions for five minutes. The liquid on the seeds was dried off with tissue paper before the wet weight was taken. Twenty seeds of each batch were then transfered to the moist filter paper in each petridish. Twenty dry seeds of each variety were also similarly placed on moist filter paper in the petridishes as control. All the treatments were replicated three times and arranged in a completely randomised design (CRD). They were kept in the incubator for seventy-two hours at 28°C. The germinating cowpea seeds in each petridish as reflected in radicle production was then recorded. The characteristics of the cowpea varieties used and details of temperature and relative humidity of the incubator during the period of the experiment are contained in Appendices 1 and 2.

3.2 Screen house Trial

3.2.1 General Screenhouse Practice

The same treatments of cowpea varieties and herbicide seed treatments concentrations were used in the laboratory the screenhouse to evaluate the tolerance of cowpea varieties to CGA 152'005 and cinosulfuron and also to evaluate the sulfonylurea herbicide for the control of *Alectra vogelii* and *Striga gesnerioides*. The trial was conducted between February and April, 1995 in the screenhouse at the Institute for Agricultural Research, Samaru. The treatments were factorially combined and laid out in a randomised design (CRD) with three replications. There were a total of 300 pots out of which 150 pots were inoculated with approximately 16000 *Alectra* seeds/pot. The remaining 150 pots were not inoculated with *Alectra* seeds and used to evaluate cowpea varieties for tolerance to the herbicide seed treatments. About 1000cc of soil was used to fill each pot whose size was 14cm x 14cm. Four seeds of cowpea were planted per pot, and thinned to two plants two weeks after seedling emergence. The pots were watered to field capacity for seven days before planting and once daily after planting.

3.2.2 Alectra seed inoculant preparation

In the screenhouse trials, 20cc of *Alectra* seeds was mixed with sieved dry sand (180μ size) in an air filled polythene bag and shaken throughly for five minutes to ensure a uniform distribution of *Alectra* seeds. Then 20cc sand was added to the 40cc of *Alectra* seed/sand mixture and again thoroughly shaken for five minutes. The *Alectra* seed/sand mixture was then mixed with equal volume of the sieved sand before the shaking process

was repeated. Subsequently 20cc, 100cc, 200cc of sand were serially added to the *Alectra* seed/sand mixture and the shaking process repeated after every addition to bring the final volume of *Alectra* seeds/sand mixture to 400cc. The mixture of the 400cc was shaken for 3minutes and the mixing process continued with addition of 400cc of the sieved sand to the 400cc *Alectra* seed/sand mixture. The 800cc *Alectra* seed/sand mixture obtained was then made upto a final volume of 1000cc by addition of 200cc of sand. The 1000cc contained about 160,000 seeds (as determined by Emechebe, 1983).

To prepare inoculated soil for each pot 100cc of the stock was used containing about 16000 *Alectra* seeds was used and to this was added 700cc of soil/sand mixture (1:1v/v). This gave 800cc of inoculated soil. To the bottom of the plastic pots (14cm x 14cm) was added about 100cc of sand. The 800cc of inoculated soil was then added to the top of the sand.

3.3 Field Trial

3.3.1 Description of Experimental Site

Two field experiments were conducted in the 1995 wet season on the farm of the Institute for Agricultural Research, Samaru (11°11'N 38E) in the Northern guinea savanna ecological zone of Nigeria. One of the fields which have been previously infested with *Alectra vogelii* and *Striga gesnerioides* was reinfested with *Alectra* seeds at approximate rate of 16,000 seeds per hill two weeks before planting the crop. The other field was completely free of *Alectra*. The two fields received the same treatments of cowpea

lines/varieties and herbicide seed treatment. The soil of the experimental sites was sandy loam. Details of the physico-chemical characteristics of the soils and rainfall distribution records during the periods of the experimentation are presented in Appendices 3 and 4 respectively.

3.3.1 Experimental Treatments and Layout

The treatments consisted of five cowpea varieties (IT81D-985, SAMPEA 7, KANO 1696, IT90K-102-6 and IT89KD-245-1), and two herbicide seed treatments (Cinosulfuron at 0.05, 0.1, 0.2 and 0.4g/l, CGA 152005 at 0.008,0.016,0.032 and 0.064g/l, dry seed planting and water soaked) seed planting laidout in a split-plot design with three replications. The cowpea varieties and herbicide seed treatment were the mainplot and sub-plot treatment, respectively. The gross and net plot size were $9m^2$ and $3m^2$, respectively.

3.3.2 Cultural Practices

The land was ploughed and disc harrowed one week later in order to get a fine tilth before ridges were made. Three cowpea seeds were planted per hill at 25cm intra row spacing on 75cm wide ridges on August 6 and 7, 1995. These were thinned to two plants per stand at two weeks after sowing (WAS). Single super phosphate was applied at the rate 24kg P/ha at cowpea emergence by spot application. In one trial, *Alectra* seeds/sand inoculum was prepared by mixing 10g of *Alectra* seeds with 250g of sieved sand (180μ size). The mixture was shaken thoroughly in an air filled polythene bag for

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five minutes to ensure a uniform distribution of Alectra seeds in the sand/seed stock. The 260g of Alectra seed/sand stock was used to inoculate the planting holes using one cover of coke (2.5g) per planting hole on the field naturally infested with *Alectra vogelii* and *Striga gesnerioides*.

Fungal diseases on cowpea plants were controlled by the application of a mixture of benomyl (Benlate) and mancozeb (Dithane M 45) at the product rate of 0.6kg and 2.5kg/ha respectively at 5 and 6 WAS. Cypermethrin (Cymbush 10EC) and dimethoate (Perfekthion 40EC) were applied forth-nightly at the rate of 1*l*/ha each as tank mixture three times at 6, 8 and 10WAS to control insect pests. The chemicals were applied with CP3 knapsack sprayer in a spray volume of 240 *l*/ha. Hoe weeding was done at 3 and 9WAS to control weeds. Harvesting was carried out by hand picking of the mature dry pods from each plot.

3.4 Observations

3.4.1 Screen House

The following observations and data recordings were carried out in the screenhouse.

- Number of days to first *Alectra* emergence
- *Alectra* shoot count, crop injury score, crop vigour score, number of cowpea nodules.

3.4.2 Field Experiment

a. <u>Alectra and Striga Parameters</u>

Data collected on *Alectra* from the net plots included the number of days to first *Alectra* emergence. This was done by counting the number of days it took the *Alectra* plants to emerged. Number of plants infected with *Alectra* and *Striga* at 8, 9 10WAS and at harvest. *Alectra* shoot count at 8, 9, 10 weeks after sowing (WAS) and at harvest. This was done by counting of *Alectra* and *Striga* that have emerged.

3.4.3 b. <u>Crop Establishment and Growth</u>

The following observations were made on the crop establishment and growth from the net plots:-

(i) <u>Crop stand count</u>: This was done by counting at 10 days the number of cowpea plants per plot.

(ii) <u>Crop injury score:</u> The description of the sacle used is presented in Appendix 5, visual observatations was done to assess the crop injury score using scale 1 - 5 at 6 and 9 WAS where 1 = normal crop plant growth, and 5 = total leaf scorching and obvious stunted or dead plants (Appendix).

(iii) <u>Crop vigour</u>: Crop vigour score at 6 and 9WAS. The scoring was done by visual observation inorder to assess the vigour of crop growth using the scale of 1 to 9, where '9' was assigned to plots with fully healthy crop and '1' to those with completely dead plants (Appendix 5). In this visual

observations, plant height, greenness of foliage and the spread of the plant canopy were considered.

(iv) Crop dry matter per plant: Crop dry matter at 3, 6 and 9 WAS was taken by uprooting 5 plant samples using hand trowel. The plant samples were oven dried at 70°C for 24 hours to a constant weight for the determination of dry matter production.

(v) The number of days to 50% flowering: The Cowpea plant on each plot was also taken by visual observation.

3.4.4 c. Yield and Yield Components

Data collected on yield and yield components from the net plots include number of pods, pod and grain (kg)weight per plot and weight of 1000 grains (g) of cowpea.

3.5 Data Analysis

All the data collected were subject to analysis of variance for test of significance and treatment means were compared using Duncan's Multiple Range Test (DMRT) at 5% levels of probability. The relationship between various crop parameters and yield components were also determined in a correlation coefficient analysis.

CHAPTER FOUR

RESULTS

4.1 The Effect of Seed Treatments of Cinosulfuron and CGA 152005 on the Germinability of Cowpea in the Laboratory

As reflected in increase in their weights, seeds of cowpea varieties imbibed liquid differentially after soaking in water and herbicide solution for five minutes. Varieties IT81D-985,and SAMPEA 6 absorbed significantly more liquid than the other three, varieties, SAMPEA 7, IT89KD-245-1 and IT90K-102-6 (Table 1).

Cowpea varieties also differed significantly with respect to their germinability after soaking in the laboratory (Table 1). IT90K-102-6 and IT89KD-245-1 exhibited significantly lower seed germinability than the other three varieties, SAMPEA 7, SAMPEA 6 and IT81D-985. CGA 152005 at all concentrations and cinosulfurin at 0.1g/l reduced the germination of cowpea seed significantly compared with the highest obtained with cinosuilfuron at 0.05g/l.

4.2 Effect of Seed Treatments of Cinosulfuron and CGA152005 on the Establishment, Growth, Yield and Yield Components of Cowpea Varieties and Parasitic Weeds.

Tables 2 - 23 contain results on crop injury score, crop vigour score, number of nodules, number of leaves, plant height, dry matter production, yield and yield components of cowpea varieties with and without parasitic weed infestation both in the screen house and the field.

Table 1: Effect of sulphonyl-urea herbicides seed treatment on the germinability of five cowpea varieties in the laboratory at Samaru, 1995 dry season.

Treatments	% in crease in weight	Seed germination No/20	%
Cowpea varieties			
IT81D-985	83.0	19.7a[1]	98.5
SAMPEA 7	68.8	18.0a	90.0
SAMPEA 6	82.6	18.0a	90.0
IT90K-102-6	79.7	14.7b	73.5
IT89KD-245-1	82.7	14.3b	71.5
SE±		0.88	
Seed treatment(g/l)			
Cinosulfuron			
0.05	77.7	18.0a	90.0
0.1	79.7	15.3bc	76.5
0.2	80.3	17.3ab	86.5
0.4	79.0	17.0ab	85.0
CGA 152005			
0.008	78.3	14.3c	71.5
0.016	78.3	13.3c	66.5
0.032	77.7	14.3c	71.3
0,064	80.3	15.3bc	76.5
H_2O soaking	77.7	17.0ab	85.0
SE±	18.8	1.10	

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

4.2.1 Crop Stand Count

Cowpea varieties differed significantly in stand count at harvest under parasitic infestation with SAMPEA 6 having the higher number of cowpea stands than IT90K-102-6 (Table 2).

Herbicide seed treatments did not have significant effect on crop stand count. The interaction of variety and herbicide seed treatments on crop stand count of cowpea was also not significant.

4.2.2 Crop Injury Score

Cowpea varieties differed significantly in crop injuryscore at 3WAS with and without parasitic weed infestation in the screen house and the field, at 6WAS with infestation only in the field (Tables 3 and 4). In the screen hous' , IT90K-102-6 had the highest injury score with and without parasitic weeds inoculation. Without *Alectra* inoculation, IT81D-985 also had higher injury score at 3 and 6WAS than the other varieties, while the least injury score was observed in SAMPEA 6 (Table 3). In the field, variety IT90KD-245-1 exhibited signifiantly higher injury score at 3WAS than all the other varieties which had similar scores. At 6WAS SAMPEA 6 and IT90K-102-6 exhibited lower injury score than the othert varieties (Table 4). Crop injury score of cowpea at 3 and 6 WAS also differed significantly among the herbicide seed treatments with and without *Alectra* inoculation in the screen house and at 6WAS with *Alectra/Striga* infestation in the field. In the screenhouse the highest concentration of CGA 152005, i.e. 0.064g/l, caused significantly higher injury score of cowpea than the other herbicide treatments with *Alectra* inoculation. Although similar trend was observed without

Table 2: Effect of sulphonyl-urea herbicide seed treatments on cowpea stand count with and without *Alectra/Striga* infestation at Samaru, 1995 wet season.

Treatments	Crop stand count at harvest (No/plot (m^2))	
	infested	unifested
Cowpea		
IT81D-985	23.4ab	23.8
SAMPEA 7	24.3ab	24.2
SAMPEA 6	25.5a	24.8
IT90K-102-6	23.0b	24.6
IT89KD-245-1	23.2ab	24.8
SE±	0.98	0.40
Seed treatment (g/l)		
Cinosulfuron		
0.05	22.3	24.7
0.1	23.5	24.4
0.2	22.9	24.4
0.4	22.8	24.1
CGA 152005		
0.008	22.7	24.4
0.016	23.5	24.7
0.032	22.9	24.3
0.032	22.5	24.3
0.064	23.9	24.8
Dry planting	24.0	24.2
SE±	0.65	0.29
Interaction		
V x H	NS	NS

1. Means followed by the same letter(s) within a column of a treatment group are not significantly different at 5% level of probability (DMRT)
2. NS = Not significant

Table 3: Effect of sulphonyl-urea herbicide seed treatments on crop injury score of cowpea varieties with and without *Alectra* inoculation in the screenhouse at Samaru, 1995 dry season.

Treatments[1]	**Crop injury score at**[1]**:**			
	3WAS[2]		6WAS	
	infested	unifested	infested	uninfested
Varieties				
IT81D-985	1.20b[3]	2.63b	1.07b	1.23b
SAMPEA 7	1.93b	2.27c	1.13b	1.47b
KANO 1696	1.83b	2.00d	1.03b	1.20b
IT90K-102-6	3.10a	3.00a	2.30a	2.20a
IT89KD-245-1	2.07b	2.30	1.27b	1.50b
SE±	0.12	0.11	0.11	0.11
Seed treatment (g/l)				
Cinosulfuron				
0.05	2.00c	2.47b	1.20c	1.27b
0.1	2.00c	2.47b	1.20c	1.27b
0.2	2.00c	2.67b	1.20c	1.47b
0.4	2.33b	2.73b	1.53b	1.53b
CGA 152005				
0.008	2.27bc	2.67b	1.47b	1.47b
0.016	2.27bc	2.67b	1.47b	1.47b
0.032	2.47b	3.27a	1.60b	2.27a
0.064	2.93a	3.47a	1.93a	2.47a
H_2O soaking	1.00d	1.00c	1.20c	1.00c
Dry planting	1.00d	1.00c	1.20c	1.00c
SE±	0.12	0.11	0.11	0.11
Intercation				
Variety x herbicide	NS[4]	NS	NS	NS

1. Based on 1-scale ; 1 = no injury; 5 = complete plant death
2. WAS = weeks after sowing
3. Means followed by the same letter(s) within a column of a treatment group are not significantly different at 5% level of probability (DMRT)
4. NS = Not significant

Table 4: Effect of sulphonyl-urea herbicide seed-treatments on crop injury score of cowpea varieties with and without *Alectra/Striga* infestation at Samaru, during the 1995 wet season.

Treatments	Crop injury score[1] at					
	3WAS[2]		6WAS		9WAS	
	infested	unifested	infested	unifested	infested	uninfested
Varieties						
IT81D-985	2.00b[3]	2.00b	1.90a	1.00	1.90	1.00
SAMPEA 7	2.00b	2.00b	1.97a	1.00	1.90	1.00
SAMPEA 6	2.27b	2.20	1.50b	1.00	1.90	1.00
IT90K-102-6	2.30b	2.00b	1.50b	1.00	1.90	1.00
IT89KD-245-1	3.00a	3.00a	2.00a	1.00	1.90	1.00
SE±	0.1	0.13	0.12	0.10	0.10	0.10
Seed treatments (g/l)						
Cinosulfuron						
0.05	2.20	2.27	1.90b	1.00	1.90	1.00
0.1	2.20	2.67	1.90b	1.00	1.90	1.00
0.2	2.13	2.27	1.50b	1.00	1.90	1.00
0.4	2.00	2.27	2.00b	1.00	1.90	1.00
CGA 152005						
0.008	1.87	2.20	1.50b	1.00	1.90	1.00
0.016	2.13	2.60	1.90b	1.00	1.90	1.00
0.032	2.00	2.13	1.90b	1.00	1.90	1.00
0.064	2.07	2.13	1.90b	1.00	1.90	1.00
H_2O soaking	2.07	2.27	2.90a	1.00	1.90	1.00
Dry planting	2.07	2.24	2.90a	1.00	1.90	1.00
SE±	0.25	0.24	0.23	0.10	0.10	0.10
Interaction variety x herbicide	NS[4]	0.5	NS	NS	NS	NS

1. Crop injury score based on 1-5 scale; where 1 = No injury; 5 = complete plant death
2. WAS = Weeks after sowing
3. Means followed by the same letter(s) are not significantly different at 5% level of probability (DMRT)
4. NS = Not significant

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inoculation CGA 152005 at 0.032 and 0.064g/l caused similar cowpea injury score (Table 3). In the field, all the herbicide seed treatments similarly caused significantly higher injury score compared with the no herbicide controls.

4.2.3. **Crop Vigour Score**

Cowpea varieties differed significantly in crop vigour score at 3 and 6 WAS in the screen house and 3 and 9 WAS in the field with parasitic weed infestation and 3WAS without infestation in the field (Tables 5 and 6). Variety IT90K-102-6 exhibited lower vigour than all the other varieties under *Alectra* inoculation and at 6 WAS without *Alectra* inoculation in the screen house. IT 89KD-245-1 was also less vigorous than IT 81D-985, SAMPEA 7 and SAMPEAS 6 at 6 WAS when infested with *Alectra*. Without inoculation, IT 81D-985, SAMPEAS 6 and IT90K-102-6 were significantly more vigorous than SAMPEA 7 and IT89KD-245-1 at 3 WAS and 6 WAS. In the field, IT90K-102-6 had significantly higher crop vigour score than IT 89KD-245-1 with and without parasitic weed infestation and SAMPEA 7 at 3 WAS with infestation (Table 6). Herbicide seed treatments only had significant effect on crop vigour score of cowpea in the screen house. The seed treatments resulted in significantly lower crop vigour compared with the no herbicide controls in the inoculated pots at 3WAS and the *Alectra* free pots at 3 and 6 WAS. The highest concentration of CGA 152005 resulted in lower vigour score than all the other herbicide treatments while the highest concentration of cinosulfuron (0.4g/l) resulted in lower vigour than its lowest concentration with and without *Alectra* inoculation. The lowest concentrations of the two chemicals, cinosulfuron at 0.05g/l and CGA 152005 at 0.008g/l caused similar crop vigour score of cowpea with *Alectra* inoculation. Cinosulfuron at 0.05, 0.1, 0.2g/l resulted

Table 5: Effect of sulphonyl-urea herbicide seed treatments on crop vigour score of cowpea varieties with and without *Alectra* inoculation in the screenhouse at Samaru, 1995 dry season.

Treatments	Crop vigour score[1] at:			
	3WAS[2]		6WAS	
	infested	unifested	infested	uninfested
Varieties				
IT81D-985	8.90a[1]	8.73a	9.80a	9.50a
SAMPEA 7	8.96a	8.10b	9.80a	9.00c
KANO 1696	8.96a	8.27a	9.80a	9.60a
IT90K-102-6	7.83b	8.53a	8.77c	8.87c
IT89KD-245-1	8.77a	7.93c	9.47b	9.23b
SE±	0.30	0.16	0.27	0.3
Seed treatment (g/l)				
Cinosulfuron				
0.05	8.80b	8.53c	9.80ab	9.53b
0.1	8.67bcd	8.47c	9.67ab	9.47bc
0.2	8.47bcd	8.53c	9.47bc	9.53b
0.4	8.27d	8.20bc	9.20c	9.20
CGA 152005				
0.008	8.73bc	8.27bc	9.73ab	9.2-cd
0.016	8.67bcd	8.07c	9.67ab	9.07d
0.032	8.33cd	7.53d	9.40bc	8.53e
0.064	7.67e	6.87e	8.60d	7.87f
H_2O soaking	9.53a	9.40a	9.73a[3]	10.00a
Dry planting	9.73a	9.27a	10.00a	10.00a
SE±	0.30	0.16	0.27	0.32
Interaction				
Variety x herbicide (SE±)	NS[4]	NS	NS	NS

1 Crop vigour score based on i to 9 scale; where 9 = very vigorous plants, 1 = completely dead plants
2 WAS = Weeks After Sowing
3 Means followed by the same letter(s) within the same column of treatment are not significantly different at 5% level of probability (DMRT)
4 NS = notsignificant

Table 6: Effect of sulphonyl-urea herbicide seed treatments on crop vigour score of cowpea varieties with and without *Alectra/Striga* infestation at Samaru, during the 1995 wet season.

Treatments	Crop vigour score[1] at			
	6WAS[2]		9WAS	
	infested	unifested	infested	unifested
Varieties				
IT81D-985	8.4ab[3]	8.4ab	8.4ab	8.3ab
SAMPEA 7	8.1b	8.3ab	8.2ab	8.3ab
KANO 1696	8.3ab	8.3ab	8.2ab	8.4ab
IT90K-102-6	8.6a	8.6a	8.6a	8.6a
IT89KD-245-1	8.0b	8.0b	8.0b	8.1b
SE±	0.13	0.17	0.15	0.16
Seed treatment (g/l)				
Cinosulfuron				
0.05	8.7	8.9	8.8	8.5
0.1	8.2	8.2	8.5	8.5
0.2	8.2	8.2	8.5	8.5
0.4	8.2	8.2	8.5	8.5
CGA 152005				
0.008	8.5	8.5	8.6	8.4
0.016	8.4	8.5	8.5	8.8
0.032	8.5	8.5	8.5	8.2
0.064	8.3	8.5	8.4	8.4
H_2O soaking	8.1	8.9	8.2	8.5
Dry planting	8.4	8.9	8.2	8.5
SE±	0.25	0.27	0.28	0.27
Interaction				
Variety x herbicide (SE±)	NS[4]	NS	NS	NS

1. Crop vigour score based on 1 to 9 scale where 9 = very vigorous plants and 1 = completely dead plants
2. WAS = Weeks after sowing
3. Means followed by the same letter(s) within the same column of treatment are not significantly different at 5% level of probability (DMRT)
4. NS = Not significant

in crop vigour score comparable to those of no herbicide control at 6 WAS. CGA 152005 at 0.064g/l resulted in lower crop vigour score at 6 WAS than the other herbicide seed treatments with and without inoculation. Without inoculation, CGA152005 at 0.032g/l resulted in lower crop vigour score than the other herbicide seed treatments.

4.2.4 **Nodulation**

Cowpea varieties differed significantly in nodulation with and without parasitic weed infestation at harvest in the screen house and 3 WAS in the field (Tables 7 and 8). IT 89KD-245-1 produced significantly higher number of nodules than the other cowpea varieties except SAMPEA 6 with and without *Alectra* inoculation in the screen house. SAMPEA 7 and SAMPEA 6 also produced significantly higher number of nodules than IT81D-985 and IT 90K-102-6.

Herbicide seed treatments had no significant effect on cowpea crop nodulation in the screen house. In the field, with parasitic weed infestation, variety SAMPEA 7 produced lower number of nodules than all the other varieties while IT81D-985 also produced higher number of nodules than the other varieties. However, without infestation, SAMPEA 6 produced significantly higher number of nodules than all the other cowpea varieties which had similar in nodulation.

Herbicide seed treatments significantly affected cowpea nodulation at 3 and 9 WAS with and without parasitic weed infestation and at 3 and 6 WAS without infestation in the field only (Table 8). With parasitic weed infestation, cinosulfuron at 0.2g/l caused significantly

Table 7: Effect of sulphonyl-urea herbicide seed treatments on the nodulation, leaf production and height of cowpea plants with and without *Alectra* inoculation in the screen house at Samaru, 1995 dry season.

Treatments	Number of nodule/plant		Number of leaves/plant		Plant height/plant (cm)	
	infected	unifected	infected	unifected	infected	uninfected
Varieties						
IT81D-985	22.77c[1]	22.35c	31.60a	30.90a	20.94c	20.53b
SAMPEA 7	31.50b	31.78b	26.60b	26.18b	25.30a	25.70a
SAMPEA 6	36.93ab	36.86ab	32.67a	32.85a	22.52b	21.05b
IT90K-102-6	18.53c	18.16c	37.00a	36.95a	23.08b	24.57a
IT89KD-245-1	41.47a	4.55a	26.90b	26.20b	26.47a	25.93a
SE±	19.44	11.37	2.08	1.27	0.83	0.42
Seed treatment (g/l)						
Cinosulfuron						
0.05	26.73	26.65	30.07c	30.37c	23.87	23.90b
0.1	29.87	29.67	31.47ab	31.50ab	23.83	23.41c
0.2	31.60	31.73	30.73bc	31.75bc	23.23	23.10cd
0.4	33.87	33.86	31.93a	31.83a	23.14	22.70de
CGA 152005						
0.008	27.87	27.00	29.93c	30.05bc	22.62	22.35ef
0.016	33.00	33.20	30.47bc	30.30bc	22.92	21.75f
0.032	29.20	29.70	32.13a	32.25a	22.59	21.13f
0.064	33.20	33.06	32.33a	32.36a	22.39	21.07f
H_2O *soaking*	28.00	28.00	29.80c	29.80c	25.75	26.09a
Dry planting	29.07	29.20	30.67bc	29.85c	26.27	26.05a
SE±	19.44	11.37	2.08	1.27	0.83	0.42
Interaction						
variety x herbicide (SE±)	NS[2]	NS	NS	NS	NS	NS

1. Means followed by the same letter(s) within a column of a treatment group are not significantly different at 5% level of probability (DMRT)
2. NS = Not significant

Table 8: Effect of sulphonyl-urea herbicide seed treatments on crop nodulation with and without *Alectra/Striga* infestation at Samaru, during the 1995 wet season.

Treatments	Number of Nodules/plant					
	3WAS[1]		6WAS		9WAS	
	infested	unifested	infested	unifested	infested	uninfested
Varieties						
IT81D-985	5.59a[2]	5.07b	9.50	18.67	14.22	12.99
SAMPEA 7	4.17c	5.27b	8.80	16.83	14.27	13.00
SAMPEA 6	5.10b	7.30a	10.37	17.23	13.92	13.55
IT90K-102-6	5.03b	5.43b	8.52	17.50	13.90	14.90
IT89KD-245-1	4.93b	3.70b	9.45	17.23	13.73	14.82
SE±	0.13	0.57	0.72	1.00	0.27	0.7
Seed treatment(g/l)						
Cinosulfuron	4.47cd	4.13c	8.87	17.07bcd	13.97a-d	13.64
0.05	5.93b	5.93abc	10.90	21.53a	14.33abc	14.17
0.1	7.40a	7.13ab	10.63	20.87a	13.50cd	13.70
0.2	4.17cd	5.27abc	8.90	16.73bcd	13.73bcd	14.43
0.4						
CGA 152005	3.97d	4.93abc	10.37	17.60bc	14.47ab	14.40
0.008	3.67d	3.79c	7.77	14.00d	13.87bcd	13.57
0.016	5.67b	7.53a	8.20	19.20ab	13.27d	13.30
0.032	4.10cd	5.73abc	8.17	16.07bcd	13.63cd	13.57
0.064	5.10bc	4.60bc	9.10	16.07cd	14.57ab	14.17
H_2O soaking	5.18bc	4.47bc	10.37	15.47cd	14.73a	13.57
Dry planting	0.33	0.90	0.97	1.03	0.27	0.51
SE±						
Interaction variety x herbicide (SE±)	**[3]	NS[4]	NS	*[5]	NS	NS

1. WAS = Weeks after sowing
2. Means followed by the same letter(s) within a column of a treatment group are not significantly different at 5% level of probability (DMRT)
3. NS = Not significant
4. ** = Significant at 1% level of probability
5. * = Significant at 5% level of probability

Table 9: Interaction between variety and herbicide seed treatments on number of nodules of cowpea plants at 3WAS with Alectra infection at Samaru , 1995 wet season.

Treatments	Cinosulfuron (g/l)					CGA 152005 (g/l)			No herbicide control	
	0.05	0.1	0.2	0.4	0.00°	0.016	0.032	0.064	H_2O soaking	Dry planting
Varieties										
IT81D-985	5.50e-m[1]	9.33ab	5.33f-n	7.67b-f	5.17f-o	4.33i-q	3.00m-q	6.67c-i	5.33f-n	3.57k-q
SAMPEA 7	3.17m-q	2.83n-q	6.00d-k	2.50pq	3.17m-q	2.67opq	4.83g-p	3.33l-q	4.33i-q	8.83bc
SAMPEA 6	5.00g-p	2.50pq	11.67a	3.17m-q	3.33l-q	4.33i-q	8.67bc	2.00q	6.33c-j	4.00j-q
IT90K-102-6	4.00j-q	8.00b-e	5.50e-m	4.00j-q	3.83j-q	3.33i-q	7.33b-g	3.83j-q	5.67e-l	4.83g-p
IT89KD-245-1	4.67h-p	7.00b-h	8.50bcd	3.50k-q	4.33i-q	3.67k-q	4.50h-q	4.67h-p	3.83j-q	4.67h-p
SE± (0.71)										

1. Means followed by the same letter(s) within a columns of a treatment group are not significantly different at 5% level of probability (DMRT)

Table 10: Interaction between varieties and herbicide seed treatments on crop number of nodules of cowpea plant at 6WAS under *Alectra/Striga* free condition at Samaru, 1995 wet season.

Treatments	Herbicide seed treatment								No herbicide control	
	Cinosulfuron (g/l)			CGA 152005 (g/l)					No herbiced control	
	0.05	0.1	0.2	0.4	0.008	0.016	0.032	0.064	H_2O soaking	Dry planting
Varieties										
IT81D-985	18.00cd[1]	25.00a	20.33c	19.33c	17.00de	16.00e	16.00e	19.00cd	16.00e	20.00c
SAMPEA 7	15.67ef	14.67ef	16.67de	16.67de	15.33ef	12.33f	27.00a	17.67d	16.33e	16.00e
SAMPEA 6	17.00de	19.33c	16.33e	14.67ef	18.00cd	15.33ef	20.67bc	16.00e	17.33d	17.67d
IT90K-102-6	15.33ef	27.33a	23.33b	20.00c	16.33e	13.33f	17.33d	15.33ef	14.33f	12.33f
IT89KD-245-1	19.33c	21.33b	27.67a	13.00f	2..33b	13.00f	15.00ef	14.00f	16.33e	11.33f
SE± (2.41)										

1. Means followed by the same letter(s) within a column of treatment group are not significantly different at 5% level of probability (DMRT)

higher nodulation of cowpea at 3 WAS than all the other herbicide seed treatments and the no herbicide controls. Cinosulfuron at 0.1 and CGA 152005 at 0.032g/l also caused higher nodulation of cowpea at 3 WAS than the other herbicide seedtreatments but comparable to the no herbicide controls (Table 8).

At 9 WAS, with parasitic weed infestation cinosulfuron at 0.2 and 0.4g/l and CGA152005 at 0.016 and 0.064g/l reduced cowpea nodulation at 9 WAS compared with the maximum obtained with dry planted treatment. Similarly planting with water soaked seeds resulted in higher nodulation of cowpea compared with cinosulfuron at 0.1 and CGA 152005 at 0.032 and 0.064g/l, also with infestation CGA 152005 at 0.008g/l caused higher nodulation of cowpea at 9WAS than the same herbicide at 0.032 and 0.064g/l. Without infestation at 3WAS cinosulfuron at 0.05g/l and CGA 152005 at 0.16g/l has lower nodulation than the maximum obtained with CGA 152005 at 0.032g/l while the no herbicide controls resulted in lower nodulation than the maximum obtained with CGA 152005 at 0.032g/l. Similarly cinosulfuron at 0.1 and 0.2g/l resulted in significantly higher nodulation than all the herbicide seedtreatments and the no-herbicide controls except CGA 152005 at 0.032g/l. CGA152005 at 0.032g/l also resulted in higher nodulation at 6 WAS than the same herbicide seed treatment at 0.064g/l and no herbicide controls without infestation.

The interactions of varieties and herbicide seed treatments on the nodulation of cowpea was significant at 3 WAS under parasitic weed infestation and at 6 WAS without infestation in the field, (Tables 9 and 10). At 3 WAS, with infestation, only IT81D-985 treated with cinosulfuron at 0.1g/l produced significantly higher number of nodules than the other varieties

Table 11: Effect of sulphonyl-urea herbicide seedtreatments on number of leaves/plant with and without *Alectra/Striga* infestation at samaru, during the 1995 wet season.

Treatments	No. of leaves/plant at 3WAS		No. of leaves/plant at 6WAS		No. of leaves/plant at 9WAS	
	Infested	Uninfested	Infested	Uninfested	Infested	Uninfested
Varieties						
IT81D-985	6.3[2]	5.5	11.8	25.6	31.6b	30.6b
SAMPEA 7	7.3	4.6	10.7	22.0	24.1b	27.4b
SAMPEA 6	10.3	5.8	12.2	21.8	54.4a	49.3a
IT90K-102-6	10.2	6.4	11.0	23.2	23.9b	25.8b
IT89KD-245-1	10.6	6.0	13.8	25.1	30.0b	31.2b
SE±	1.65	0.63	0.79	2.96	3.54	3.56
Seed treatment(g/l)						
Cinosulfuron						
0.05	8.1	5.3	11.3	23.8	38.8a	38.7a
0.1	9.0	5.3	11.5	22.7	35.8ab	38.2a
0.2	8.0	5.0	11.5	22.3	36.5ab	34.2ab
0.4	9.2	5.8	11.5	22.7	30.3ab	31.9ab
CGA 152005						
0.008	9.4	5.9	12.2	24.5	32.7ab	31.5ab
0.016	9.0	5.5	11.7	24.3	29.4ab	26.5b
0.032	9.1	5.1	12.3	23.8	28.1ab	39.5a
0.064	9.2	5.4	10.4	23.4	27.2ab	31.2ab
H_2O soaking	8.7	7.7	13.7	22.1	37.7ab	28.8b
Dry planting	9.5	5.5	12.6	24.7	31.7ab	28.7b
SE±	0.44	0.87	1.73	0.84	3.54	2.95
Interaction Variety x herbicide (SE±)	*[4]	NS[3]	NS	NS	NS	NS

1. WAS = Weeks after sowing
2. Means followed by the same letter(s) within a column of a treatment group are r * significantly different at 5% level of probability (DMRT)
3. NS = Not signifance
4. * = Significant at 5% level of probability

Table 12:Interaction of varieties and herbicide seed treatments on number of leaves at 3WAS at Samaru, 1995 wet season.

Treatments	Seed treatment									
	Cinosulfuron			CGA 152005					No-herbicide Control	
	0.05	0.1	0.2	0.4	0.008	0.016	0.032	0.064	H_2O soaking	Dry planting
Varieties										
IT81D-985	5.67c[1]	6.00c	6.17c	6.00c	7.00bc	5.83c	6.83c	7.00bc	6.50c	6.00c
SAMPEA 7	7.00bc	7.33bc	9.17bc	6.00c	6.00c	8.67bc	7.50bc	6.17c	7.17bc	7.83bc
SAMPEA 6	7.50bc	11.33abc	7.00bc	12.50abc	12.67abc	8.50bc	10.17abc	14.00ab	10.67abc	8.33bc
IT90K-102-6	9.33bc	8.00bc	9.50bc	9.33bc	9.17bc	10.17abc	10.83abc	9.50bc	9.50bc	16.83a
IT89KD-245-1	11.00abc	12.5abc	8.33bc	12.33abc	12.33abc	11.83abc	10.00abc	9.50bc	9.67bc	8.33bc
SE± (1.90)										

1. Means followed by the same letter(s) within a column of treatment group are not significantly different at 5% level of probability (DMRT)

and CGA 152005 at 0.008g/l, in addition with infestation. In the field, with infestation, cinosulfuron at 0.05g/l produced higher number of leaves than CGA 152005 at 0.064g/l. However, without parasitic weed infestation both cinosulfuron at 0.05 and 0.1g/l and CGA 152005 at 0.032g/l produced higher number of leaves than CGA 152005 at 0.016g/l as well as the no-herbicide treatments. In the screen house house, cinosulfuron at 0.4g/l and CGA 152005 at 0.032 amd 0.064g/l resulted in higher number of leaves than the same herbicide at 0.05g/l and the no-herbicide controls without parasitic weed infestation and CGA 152005 at 0.008g/l in addition with infestaton. In the field, with infestation, cinosulfuron at 0.05g/l produced higher number of leaves than CGA 152005 at 0.064g/l. However, without parasitic weed infestation both cinosulfuron at 0.05 and 0.1g/l and CGA 152005 at 0.032g/l produced higher number of leaves than CGA 152005 at 0.016g/l as well as the no-herbicide treatments.

The interaction of varieties and herbicide seed treatments was significant on number of leaves per plant at 3 WAS with parasitic weed infestation in the field (Table 12). Plants of variety IT90K-102-6 from dry seeds produced the highest number of leaves per plant. Among the combination of treatments, seed treatments of variety IT90K-102-6 with CGA 152005 at 0.016 and 0.032g/l, IT 89KD-245-1 with cinosulfuron at 0.05 0.1 and 0.4g/l and CGA 152005 at 0.08, 0.016 and 0.032g/l caused the production of leaf number comparable to the highest. With dry planting, IT90K-102-6 resulted in higher leaf number production than all the other varieties, while SAMPEA 6 produced more leaves than SAMPEA 7 with seed treatment of CGA 152005 at 0.064g/l.

4.2.6 Plant Height

Cowpea varieties differed significantly in plant height (Tables 7 and 13) with and without inoculation at harvest in the screen house and at 6 WAS without infestation and 9 and 12 WAS with and without parasitic weed infestation in the field. Without inoculation, SAMPEA 7, IT90K-102-6 and IT89KD-245-1 produced taller plants than the other two varieties. In the field, variety IT90K-102-6 produced taller plants than IT81D-985 at 9 and 12 WAS with and without infestation. In addition, IT89KD-245-1 also produced taller plants than SAMPEA 7 and SAMPEA 6 with parasitic weed infestation. Herbicide seed treatments resulted in significantly shorter plants than no-herbicide treatments in the screen house. Similarly, cinosulfuron at 0.05g/l resulted in taller plants than all the other herbicide treatments. Cinosulfuron at 0.1g/l also caused taller plants than the higher concentrations of the herbicides and all the concentrations of CGA 152005 except cinosulfuron at 0.4g/l that was comparable to the lowest concentration of CGA 152005. Cinosulfuron seedtreatments resulted in taller plants than CGA 152005.

At 12 WAS, with and without parasitic weed infestation cowpea varieties treated with cinosulfuron at 0.05 and 0.1g/l as well as CGA 152005 at 0.008 and 0.016g/l produced plants of height comparable to the no herbicide treatments but significantly taller than those of the higher herbicide concentration except CGA152005 at 0.032g/l. The interaction of varieties and herbicide seedtreatments was not significant on crop plant height.

Table 13: Effect of sulphonyl-urea herbicide seedtreatments on plant height of cowpea with and without *Alectra/Striga* infestation at Samaru, during the 1995 wet season.

Treatments	Plant Height (cm) at					
	6WAS[1]		9WAS		12WAS	
	Infested	Uninfested	Infested	Uninfested	Infested	Uninfested
Varieties						
IT81D-985	12.5[2]	12.8b	13.5c	14.4c	18.1c	17.1c
SAMPEA 7	12.3	13.9b	13.7c	16.6b	25.6b	29.6a
SAMPEA 6	12.3	13.7b	13.6c	17.9a	25.8b	24.76
IT90K-102-6	12.5	14.0a	18.0a	18.6a	30.7a	31.7b
IT89KD-245-1	12.4	12.4b	15.1b	15.5b	25.2b	24.2b
SE±	0.4	0.45	0.45	0.44	0.67	0.70
Seed treatment(g/l)						
Cinosulfuron						
0.05	13.1					
0.1	13.3	13.1	17.5	16.6	25.4a	26.4a
0.2	13.4	13.2	17.7	16.7	25.4a	26.4a
0.4	13.5	13.4	17.7	16.7	18.9b	24.0b
CGA 152005		13.6	17.6	16.6	18.9b	23.9b
0.008	13.1					
0.016	13.3	13.1	17.6	16.4	25.9a	26.9a
0.032	13.4	13.3	17.4	16.2	25.5a	26.1a
0.064	13.5	13.4	17.4	16.7	18.7b	24.7a
H_2O soaking	13.4	13.4	17.2	16.5	18.5b	23.7b
Dry planting	13.4	13.4	17.7	16.7	25.9a	26.9a
SE±	0.20	13.6	17.7	16.8	25.8a	25.8a
		0.19	0.26	0.27	0.55	0.56
Interaction						
Variety x herbicide (SE±)	NS[3]	NS	NS	NS	NS	NS

1. WAS = Weeks after sowing
2 Means followed by the same letter(s) within a column of treatment group are not significantly different at 5% level of probability (DMRT)
3. *NS = Not significant*

4.2.7 Leaf Dry Matter

Cowpea varieties differed significantly in crop leaf dry matter production at 6 and 9 WAS with infestation and at 9 WAS without infestation (Table 14). Variety IT90K-102-6 produced lower leaf dry matter than the maximum throughout the trial. At 6 WAS, all the other varieties produced higher leaf dry matter than IT90K-102-6. At 9 WAS, with and without parasitic weed infestation, SAMPEA 6 produced higher leaf dry matter per plant compared with SAMPEA 7, IT90k-102-6 and IT89KD-245-1. Leaf dry matter production with IT 81D - 985 was also higher than that of SAMPEA 7, but lower than SAMPEA 6.

Herbicide seed treatments had significant effect on cowpea leaf dry matter with parasitic weed infection at 3, 6 and 9 WAS. There was no significant difference among the herbicide rates used. Dry planting control caused the production of significantly higher leaf dry weight at 3 and 6 WAS than the other hericide seedtreatments except cinosulfuron at 0.05g/l at 3 WAS and water soaking at 6 WAS. At 9 WAS, leaf dry matter production was higher with cinosulfuron at 0.05g/l than all the other seed treatments including the no-herbicide control treatments. The plants of the water soaked seeds also produced higher leaf dry matter than those treated with CGA 152005 at all concentrations and cinosulfuron at 0.2 and 0.4g/l as well as dry planting. The dry planting treatment however produced higher leaf dry weight than the highest concentration of cinosulfuron and all concentrations of CGA 152005.

Table 14: Effect of sulphonyl-urea herbicide seed treatments on leaf dry weight of cowpea with and without *Alectra/Striga* infestation at Samaru, during the 1995 wet season.

Treatments	Leaf dry weight (g/plant) at					
	3WAS[1]		6WAS		9WAS	
	infested	unifested	infested	unifested	infested	uninfested
Varieties						16.18a
IT81D-985	0.53[2]	0.58	5.72a	5.30	17.92ab	11.99b
SAMPEA 7	0.64	0.49	5.93a	4.90	11.15b	22.92a
SAMPEA 6	0.54	0.56	3.77a	4.00	18.80a	14.51b
IT90K-102-6	0.50	0.63	3.17b	3.75	10.04b	15.86b
IT89KD-245-1	0.45	0.57	4.11	4.68	14.97b	1.33
SE±	0.04	0.05	0.69	0.68	1.75	
Seed treatment(g/l)						
Cinosulfuron						30.90
0.05	0.53ab	0.78	4.02b	4.00	18.82a	26.82
0.1	0.48b	0.68	4.14b	4.00	16.03bc	25.37
0.2	0.47b	0.51	3.62b	3.58	14.82cd	24.78
0.4	0.46b	0.46	3.56b	3.42	14.51de	
CGA 152005						21.38
0.008	0.40b	0.51	4.00b	4.03	13.27e	25.36
0.016	0.43b	0.50	2.79b	3.00	12.89e	20.52
0.032	0.43b	0.48	4.70b	3.45	11.70e	24.21
0.064	0.41b	0.58	2.62b	2.90	11.64e	23.83
H_2O soaking	0.49b	0.48	7.237ab	7.50	16.88b	25.27
Dry planting	0.86a	0.69	8.70a	7.98	15.19c	2.55
SE±	0.03	0.08	0.92	0.91	1.50	
Interaction variety x herbicide (SE±)	**[4]		NS[3]	NS	NS	NS

1. WAS = Weeks after sowing
2. Means followed by the same letter(s) within a column of treatment group are not significantly different at 5% level of probability (DMRT)
3. NS = Not significant
4. ** = Significant at 1% level of probability

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4.2.8 Crop Shoot Dry Matter

Herbicide seed treatment had significant effect on crop shoot dry matter production at 3,6, and 9 WAS with parasitic weed infestation and at 9WAS without infestation in the field (Table 15). Shoot dry matter production were similar at 3 WAS for all the herbicide seed treatments and significantly lower than those of the no-herbicide controls with *Alectra* infestation. Similarly, crop shoot dry matter production at 6 WAS with parasitic weed infestation were similar for all the herbicide seed treatments. The no-herbicide control produced the higher shoot dry matter than the other hericide seedtreatments. However, the dry planting control was comparable to all the herbicide seedtreatments in shoot dry matter production. Cinosulfuron at 0.05 and 0.1g/l caused the production of shoot dry matter comparable to the no-herbicide control at 9 WAS with parasitic weed infestation. Similarly, cinosulfuron at 0.2 and 0.4g/l resulted in shoot dry matter comparable to the no- herbicide control at 9 WAS with parasitic weed infestation. Cinosulfuron at 0.2 and 0.4g/l and CGA 152005 at all concentrations were comparable to the water soaked planting control. The interaction of varieties and herbicide seed treatments was significant on shoot dry matter production at 3 WAS with parasitic weed infestation (Table 16). Among the herbicide seedtreatments and cowpea variety combinations, variety IT81D - 985 plants grown from water soaked seeds and SAMPEA 7 from dry planting produced shoot dry matter comparable to the highest obtained with SAMPEA 6 with dry planting. Variety SAMPEA 6 treated with cinosulfuron at all rates and CGA 152005 at 0.008, 0.016 and 0.064g/l, IT90K-102- 6 treated with cinosulfuron 0.2g/l, and CGA 152005 at 0.032 and 0.064g/l and variety IT 81D-985 treated with cinosulfuron 0.4g/l and CGA 152005 at 0.032g/l gave high shoot dry matter

Table 15: Effect of sulphonyl-urea herbicide seedtreatments on shoot dry weight of cowpea with and without *Alectra/Striga* infestation at Samaru, 1995 wet season.

Treatments	Shoot dry weight (g/plant) at					
	3WAS[2]		6WAS		9WAS	
	infested	unifested	infested	unifested	infested	uninfested
Varieties						
IT81D-985	0.31[1]	0.31	2.33	2.00	14.20	12.26
SAMPEA 7	0.30	0.22	2.00	2.00	9.13	11.23
SAMPEA 6	0.38	0.26	1.32	1.46	10.11	11.19
IT90K-102-6	0.29	0.32	0.65	0.87	10.85	11.28
IT89KD-245-1	0.30	0.39	0.89	0.96	10.79	10.67
SE±	0.02	0.02	0.57	0.56	1.56	0.96
Seed treatment(g/l)						
Cinosulfuron						
0.05	0.31b	0.36	1.67b	1.75	14.52a	15.04a
0.1	0.28b	0.32	1.45b	1.50	13.58a	12.11a
0.2	0.30b	0.24	0.79b	0.79	10.54ab	10.87b
0.4	0.29b	0.24	1.37b	1.50	10.49ab	10.54b
CGA 152005						
0.008	0.30b	0.31	1.47b	1.49	10.21b	10.71b
0.016	0.28b	0.36	0.84b	0.79	8.43b	10.72b
0.032	0.28b	0.29	1.42b	1.45	7.53b	10.54b
0.064	0.30b	0.29	1.16b	1.06	7.04b	10.22b
H_2O soaking	0.37ab	0.24	2.16a	2.14	15.33a	11.57ab
Dry planting	0.45a	0.34	2.05ab	2.18	12.49ab	11.94a
SE±	0.03	0.04	0.22	0.23	1.39	1.07
Interaction variety x herbicide (*SE*±)	**[4]	NS[3]	NS	NS	NS	NS

1. WAS = Weeks after sowing
2. Means followed by the same letter(s) within a column of treatment group are not significantly different at 5% level of probability (DMRT)
3. NS = Not significant
4. ** = Significant at 1% level of probability

Table 16: Interaction of varieties and herbicide seed reatment on crop shoot dry weight at 3WAS with *Alectra/Striga* infection at Samaru, 1995 wet season.

Treatments	Seed treatment (g/l)									
	Cinosulfuron			CGA 152005					No-herbicide Control	
	0.05	**0.1**	**0.2**	**0.4**	**0.008**	**0.016**	**0.032**	**0.064**	**H_2O soaking**	**Dry planting**
Varieties										
IT81D-985	0.267def[1]	0.230def	0.217def	0.319b-f	0.288def	0.247def	0.330b-f	0.237def	0.513abc	0.427' :d
SAMPEA 7	0.287def	0.280def	0.193ef	0.270def	0.330b-f	0.395b-e	0.228def	0.158f	0.328b-f	0.525a'>
SAMPEA 6	0.320b-f	0.318b-f	0.412b-e	0.400b-e	0.355b-f	0.242def	0.263def	0.388b-e	0.363b-f	0.717
IT90K-102-6	0.282def	0.293c-f	0.358b-f	0.250def	0.230def	0.20ef	0.323b-f	0.342b-f	0.322b-f	0.317b-f
IT89KD-245-1	0.412b-e	0.255def	0.312b-f	0.222def	0.310b-f	0.320b-f	0.252def	0.357b-f	0.327b-f	0.262def
SE± (0.06)										

1. Means followed by the same letter(s) within a column of treatment group are not significantly different at 5% level of probability (DMRT)

which was comparable to the maximum produced for each of the variety cowpea produced from water soaked seeds and seeds planted dry.

4.2.9 Root Dry Matter

Root dry matter production of cowpea was only significantly affected by seed treatments at 9WAS with parasitic weed infestation (Table 17). CGA 152005 at 0.032 and 0.064g/l resulted in significantly lower root dry matter production of cowpea compared with dry planting. CGA 152005 at 0.064g/l also caused lower root dry matter production than all the other treatments except the same herbicide at 0.032g/l.

4.2.10 Number of Days to 50% Flowering

The number of days to 50% flowering which varied between 42 and 63 days differed significantly among the cowpea varieties (Table 18). Variety SAMPEA 6 had the highest number of days to 50% flowering with and without parasitic weed infestation. IT 89KD-245-1 also took more days to 50% flowering than the other varieties except IT 90K-102-6 without infestation.

Herbicide seed treatments also had significant effect on number of days to 50% flowering. With parasitic weed infestation, dry planting resulted in shorter period to flowering compared with all the other treatments including those from water soaked seeds. On the other hand, without infestation, only cinosulfuron at 0.2 and CGA 152005 at 0.032g/l caused more days to flowering than the no herbicide controls. With infestation cinosulfuron at 0.2g/l caused more days to flowering than CGA 152005 at 0.064g/l and water soaked

Table 17: Effect of sulphonyl-urea herbicide seedtreatments on crop root dry weight of cowpea with and without *Alectra/Striga* infestation at Samaru, during the 1995 wet season.

	Root dry weight (g/plant) at					
	3WAS[1]		6WAS		9WAS	
	infested	unifested	infested	unifested	infested	uninfested
Varieties						
IT81D-985	0.14	0.11	1.81	1.50	2.63	2.49
SAMPEA 7	0.78	0.08	1.01	1.00	2.95	1.96
KANO 1696	0.11	0.09	1.95	1.00	2.15	1.75
IT90K-102-6	0.11	0.13	0.61	0.58	2.70	2.25
IT89KD-245-1	0.10	0.11	0.67	0.69	2.32	2.09
SE±	0.02	0.01	0.46	0.45	0.23	0.14
Seed treatment(g/l)						
Cinosulfuron						
0.05	0.11	0.13	0.89	0.80	2.94ab	2.07
0.1	0.11	0.10	0.65	0.75	2.91ab	1.88
0.2	0.13	0.13	0.51	0.65	2.30ab	2.28
0.4	0.09	0.07	0.73	0.75	2.56ab	2.19
CGA 152005						
0.008	0.11	0.09	1.30	1.25	2.58ab	2.29
0.016	0.12	0.09	0.79	0.80	2.32ab	2.35
0.032	0.09	0.10	0.84	0.77	2.21bc	1.81
0.064	0.06	0.08	0.47	0.50	1.94c	1.74
H_2O soaking	0.11	0.10	2.87	2.00	272ab	2.24
Dry planting	0.16	0.13	1.05	1.78	3.02a	2.24
SE±	0.03	0.02	0.66	0.65	0.24	0.18
Interaction Variety x herbicide (SE±)	NS[3]	NS	NS	NS	NS	NS

1. Weeks after sowing
2. Means followed by the same letter(s) within a column of treatment are not significantly different at 5% level of probability (DMRT)
3. Not significant

Table 18: Effect of sulphonyl-urea herbicide seed treatments on number of days to 50% flowering of cowpea varieties with and without *Alectra/Striga* infestation at Samaru, 1995 wet season.

Treatments	Number of days to 50% flowering	
	infested	uninfested
Varieties		
IT81D-985	44.0c[1]	44.1c
SAMPEA 7	43.0c	42.9c
SAMPEA 6	63.3a	62.9a
IT90K-102-6	44.3c	43.0c
IT89KD-245-1	50.6b	48.7b
SE±	0.81	0.82
Seed treatment		
Cinosulfuron (g/l)		
0.05	48.9b	48.7ab
0.1	49.1ab	48.8a
0.2	49.9a	48.7ab
0.4	49.4ab	48.8a
CGA 152005		
0.008	49.1ab	48.4ab
0.016	49.2ab	48.4ab
0.032	49.4ab	48.9a
0.064	48.7b	48.5ab
9	48.7b	47.0b
Dry planting	47.9c	46.8b
SE±	0.28	0.27
Interaction		
V x H (SE±)	NS[2]	*[3]

1. Means followed by the same letter(s) are not significantly different at 5% level of probability (DMRT)
2. NS = Not significant
3. * = Significant at 5% level of probability

Table 19: Interaction of variety and herbicde on days to 50% flowering of cowpea under *Alectra/Striga* free condition at Samaru, 1995 wet season.

	Seed treatment									
	Cinosulfuron g/l				CGA 152005 g/l				No-herbicide Control	
Treatments	0.05	0.1	0.2	0.4	0.008	0.016	0.032	0.064	H_2O soaking	Dry planting
Varieties										
IT81D-985	44.33f[§]	44.33f	44.67f	44.67f	44.33f	45.33f	43.67g	45.00f	42.00h	42.33h
SAMPEA 7	43.00gh	43.00gh	43.00gh	43.33f	43.00g	42.67h	43.33g	41.67i	42.00h	42.67h
SAMPEA 6	62.67bc	63.33a	63.33a	63.67a	63.00a	61.67c	64.00a	63.67a	60.67c	62.67bc
IT90K-102-6	44.00fg	43.33g	43.67g	42.67h	42.33h	43.00h	43.67g	43.00g	42.67h	41.33i
IT89KD-245-1	49.67d	50.00d	49.00d	48.67e	49.33d	49.33d	49.67d	49.00d	47.67e	45.00f
SE±	0.99									

[§] Means followed by the same letter(s) within a column of treatment groups are not significantly different at 5% level of probability (DMRT)

plants. The interactions of varieties and herbicide seed treatments on number of days to 50% flowering was significant (Table 19). Without parasitic weed infestation, variety SAMPEA 6 treated with cinosulfuron at 0.1, 0.2, 0.4g/l and CGA 152005 at 0.032 and 0.064g/l had the maximum number of days 50% flowering of cowpea. However, SAMPEA 7 had shortest number of days to 50% flowering, although comparable to those of IT81D-985 with seed treatments of cinosulfuron at 0.4g/l and the no-herbicide controls.

4.4.11 **Number and Weight of Cowpea Pods**

Cowpea varieties differed significantly in number of pods at harvest without parasitic weed infestation (Table 20). Variety SAMPEA 6 produced significantly higher number of pods than varieties IT90K-102-6, IT89KD-245-1 and IT 81D-985. SAMPEA 7 however produced higher pod number than IT81D-985 in the trial. Although the herbicide seed treatments did not have signific..nt effect on the number of cowpea pods at harvest, the interaction of variety and herbicide seed treatments was significant without infestation (Table 21). The highest pod number was produced by SAMPEA 6 treated with CGA 152005 at 0.032g/l, variety IT81D-985 not treated with herbicide and those treated with cinosulfuron at 0.4g/l, SAMPEA 7 from cinosulfuron at 0.1g/l and CGA 152005 at 0.008 to 0.32g/l as well as dry planting, SAMPEA 6 from cinosulfuron at 0.05 and 0.4g/l and CGA 152005 at 0.064g/l as well as dry planting; IT90K-102-6 as well as dry planting; IT90K-102-6 from water soaked seeds and IT 89KD-245-1 from seeds treated with cinosulfuron at 0.1g/l and CGA 152005 at 0.032g/l as well as water soaked produced pod number comparable to the highest and significantly higher than the least obtained with IT89KD-245-1 seeds treated with CGA 152005 at 0.008g/l without parasitic weed infestation. The weight of cowpea pods was

neither affected by varieties nor herbicide seed treatments.

4.2.12 Grain Yield

Cowpea varieties only differed significantly in grain yield under parasitic weed infestation (Table 20). Variety SAMPEA 6 produced significantly higher cowpea grain yield than SAMPEA 7 and IT81D-985 while IT90K-102-6 and IT 89KD-245-1 produced significantly higher grain yield than SAMPEA 7. Parasitic weed infestation caused cowpea grain yield reduction of between 12.7% in tolerant SAMPEA 6 and 34.7% in susceptible SAMPEA 7 in the study.

Herbicide seed treatments also had significant effect on cowpea grain yield with parasitic weed infestation (Table 20). Seed treatment with CGA 152005 at 0.032g/l and 0.064g/l resulted in significantly higher cowpea grain yield than cinosulfuron at 0.05 and 0.1g/l, CGA 152005 at 0.008g/l and dry planting no-herbicide control. Cinosulfuron at 0.4g/l and the water soaked seed treatments caused higher cowpea grain yield than CGA at 0.008g/l and the dry planting no-herbicide control (Table 20). Furthermore grain yield reduction due to parasitic weed infestation was between 25.5% for dry planting and 71% for CGA at 0.064 in the trial.

The interactions between varieties and herbicide seed treatments on cowpea grain weight was not significant with and without parasitic weed infestation (Table 20).

Table 20: Effect of sulphonyl-urea herbicide seed treatments on the number and weight of pod and grain yield of cowpea varieties with and without *Alectra/Striga* infestation at Samaru, during the 1995 wet season.

Treatments	Pod number per plot[2]		Pod weight kg/ha		Grain yield kg/ha	
	infested	uninfested	infested	uninfested	infested	uninfested
Varieties						
IT81D-985	765	850c[1]	1848	1777	1432b	1848
SAMPEA 7	838	991ab	1564	1773	1157c	1772
SAMPEA 6	879	1053a	2123	1650	1681a	1916
IT90K-102-6	832	940bc	2015	1578	1479ab	1701
IT89KD-245-1	762	900bc	2207	193	1476ab	1752
SE±	57.21	29.99	168.63	88.83	74.26	80.13
Seed treatment(g/l)						
Cinosulfuron				1637	1354bc	1599
0.05	793	919	189?	1658	1392bc	1744
0.1	838	958	1843	1698	1447abc	1824
0.2	825	872	1940	1701	1574ab	1872
0.4	848	1000	2112			
CGA 152005						
0.008	782	882	1916	1615	1135abc	1875
0.016	821	887	1879	1629	1502abc	1869
0.032	822	968	3035	1695	1633a	1838
0.064	838	1052	2151	1686	1641a	1767
H_2O soaking	792	959	1768	1725	1497ab	1832
Dry planting	792	969	1854	1698	1310c	1759
SE±	43.71	47.24	96.96	82.89	73.55	58.35
Interaction variety x herbicide (SE±)	*[4]	NS[3]	NS	NS	NS	NS

1. Means followed by the same letter(s) in the same column are not significantly different at 5% level of probability (DMRT)
2. Plot size = $9m^2$
3. Not significant
4. Significant at 1% level of probability

Table 21: Interaction of variety and herbicde seed treatment on number of pods of cowpea varieties under *Alectra/Striga* free condition at Samaru, 1995 wet season.

	Seed treatment									
	Cinosulfuron				CGA 152005				No-herbicide Control	
Treatments	0.05	0.1	0.2	0.4	0.008	0.016	0.032	0.064	H_2O soaking	Dry planting
Varieties										
IT81D-985	801def[1]	679f	835def	1055a-e	724f	775ef	713f	796def	1061a-e	1066a-e
SAMPEA 7	871c-f	1033a-e	925b-f	944b-f	1032a-e	1018a-e	1117a-d	988b-f	933b-f	1050a-e
SAMPEA 6	1172a-d	999b-e	979b-f	1074a-e	991b-f	1007b-e	1328a	1033a-e	895c-f	1049a-e
IT90K-102-6	1000b-e	910b-f	854c-f	954b-f	1006b-e	843def	937b-f	831def	1212ab	853c-f
IT89KD-245-1	751ef	1171a-d	767ef	972b-f	657f	792ef	747ef	1148abc	1162abc	830def
SE± (104.59)										

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

4.2.13 **1000-Grain Weight of Cowpea**

Cowpea varieties differed significantly in 1000-grain weight with and without parasitic weed infestation (Table 28). Variety SAMPEA 7 produced the least 1000-grain weight with and without infestation while the heaviest seed was produced by IT89KD-245-1 with and without infestation. IT 81D-985 produced similar 1000-grain weight with infestation and lower weight without infestation compared with the maximum with IT 89KD-245-1. IT81D-985 however produced higher 1000-grain weight than the other varieties. Without infestation both SAMPEA 6 and IT 90K-102-6 produced heavier grains than SAMPEA 7, while with infestation both IT90K-102-6 and SAMPEA 7 produced seeds of similar weight that were however lighter than that of SAMPEA 6.

Herbicide seed treatments had significant effect on the of 1000-grain weight of cowpea with and without parasitic weed infestation. With infestation, cinosulfuron at 0.1 and 0.4g/l and CGA 152005 at 0.008g/l produced seeds of significantly lower grain weight than the seed treated with cinosulfuron at 0.05g/l. However without infestation, cinosulfuron at 0.1 and 0.2g/l and CGA 152005 at 0.008 and 0.032g/l produced heavier seeds than CGA 152005 at 0.016g/l and the no-herbicide controls.

The interaction between variety and herbicide seed treatments was significant on 1000 grain weight of cowpea without parasitic weed infestation (Table 23). Variety IT81D - 985 with seed treatments of cinosulfuron at 0.2g/l and IT89KD-245-1 with cinosulfuron at 0.1g/l produced the highest 1000-grain weights. Heavier cowpea seeds compared with the dry planting no-herbicide controls were produced by IT81D-985 with seed treatments of both

Table 22: Effect of sulphonyl-urea herbicide seedtreatments on 1000-grain weight of cowpea under *Alectra/Striga* infestation and uninfested condition at Samaru, 1995 wet season.

Treatments	1000-grain weight (g)	
	Infested	Uninfested
Varieties		
IT81D-985	238.3a[1]	213.9b
SAMPEA 7	180.9c	182.6d
SAMPEA 6	193.4b	202.2c
IT90K-102-6	201.5b	179.5d
IT89KD-245-1	248.4a	241.9a
SE±	3.90	2.10
Seed treatment(g/l)		
Cinosulfuron		
0.05	220.7a	199.3bc
0.1	202.7c	211.0ab
0.2	217.6ab	212.9a
0.4	207.2bc	203.6abc
CGA 152005		
0.008	207.4bc	211.6ab
0.016	214.0abc	197.7c
0.032	208.2abc	206.1abc
0.064	211.1abc	203.9abc
H_2O soaking	216.6ab	198.0c
Dry planting	115ab	196.2c
SE±		4.0
Interaction		
Variety x herbicide (SE±)	NS[2]	*[3]

1. Means followed by the same letter(s) in the same column are not significantly different at 5% level of probability (DMRT)
2. NS = Not significant
3. * = Significant at 5% level of probability

Table 23: Interaction of varieties and herbicde on crop 1000 seed weight under *Alectra/Striga* free condition at Samaru, 1995 wet season.

Treatments	Seed treatment									
	Cinosulfuron				CGA 152005				No-herbicide Control	
	0.05	0.1	0.2	0.4	0.008	0.016	0.032	0.064	H_2O soaking	Dry planting
Varieties										
IT81D-985	21.50de[1]	22.47d	25.40a	19.53gh	24.03b	20.72ef	20.80e	22.71ed	18.82h	17.91i
SAMPEA 7	17.60j	18.92h	19.22h	18.49i	18.47i	16.20k	17.93i	19.05h	18.89h	17.87i
SAMPEA 6	20.52f	21.21de	19.72fg	20.67ef	20.03fg	19.72fg	20.94e	19.61g	19.30h	20.46fg
IT90K-102-6	16.81k	17.48j	17.86i	18.99h	18.74h	17.98i	18.68hi	17.96i	17.83ij	17.18j
IT89KD-245-1	23.21bc	25.40a	24.26b	24.14h	24.53b	24.24b	24.73ab	22.60cd	24.15b	24.69b
SE± (0.88)										

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

herbicides at all concentrations; SAMPEA 7 with cinosulfuron at 0.1 and 0.2g/l and CGA 152005 at 0.064g/l as well as water soaking before planting; SAMPEA 6 with CGA 152005 at 0.032g/l, IT90K-102-6 with cinosulfuron at 0.2 and 0.4g/l and CGA 152005 at all concentrations; and IT89KD-245-1 with cinosulfuron at 0.1g/l produced heavier seeds than the other herbicide seedtreatments. Heavier seeds were produced by SAMPEA 7 compared with IT90K-102-6 with cinosulfuron at 0.05 to 0.2g/l while seeds of IT90K-102-6 were heavier with CGA152005 at all concentrations. Seeds of SAMPEA 6 and IT89KD-245-1 were heavier than those of IT90K-102-6 with all seedtreatments. Dry planting resulted in lower 1000-grain weight than water soaking control in varieties IT81D-985 SAMPEA 7 and SAMPEA 6. Variety IT90K-102-6 increased in 1000-grain weight with increased in the rate of cinosulfuron concentration. IT 89KD-245-1 produced highest 1000-grain weight at all seed treatments except cinosulfuron at 0.2g/l (Table 23).

4.3 Effect of Sulphonylurea Herbicide Seed treatments on the Infection of Cowpea Varieties by *Alectra* and *Striga*

Effect of sulphonylurea herbicide seed treatments on *Alectra/Striga* parameters viz emerged and unemerged *Alectra* in the screen house as well as *Alectra* shoot counts, *Striga* shoot count, number of plants infected by *Alectra*, number of plants infected by *Striga*, and number of days to first emergence of *Alectra* and *Striga* in the field are presented in Table 24 to 30.

4.3.1 Number of Days to First *Alectra* Emergence

Cowpea varieties did not differ significantly in the number of days to first *Alectra*

emergence both in the screen house and field (Tables 24 and 25). Cinosulfuron at 0.4g/l and CGA 152005 at 0.064g/l delayed *Alectra* emergence significantly compared with lower herbicide concentrations and the no herbicide controls both in the screen house and field. Cinosulfuron at 0.2g/l and CGA 152005 at 0.032g/l also significantly delayed *Alectra* emergence compared with the no herbicide and the lowest concentration of the two herbicides in the trial (Tables 24 and 25). No difference was observed between the two no herbicide controls.

The interactions of varieties and herbicide seed treatments was not significant on the number of days to first *Alectra* emergence.

4.3.2 Number of Days to First *Striga* Emergence

Cowpea varieties differed significantly in number of days to first *Striga* emergence on them (Table 25). Varieties IT 81D-985 and IT 89KD-245-1 significantly delayed *Striga* emergence compared with SAMPEA 6, SAMPEA 7 and IT 90K-102-6. *Striga* emergence on IT90K-102-6 was also significantly delayed compared with SAMPEA 7 and SAMPEA 6. Herbicide seed treatments with cinosulfuron at 0.2 and 0.4g/l and CGA 152005 at 0.032 and 0.064g/l significantly delayed striga emergence on cowpea varieties compared with the lower herbicide seedtreatment concentrations and the no-herbicide controls. The interactions of varieties and herbicide seedtreatments was not significant.

4.3.3 Number of Unemerged *Alectra*

In the screen house, varieties IT81D-985, IT90K-102-6 and IT89KD-245-1 supported significantly lower number of unemerged *Alectra* than SAMPEA 7 (Table 24). Although,

Table 24: Effect of sulphonyl-urea herbicide seed treatments on number of emerged and unemerged *Alectra* and number of days to first *Alectra* emergence in the screen house at Samaru, 1995 dry season.

Treatments	Number of days to first *Alectra* emergence	Emerged *Alectra*	Unemerged *Alectra*
Varieties			
IT81D-985	48.60	2.73bc[1]	3.07bc
SAMPEA 7	48.23	23.97a	8.03a
SAMPEA 6	47.93	6.97b	5.37ab
IT90K-102-6	48.43	0.20c	1.00c
IT89KD-245-1	48.73	1.87bc	0.73c
SE±	0.51	0.12	0.38
Seed treatment (g/l)			
Cinosulfuron			
0.05	43.07c	9.67d	4.67b
0.1	46.93bc	3.67e	2.07de
0.2	51.27b	3.00f	1.67e
0.4	56.27a	0.20i	0.80f
CGA 152005			
0.008	43.13c	10.27c	3.47c
0.016	49.27bc	5.07e	3.87c
0.032	50.67b	1.73h	3.20cd
0.064	56.07a	0.60i	2.27d
H_2O soaking	42.07c	18.40b	6.87a
Dry planting	45.13c	18.87a	7.53a
SE±	0.26	0.12	0.38
Interaction Variety x herbicide (SE±)	NS	NS[2]	NS

1. Means followed by the same letter(s) in the same column are not significantly different at 5% level of probability (DMRT)
2. NS = Not significant

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Table 25: Effect of sulphonyl-urea herbicide seed treatments on number of days to first *Alectra* and *Striga* emergence at Samaru, 1995 wet season.

Treatments	No of days to first emergence	
	Alectra	Striga
Varieties		
IT81D-985	48.60	77.2a
SAMPEA 7	48.23	63.5c
SAMPEA 6	47.93	63.2c
IT90K-102-6	48.43	70.5b
IT89KD-245-1	48.73	78.2a
SE±	0.52	2.57
Seed treatment (g/l)		
Cinosulfuron		
0.5	43.07c[1]	63.5b
0.1	46.93bc	63.2b
0.2	51.27b	70.6a
0.4	56.27a	70.3a
CGA 152005		
0.008	43.13c	64.6b
0.016	49.27bc	63.5b
0.032	50.67b	70.0a
0.064	56.07a	70.3a
H_2O soaking	42.07c	62.7b
Dry planting	45.13c	63.5b
SE±	0.69	2.90
Interaction		
Variety x Herbicide (SE±)	NS[2]	NS

1. Means followed by the same letter(s) within the same column are not significantly different at 5% level probability (DMRT)
2. NS = Not significant

SAMPEA 6 also supported higher number of unemerged Alectra than IT90K-102-6 and IT 89KD - 245-1 (Table 24). The effect of herbicide seedtreatments was not significant on unemerged *Alectra*. Interaction between the varieties and herbicides seed treatments was not significant.

4.3.4 Shoot Count of *Alectra vogelii*

Cowpea varieties differed significantly in their support for emerged *Alectra* shoots in the screen house and field at 9, 10, 11 WAS and at harvest (Table 24 and 26). In the screen house, SAMPEA 7 supported higher number of emerged *Alectra* shoots than all the other varieties (Table 24). SAMPEA 7 also supported higher *Alectra* than IT90K-102-6 and IT89KD-245-1. Generally, SAMPEA 7 supported higher number of *Alectra* emergence than IT81D-985 IT90K-102-6 and IT89KD-245-1 at all stages and SAMPEA 6 in addition at 10 WAS. The variety SAMPEA 6 also supported significantly higher *Alectra* shoot count than IT89KD-245-1 at all stages and IT90K-102-6 at 10 WAS and 11 WAS and at harvest, as well as IT81D-985 at 11 WAS. The herbicide seed treatments also had significant effect on *Alectra* in the screen house and at 9, 10 and 11 WAS and at harvest in the field. In the screen house, all the herbicide seed treatments resulted in significantly lower number of emerged *Alectra* on cowpea compared with no-herbicide controls (Table 24). Plants of the water-soaked seeds supported higher *Alectra* emergence than those of the dry seeds. Emerged *Alectra* shoot count decreased with increasing concentration of each herbicide seedtreatment. At 9 WAS, cinosulfuron at 0.2 and 0.4g/l and CGA 152005 at 0.016, 0.032 and 0.064g/l caused significantly lower *Alectra* shoot emergence compared with the maximum observed with cinosulfuron at 0.05g/l. Cinosulfuron at 0.4g/l and CGA 152005 at 0.032 and 0.064g/l

supported lower *Alectra* emergence than the no-herbicide controls at this stage. At 10 WAS and at harvest all the herbicide seed treatments also resulted in lower *Alectra* shoot count than the maximum obtained with dry cowpea planting. Planting of water soaked seeds resulted in *Alectra* shoot count comparable to that caused by cinosulfuron at 0.05g/L and higher than all the other herbicide seed treatment. At 11 WAS seed treatments with cinosulfuron at 0.4g/l and CGA 152005 at 0.032 and 0.064g/l resulted in significantly lower *Alectra* emergence than the two no-herbicide controls. While all the herbicide seedtreatments caused lower *Alectra* emergence than the maximum obtained with the water soaked seeds. Generally, herbicide seedtreatments with cinosulfuron at 0.05 to 0.2g/l and CGA 152005 at 0.008 to 0.016g/l supported comparable *Alectra* shoot count. *Alectra* shoot count in the two no-herbicide controls did not differ significantly at all stages of growth. *Alectra* shoot count also reached the peak at 9 WAS and declined subsequently due to senescence and death. All the herbicide seed treatments supported lower Alectra emergence than the no-herbicide dry planting controls at harvest. Similarly, cinosulfuron at 0.4 and CGA 152005 at 0.032 and 0.064g/l supported low *Alectra* shoot emergence than the lower rates.The interaction between varieties and herbicide seed treatment was not significant.

4.3.5 Number of plants infected by *Alectra*

Cowpea varieties differed significantly in *Alectra* incidence at 9, 10 and 11 WAS and at harvest (Table 26). SAMPEA 7 had higher number of cowpea plants infested than varieties IT 81D-985 and IT 89 KD-245-1 at all stages and IT 90K-102-6 at 10, 11, WAS and at harvest. At 10 and 11 WAS varieties IT 90K-102-6 and IT 89KD-245-1 supported significantly lower incidence of *Alectra* than IT 81D-985. The three varieties also had lower

Alectra incidence than SAMPEA 6 at 11 WAS at harvest.

Generally, all the herbicide seed treatments reduced *Alectra* incidence compared with the no herbicide controls at 10 and 11 WAS and at harvest. Similarly at the stages indicated, cinosulfuron at 0.1 to 0.4g/l and CGA 0.008 to 0.064g/l resulted in significantly lower *Alectra* incidence than their lowest concentrations. Cinosulfuron at 0.2g/l also caused lower incidence than 0.05g/l water. Cinosulfuron at 0.05g/l and CGA 152005 at 0.064g/l at 10 WAS resulted in lower *Alectra* incidence than cinosulfuron at 0.4g/l. Similarly, CGA at 0.008g/l caused higher incidence than at 0.064g/l and cinosulfuron at 0.4g/l at 10 WAS, and the highest concentrations of the two herbicide at 11 WAS. There was no significant difference between the no-herbicide controls.

Table 26: Effect of sulphonyl-urea herbicide seed treatments on *Alectra* shoot count and number of plants infected at Samaru, during the 1995 wet season.

Treatments	*Alectra* Shoot count/(9m²)					Number of plants infected/(9m²)				
	8WAS[1]	9WAS	10WAS	11WAS	Harvest	8WAS	9WAS	10WAS	11WAS	Harvest
Varieties										
IT81D-985	15.6	21.0bc[2]	11.8b	7.6c	5.20bc	3.2	4.07b	4.00b	4.33c	2.07bc
SAMPEA 7	32.4	75.1a	35.8a	34.8a	11.6a	7.6	9.97a	8.83a	10.83a	5.90a
SAMPEA 6	43.9	53.1ab	16.8b	15.6b	9.5ab	10.0	6.60ab	5.7ab	6.83b	4.70abc
IT90K-102-6	25.7	23.7bc	1.8c	2.2c	0.87c	6.7	8.40ab	0.97c	1.40d	0.47c
IT89KD-245-1	10.2	12.0c	3.3c	2.8c	1.20c	3.0	5.5b	1.03c	1.50d	0.57b
SE±	10.12	9.77	2.11	2.41	1.33	1.6	1.26	0.45	0.83	0.37
Seed treatment(g/l)										
Cinosulfuron										
0.05	37.1	61.9a	14.9bc	17.4b	5.27bc	6.20	7.60	4.47b	7.13bc	3.40bcd
0.1	26.3	47.1ab	9.1c	10.3bc	5.13bc	6.47	7.73	3.47bc	3.93de	3.93bc
0.2	20.6	33.9bc	7.1c	11.7bc	3.67bc	5.87	7.87	3.07bc	3.93de	2.40cde
0.4	14.3	28.5c	6.5c	6.1c	3.13c	3.87	4.40	2.27c	2.00e	1.60de
CGA 152005										
0.008	32.1	42.3ab	13.3c	12.4bc	4.13b	8.13	9.13	4.20b	4.87cd	2.27cde
0.016	27.7	33.3bc	10.5c	9.4b	4.00b	5.80	8.20	3.40bc	3.20de	1.80de
0.032	21.6	26.2c	9.5c	7.1c	1.93c	5.80	6.53	2.93bc	2.67de	1.47e
0.064	14.4	18.5c	5.8c	6.0c	1.27c	4.60	4.73	1.87c	1.73e	0.87e
H_2O soaking	30.7	42.4ab	28.2ab	26.7a	10.07b	6.00	6.67	7.87a	10.93a	4.73b
Dry planting	30.7	35.5ab	34.0a	19.1ab	18.07a	8.00	6.13	7.47a	9.40ab	5.93a
SE±	5.93	7.23	3.87	3.80	2.29	1.15	1.19	0.76	0.94	0.60
Interaction variety x herbicide	NS[3]		NS	NS	NS	NS	NS	NS	NS	*[4]

1. WAS = Weeks after sowing
2. Means followed by the same letter(s) within the same column are not significantly different at 5% level of probability (DMRT)
3. NS = Not significant
4. * = Significant at 5% level of probability

Table 27: Interaction between varieties and herbicide seed treatment on number of cowpea plants infected by Alectra vogelii at harvest at Samaru, 1995 wet season.

Treatments	Herbicide seed treatment (g/l)									
	Cinosulfuron				CGA 152005				No-herbicide Control	
	0.05	0.1	0.2	0.4	0.008	0.016	0.032	0.064	H_2O soaking	Dry planting
Varieties										
IT81D-985	2.00e-h[1]	0.67gh	1.00gh	0.67gh	2.33e-h	1.00gh	1.00gh	1.00gh	6.00b-f	5.00c-g
SAMPEA 7	7.67a-d	8.00abc	7.33a-d	4.33c-h	3.67c-h	3.67c-h	3.33d-h	2.00e-h	8.33abc	10.67ab
SAMPEA 6	6.67b-e	4.67c-h	3.00d-h	2.00e-h	4.67c-h	2.00e-h	2.33e-h	1.00gh	8.33abc	12.33a
IT90K-102-6	-0.00h	0.33h	0.67gh	0.33h	0.33h	0.33h	0.33h	-0.00h	1.00gh	1.33fgh
IT89KD-245-1	0.678gh	1.00gh	-0.00h	0.67gh	0 33h	2.00e-h	0.33h	0.33h	-0.00h	0.33h
SE±	1.32									

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

4.3.6 Shoot Count of *Striga gesnerioides*

Striga emergence on cowpea increased up to harvest in the field (Table 28). Cowpea varieties SAMPEA 7 and SAMPEA 6 supported significantly higher *Striga* shoot count than the other varieties at 10 and 11 WAS and at harvest (Table 28).

Herbicide seed treatments had significant effect on *Striga* shoot emergence on cowpea varieties at 10 and 11 WAS and at harvest. At the three stages indicated, all the herbicide seed treatments except cinosulfuron at 0.05g/l at 10 WAS as well as cinosulfuron at 0.1g/l and CGA 152005 at 0.008g/l at 11 WAS significantly reduced shoot emergence on cowpea compared with the maximum observed with water soaked planting. *Striga* emergence was however higher on the plants of dry planting compared with cinosulfuron at 0.4g/l and CGA 152005 at 0.016 to 0.064g/l at 10 WAS. Cinosulfuron at 0.4g/l and CGA 152005 at 0.032 and 0.064g/l at 11 WAS and cinosulfuron at 0.2 and 0.4g/l and CGA 152005 at 0.016 to 0.064g/l at harvest resulted in lower *Alectra* shoot count than the other herbicide treatments. No significant difference was however observed between the two no-herbicide controls. Interaction between varieties and herbicide seed treatments was not significant.

4.3.7. Number of Plants Infected by *Striga*

Cowpea varieties differed significantly in number of plants infected by *Striga* at 10 and 11 WAS (Table 28). Varieties SAMPEA 7 and SAMPEA 6 at 10 WAS and IT81D-985 in addition at 11 WAS supported significantly highest *Striga* incidence than the other cowpea varieties.

Herbicide seedtreatments had significant effect on number of plants infected by *Striga* at 9, 10, 11 WAS and at harvest. At 9 WAS and 11 WAS, the herbicide treatments caused lower *Striga* incidence on cowpea than the two no herbicide seed treatment controls although the dry planting caused lower incidence than the water soaked. At the stages, seed treatment with cinosulfuron at 0.5g/l resulted in higher *Striga* incidence on cowpea than the highest concentration of the chemical while CGA 152005 at 0.00g/l also caused higher incidence than the lower concentrations at 9 WAS and at 0.032 and 0.064g/l at 11 WAS. At 10 WAS and harvest, all the herbicide seed treatments were comparable to water soaking control in *Striga* incidence. The cowpea plants produced from dry seeds however had higher *Striga* incidence than all the herbicide treatments at 10 WAS and cinosulfuron at 0.2 and 0.4g/l at harvest and all the CGA 152005 concentrations at harvest. The interaction of varieties and herbicide seed treatments on *Striga* incidence was significant at 10 WAS. The plants of SAMPEA 7 from dry and soaked seeds had significantly higher incidence of *Striga* than the least in the field while SAMPEA 6 plants also only had higher incidence with dry planting.

Table 28: Effect of herbicide seed treatments on *Striga* shoot count and number of cowpea plants infected at Samaru, during 1995 wet season.

Treatments	Number of Striga ($9m^2$)				Number of plants infected by *Striga gesnerioides*			
	9WAS	10WAS[1]	11WAS	Harvest	9WAS	10WAS	11WAS	Harvest
Varieties								
IT81D-985	0.07	2.50b[2]	5.9b	10.0b	0.03	1.00b	3.07a	2.37
SAMPEA 7	2.47	11.73a	20.2a	37.2a	1.17	4.47a	5.77a	6.47
SAMPEA 6	3.47	10.80a	21.9a	38.2a	1.80	3.63a	4.47a	5.20
IT90K-102-6	1.40	1.47b	1.4b	3.5b	0.90	0.53b	0.83b	3.50
IT89KD-245-1	0.07	1.27b	1.6b	5.2b	0.07	0.60b	0.53b	1.07
SE±	0.87	2.08	5.60	7.94	0.39	0.52	0.95	1.33
Seed treatment(g/l)								
Cinosulfuron								
0.05	1.53	7.73abc	9.5bc	21.6bc	1.00c	2.00b	3.00c	4.87ab
0.1	1.27	5.60bc	10.3abc	17.3bc	0.93c	2.07b	2.33c	4.07ab
0.2	1.07	4.73bc	9.3bc	12.7c	0.60cd	1.73b	2.07cd	2.60b
0.4	0.60	2.40c	2.3c	7.9c	0.47d	1.53b	1.33d	2.73b
CGA 152005								
0.008	1.27	4.67bc	12.2abc	21.5bc	0.93c	1.53b	3.07c	2.27b
0.016	1.07	3.47c	5.4bc	6.6c	0.47d	1.20b	2.53c	2.67b
0.032	0.80	1.60c	2.1c	4.9c	0.20d	0.67b	1.27d	2.60b
0.064	0.00	0.87c	0.7c	3.1c	0.00d	0.47b	0.53d	1.27b
H_2O soaking	4.13	13.40a	27.7a	53.7a	1.93a	4.27ab	8.60a	6.33ab
Dry planting	3.20	11.07ab	22.5ab	38.7ab	1.40b	5.00a	4.60b	8.60a
SE±	0.95	2.17	4.78	6.97	0.33	0.64	1.19	1.39
Interaction variety x herbicide (SE±)	NS[3]	NS	NS	NS	NS	**[4]	NS	NS

1. WAS = Weeks after sowing
2. Means followed by the same letter(s)within the same column are not significantly different at 5% level of probability (DMRT)
3. NS = Not significant
4. ** = Significant at 1% level of probability

Table 29: Interaction between varieties and herbicde on crop number of plants infected by *Striga gesneroides* at 10WAS at Samaru, 1995 wet season.

Treatments	Herbicide seed treatment (g/l)									
	Cinosulfuron				CGA 152005				No herbicide control	
	0.05	0.1	0.2	0.4	0.008	0.016	0.032	0.064	H_2O soaking	Dry planting
Varieties										
IT81D-985	0.67c[1]	0.67c	1.00c	1.00c	1.33c	1.33c	0.00c	0.00c	2.00c	2.00c
SAMPEA 7	2.67c	3.67c	3.00c	4.33bc	3.67c	2.00c	2.33c	1.67c	11.67a	9.67ab
SAMPEA 6	5.00bc	5.00bc	4.33bc	1.67c	1.33c	1.33c	0.67c	0.67c	4.67bc	11.67a
IT90K-102-6	1.33c	0.67c	0.33c	0.33c	0.67c	0.33c	0.33c	0.00c	0.67c	0.67c
IT89KD-245-1	0.33c	0.33c	0.00c	0.33c	0.67c	1.00c	0.00c	0.00c	2.33c	1.00c
SE±	1.46									

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

4.4 Correlation Coefficient

4.4.1 Relationship between cowpea and Parasitic Weed (*Alectra* and *Striga*) parameters in the screenhouse and field

As shown in Table 30, the number of nodules of cowpea at 9 WAS was significantly negatively correlated with the number of leaves in the screen house (r = -0.21). The number of leaves of cowpea was also negatively correlated with the number of emerged and umemerged *Alectra*, crop injury score and crop vigour scores of cowpea (r = -0.55, -0.41, -0.63, -0.76, respectively). While the number of emerged and unemerged *Alectra* were negatively correlated with crop injury score and crop vigour scores of cowpea.

The relationship between various parasitic weeds (*Alectra* and *Striga*) and crop parameters with cowpea grain yield under parasitic weed infestation in the field is presented in Table 31. Grain yield was positively correlated with number of days to 50% flowering, number of leaves at 9 WAS, leaf dry weight at 9 WAS and weight of pod at harvest (r = 0.36, 0.56, 0.30, 0.21 respectively. However, number of *Striga* at 11 WAS, number of leaves at 9 WAS, root dry weight at 9 WAs were all negatively correlated with grain yield. Number of days to 50% flowering was significantly correlated with number of *Striga* at 11 WAS, root dry weight at 9 WAS (r = -0.28, -0.21). Number of days to 50% flowering was positively correlated with weight of pod at harvest (r = 0.85). Time of first *Alectra* emergence was negatively correlated with number of nodules at 9 WAS r = -0.33).

The relationship between cowpea grain yield and other parameters without parasitic weed infestation in the screen house and field is presented in Tables 32 and 33. The number

of nodules of cowpea at 9 WAS was negatively correlated with crop injury score and crop vigour scores of cowpea in the screen house (r = 0.67 and -0.37 respectively). In the field grain yield was positively correlated with 1000 grain weight but negatively correlated with shoot dry weight of cowpea at 9 WAS (r = -0.72 and -0.21). Grain yield was however positively correlated with root dry weight at 9 WAS (r = -0.8). Shoot dry weight of cowpea at 9 WAS was also negatively correlated with crop injury score at 3 WAS (r = -0.23).

Number of nodules was negatively and significantly correlated with the number of leaves (r = value -0.21) (Table 30), it was positively correlated with crop injury score and crop vigour score (r value = 0.67, 0.37) (Table 28) without *Alectra* inoculation in the screen house.

Table 30: Correlation between *Alectra* and crop parameters under *Alectra/Striga* infestation in the screen house

	1	2	3	4	5	6
1 Number of nodules	1.0					
2 Number of leaves	-0.21*	1.0				
3 Emerged *Alectra*	-0.15	-0.55**	1.0			
4 Unemerged *Alectra*	-0.09	-0.41**	0.15	1.0		
5 Crop injury score	-0.06	-0.63**	-0.19*	-0.25**	1.0	
6 Crop vigour score	-0.08	-0.76**	0.19*	-0.34**	-0.20*	1.0

* significant at 5% level of probability (r=0.19)

** significant at 1% level of probability (r=0.25)

Table 31: Correlation between grain yield and various crop and parasitic weed parameters and various parameters under *Alectra/Striga* infestation in the field

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1.00000																
2	0.33656**	1.00000															
3	0.01618	0.016173	1.00000														
4	0.06199*	-0.17499	-0.21109	1.00000													
5	-0.20384*	-0.28432**	-0.30534*	0.40073**	1.00000												
6	0.11776	-0.17562	-0.26878**	0.83828**	0.44893**	1.00000											
7	0.03040	-0.18426	-0.20774	0.28058**	0.57671**	0.31079**	1.00000										
8	-0.09116	-0.02158	-0.02217	-0.010900	-0.06356	-0.08402	-0.01927	1.00000									
9	0.06657	0.07229	-0.02890	0.06429	0.02246	-0.02223	-0.09313	-0.42661	1.00000								
10	0.56102**	0.15808	-0.15027	0.14200	0.16570	0.23787*	0.01617	0.02258	0.10075	1.00000							
11	-0.11398	0.01533	-0.32611**	0.06372	0.06790	0.09428	0.14227	-0.10004	-0.00418	-0.01872	1.00000						
12	0.30200**	0.01242	-0.17856	0.11576	0.07071	0.21057*	0.00591	0.17975	-0.01552	0.76101**	0.01072	1.00000					
13	-0.07842	-0.12686	-0.27564	0.00355	0.01901	0.10413	-0.05805	0.07328	0.13630	0.41736**	0.09947	0.72621**	1.00000				
14	-0.22200**	-0.21060*	-0.18319	0.16936	0.17937	0.22463*	0.05647	-0.03504	0.13188	-0.00344	0.17283	0.30881**	0.48137**	1.0000			
15	0.15579	0.24114*	-0.16655	0.29240**	0.21476*	0.35200**	0.21192*	0.01647	-0.07691	0.26998*	0.25618**	0.18568	0.16394	0.19865*	1.00000		
16	0.21306*	0.85300**	0.09010	-0.14784	-0.18729	-0.17253	-0.11897	-0.07725	0.16268	0.05449	0.02429	0.00262	-0.08392	-0.10342	0.18019	1.00000	
17	-0.11168	0.06635	-0.00625	-0.19156	-0.32795**	-0.35557**	-0.26882	-0.05958	0.18220	0.05449	-0.00612	0.20271*	0.18500	-0.09074	-0.24858*	-0.24858*	1.0000

1 Grain yield
2 Number of days to 50% flowering
3 Time of first Alectra emergence
4 Number of Alectra at harvest
5 Number of Striga at 11WAS
6 Number of plants infected by Alectra at harvest
7 Number of plants infected by Striga at 11WAS
8 Crop vigour at 3WAS
9 Crop injury at 3WAS
10 Number of leaf at 9WAS
11 Number of nodules at 9WAS
12 Leaf dry weight at 9WAS
13 Shoot dry weight at 9WAS
14 Root dry weight at 9WAS
15 Stand count at harvest
16 Weight of pod at harvest
17 1000 grain weight

Table 32: Correlation between number of nodules and other parameters without parasitic weed infestation in screen house

	1	2	3	4
1 Number of nodules	1.00			
2 Number of leaves	-0.16	1.00		
3 Crop injury score	0.01	0.67**	1.00	
4 Crop vigour score	0.20	-0.37**	-0.47**	1.00

* r = 0.27 significant at 5% level of probability

** r = 0.35 significant at 1% level of probability

Table 33: Correlation between numberof nodules and other parameters without parasitic weed infestation in field

	1	2	3	4	5	6	7	8	9	10	11
1	1.0000										
2	0.0133	1.0000									
3	0.1567	0.0046	1.0000								
4	-0.1880	0.1026	-0.0810	1.0000							
5	-0.2117*	-0.0383	-0.1355	0.5089**	1.000						
6	-0.0302	-0.1080	0.0032	0.6073**	0.3793**	1.0000					
7	-0.1224	-0.1947	-0.0566	-0.0081	-01159	0.0019	1.0000				
8	0.1251	-0.0438	-0.0095	-0.0102	-0.0154	-0.0910	-0.1470	1.0000			
9	0.0344	-0.2026*	-0.1343	-0.1339	-0.1391	-0.0914	0.0520	0.1975	1.0000		
10	0.7186**	0.0514	0.0377	-0.1456	-0.1390	-0.. '19	-0.1788	-0.0882	0.1894	1.0000	
11	0.0161	0.1281	-0.0112	-0.0574	0.2323*	-0.0034	-0.4524**	0.1815	-0.1876	-0.0811	1.0000

1 Grain yield
2 Leaf number at 9WAS
3 Number of nodules 9WAS
4 Dry weight of leaf 9WAS
5 Dry weight of shoot 9WAS
6 Dry weight of root 9WAS
7 Number of days to 50% flowering
8 Stand count at harvest
9 Weight of pod
10 1000 seed weight
11 Injury score at 3WAS

* significant at 5% level of probability (r=0.20)
** significant at 1% level of probability (r=0.25)

CHAPTER FIVE

DISCUSSION

5.1 Performance of Cowpea Varieties as Affected by Seed Treatment and Parasitic Weed Infestation

The yield of 1.07 kg/t to 1.91 kg/t recorded in the trial without parasitic weed infestation compares favourably with earlier report at Samaru (Zaria, 1995). However, the mean yield of 1.16/ha to 1.68l/ha obtained with different varieties under parasitic weed infestation in the study were slightly lower by 12.7% to 34.7%, compared with *Alectra* free situation. Earlier report by Lagoke *et al.* (1996b) has indicated yield losses of 9.1 to 52.5% in cowpea varieties due to *Alectra* infestation. In the study, the white seeded varieties, IT81D-985 and SAMPEA 6, imbibed more liquid (i.e water and herbicide), when soaked, than the brown varieties, SAMPEA 7 and IT 90K-102-6. This probably was due to the larger surface area and higher absorptive capacity of the white varieties compared with the brown varieties used in the study. Earlier report by Maigida *et al.* (1996) has confirmed differential absorptive capacity and retention of shape by seeds of cowpea varieties. They observed that the white varieties retained their forms more easily than the brown forms. Despite lower imbibition of liquid, the varieties IT90K-102-6 and IT89KD-245-1 exhibited lower germinatibility than the other two white seeded varieties (SAMPEA 6 and IT81D-985). Similarly in the field, IT90K-102-6 had significantly lower stand count than the maximum obtained with SAMPEA 6. Also with and without parasitic weed infestation, variety IT90K-102-6 exhibited higher injury score and lower crop vigour at 6WAS than the other varieties in the greenhouse. In the screenhouse. IT90K-102-6 and IT81D-985 produced significantly

lower number of nodules than the other varieties, SAMPEA 7, SAMPEA 6 and IT89KD-245-1, while SAMPEA 7 produced lower number of nodules than the maximum by IT89KD-245-1 with and without infestation. Adu-Tutu and Drenan (1991) reported that sulfonylurea herbicides particularly chlorosulfuron at the rate of 40-60 g a.i./ha damaged maize plants. Bec *et al.* (1989) and Nbaki *et al.* (1992) also reported that sulfonylurea herbicides (Cinosulfuron) was slightly toxic to rice at the rate of 40 - 80 a.i./ha inspite of the fact that the chemical is recommended for spray application in the crop.

In the field, IT90K-102-6 and IT81D-985 also produced lower number of leaves than the appropriate maximum by SAMPEA 6. With and without parasitic weed infestation, IT89KD-245-1 produced shorter plants than IT90k-102-6 in the field. Without infestation, SAMPEA 6 at 9WAS, SAMPEA 7 at 12WAS were comparable to IT90K-102-6 that produced the tallest plants.

The yields of the cowpea varieties evaluated only differed significantly under parasitic weed infestation with SAMPEA 6 producing significantly higher yield than SAMPEA 7. Inspite of depression in various growth parameters IT90K-102-6 and IT89KD-245-1 produced grain yield comparable to the highest obtained with SAMPEA 6. The parasitic weed incidence and infestation on this two varieties were also low thus indicating resistance. The varieties are product of cross of B301 with other parents and therefore have exhibited the resistance of B301 to *Striga* and *Alectra* which are simply inherited traits. The fact that IT89KD-245-1, a cross of B301 and the local Kananado, is a prostrate variety could be responsible for the shorter plants observed in the field. The production of high cowpea grain

yield by SAMPEA 6 inspite of high support for parasitic weed infestation and incidence confirms earlier report by Magani (1994) and Lagoke *et al*. (1996a) that the variety is tolerant to parasitic weed infestation at Samaru. Magani (1994) attributed this to the production of big cowpea seeds in compensation for the reduction of cowpea pod number caused by the parasitic weed. However, in this trial, SAMPEA 6 was observed to produce the highest number of pods. The tolerance could therefore be attributed to the ability of the variety to produce more vegetative and floral shoots inspite of initial injury caused since it is a late maturing and photosensitive variety. The variety took more days to 50% flowering than the other ones with and without parasitic weed infestation in the study. In this study, parasitic weed infestation caused 12.7%, 13.1% and 15.8% reduction in yield of SAMPEA 6, IT90K-102-6 and IT89KD-245-1 compared with 34.7% in SAMPEA 7. IT81D-985 which also supported moderate infestation and incidence of the parasitic weeds had yield reduction of 22%. This confirms an earlier report by Lagoke *et al.*(1996b) that the variety is moderately resistant to the parasitic weeds.

SAMPEA 7 obviously supported very high infestation and incidence of parasitic weed with consequent high reduction of grain yield inspite of the production of pod number comparable to the maximum produced by SAMPEA 6. This is an indication of the adverse effect of parasitic weeds on grain filling in the susceptible variety SAMPEA 7. The susceptibility of SAMPEA 7 to *Alectra* and *Striga* have earlier been reported by Lagoke et al (1996b) and Magani *et al*. (1994). Lagoke *et al* (1996a) reported 12.3% and 34.7% reduction in yield due to parasitic weed infestation in the tolerant SAMPEA 6 and susceptible SAMPEA 7 respectively. In this study SAMPEA 7 supported higher incidence of *Alectra* and *Striga*

than all the other varieties. Among the varieties, SAMPEA 6 supported *Alectra* shoot count at 9WAS and at harvest and incidence at 9 and 10WAS and at harvest comparable to SAMPEA 7. The infestation and incidence of striga on SAMPEA 6 were comparable to that of SAMPEA 7 throughout the crop growth. The remaining three varieties, IT90K-102-6, IT89KD-245-1 and IT81D-985 supported lower infestation of *Striga* than SAMPEA 7 and SAMPEA 6. IT90K-102-6 and IT89KD-245-1 supported lower *Alectra* infestation and incidence than IT81D-985 and SAMPEA 6 at some stages of crop growth. This result confirms an earlier report by Lagoke *et al.* (1996b) that IT90K-102-6 exhibited high resistance to the parasitic needs while IT89KD-245-1 and IT81D-985 were moderately resistant.

Varieties IT89KD-245-1 and IT81D-985 gave the largest seed size with infestation while without infestation only IT89KD-245-1 produced largeseed size than the other varieties. This may be due to the fact that these two varieties are known for their big seed sizes. In this trial, variety SAMPEA 6 took more days to 50% flowering compared with the other varieties with and without parasitic weed infestation. This could be attributed to the fact that the variety is a late maturing and photosensitive variety. IT89KD-245-1 also took more days to 50% flowering than the other varieties, probable due to the fact that it is a product of crosses of B301 with the local kananodo, a late maturing photosensitive variety.

5.2 Effect of herbicide seed-treatment on cowpea varieties

The germination of cowpea seeds was significantly affected by the herbicide seed-treatments. The CGA 152005 herbicide seed-treatments generally resulted in lower germinability of cowpea seeds compared with cinosulfuron and the no herbicide control. It

was apparent that at all the concentrations tested, CGA 152005 adversely affected the germination of cowpea seeds, while the cinosulfuron seed treatments were tolerated by the cowpea varieties. The observed depression in the germination of cowpea seeds at cinosulfuron 0.1g/l of water could not be explained but only attributed to experimental defects. Cinosulfuron at 0.05g/l obviously supported higher cowpea seed germinability than all the concentrations of CGA 152005. No differences were observed in the level of germinability with respect to concentration within each herbicide treatment. However, the herbicide seed treatments did not have significant effect on the stand count of cowpea in the field with and without parasitic weed infestation. Herbicides, especially seed treatments are usually better tolerated in the field than in the laboratory due to less availability of the herbicides to the seeds as a result of various factors including adsorption to soil colloids and possible dilution (Lagoke, personal communication). All the herbicide seed treatments were differentially toxic to cowpea plants with and without parasitic weed infestation especially at 3WAS with the highest concentration of CGA 152005 causing the maximum injury in the screen house and field. Cinosulfuron at 0.4g/l also caused significantly higher injury than the lowest concentration under parasitic weeds infestation, while CGA 152005 at 0.032g/l of water caused higher injury than the lower concentrations and all concentration of cinosulfuron without infestation. Similarly, crop vigour score at 3 and 6WAS was significantly affected by the herbicide seed treatments in the greenhouse, while in the field no difference was observed at 6 and 9WAS. The herbicide seed treatments reduced crop vigour score with and without infestation at 3WAS while the lower rates of cinosufuron at 0.05 and 0.1g/l of water and CGA 152005 at 0.008 and 0.016g/l of water caused comparable vigour score of cowpea to the no herbicide control at 6WAS with parasitic weed infestation. The higher susceptibility

of the cowpea to the herbicide in the greenhouse than the field could be attributed to a greater exposure of the cowpea plant to the herbicide in the pot than in the field as earlier observed by (Ishaya, 1997).

Generally the herbicide seed treatments reduced parasitic weed count and incidence throughout the trial. Although only cinosulfuron at 0.2 and 0.4g/l and CGA 152005 at 0.032 and 0.064g/l reduced *Alectra* shoot count at 9WAS, all the herbicide concentrations caused significant depression of the parasitic weed subsequently until harvest. Similarly, the high concentration of the herbicide seed treatments, cinosulfuron at 0.2 and 0.4g/l and CGA 152005 at 0.032 and 0.064g/l reduced *Alectra* incidence at 9 and 10WAS while all the rates depressed the parameter subsequently. In actual fact, the depression of *Alectra* infestation and incidence by the herbicide seed treatment was more intensified as the crop advanced in growth stage. This indicates that the effect of the seed treatment of host crop on the parasitic weed was probably related to the physiological activities of the crop. Acetolactate synthase (ALS) inhibitor compounds have been reported to cause the inhibition of the enzyme acetolactate synthase thus blocking the biosynthesis of branched chain amino acids like valine, leucine and isoleucine, and hence growth inhibition after the treatment of susceptible plant species (Anon., 1993). Legumes generally including cowpea tolerated the groups of chemicals at herbicidal rate of 0.025kg/ha (O'neil *et al.* 1983).

The low concentration of the two herbicides, cinosulfuron at 0.05 and 0.1g/l, CGA 152005 at 0.008 and 0.016g/l supported higher *Alectra* emergence than the corresponding highest concentration while cinosulfuron at 0.05g/l also caused higher incidence than all the

other higher rates of the herbicide. This confirms the fact that the low concentration of CGA 152005 at 0.008 and 0.016g/l is obviously more effective on *Alectra* than those of cinosulfuron (0.05 and 0.1g/l). Similarly, all the herbicide seed treatments reduced both incidence and infestation of *Striga gesnerioides* on cowpea compared with the no herbicide controls. The reduction of the parasitic weed shoot count and incidence could be attributed to the toxicity of the seed treatment on the parasitic weeds. This agrees with earlier report by Burhan *et al.* (1989) and Anon, (1993) that cinosulfuron and CGA 152005 when applied at 0,01 to 0.45kg a.i/ha to transplanted rice and maize resulted in more than 85% weed control. Generally, the no herbicide control supported higher infestation and incidence of parasitic weeds than the herbicide seed treatment in the study. Similar reduction in parasitic weed infestation by ALS onhibitor compounds have been reported by Berner *et al.* (1997) and Lagoke *et al.* (1996a). A major advantage in the use of seed treatments resides in the low rate required hence less environmental hazard due to herbicide residue. The treatment is cost effective and the method is an already acquired skill in crop production.

Herbicide seed treatment with cinosulfuron at 0.2 and 0.4g/l and CGA 152005 at 0.032 and 0.064g/l produced significantly higher cowpea grain yield than the lower concentrations and the dry planting control with and without parasitic weed infestation. The high grain yield was a consequence of the effective reduction of the parasitic weeds.

5.3 Interactions Between Cowpea Varieties and Herbicide Seed Treatments

The interaction between cowpea varieties and herbicide seed treatments was significant on some cowpea parameters including number of nodules at 6WAS, number of days to 50%

flowering and number of pods without parasitic weed infestation.

The nodulation of cowpea varieties was differentially affected by herbicide seed treatments. The nodulation of cowpea varieties IT81D-985, IT89KD-245-1 and IT90K-102-6 were generally increased by cinosulfuron while all the herbicide seed treatments with the exception of CGA 152005 at 0.032g/l reduced nodulation in SAMPEA 7 and SAMPEA 6. Nodulation in IT81D-985 was increased by seed treatments with cinosulfuron at all concentrations and water soaking before planting while that of SAMPEA 7 and SAMPEA 6 was increased by CGA 152005 at 0.032g/l compared with dry planting, no herbicide treatment. Similarly, cinosulfuron at 0.1 to 0.4g/l increased the nodulation of IT90K-102-6 and cinosulfuron at 0.05 to 0.1g/l and CGA 152005 at 0.008g/l increased nodulation in cowpea. The number of days to 50% flowering of cowpea was differentially increased by herbicide seed treatment in all the cowpea varieties. While all the treatments increased it in IT81D-985 and SAMPEA 6 only the low concentration of cinosulfuron and all the of CGA 152005 increased the number of days to 50% flowering in IT89KD-245-1. Number of days to 50% flowering of SAMPEA 7 was increased by all the concentrations of cinosulfuron compared with the no herbicide control. At cinosulfuron 0.1g/l, SAMPEA 7, SAMPEA 6 and IT89KD-245-1 produced higher pod number than IT81D-985. Similarly, at CGA 152005 at 0.032g/l, both SAMPEA 7 and SAMPEA 6 produced higher pod number than IT81D-985. In actual fact, IT81D-985 produced the least number of pods at all concentrations of CGA 152005. This may be due to the higher susceptability of the variety to the herbicide compared with the others. This agrees with the findings of Imeokparia (1989) and Abubakar (1991) that the number of spikelets per panicle of rice was significantly reduced by the

application of CGA 152005 at 0.04kg a.i/ha than the no herbicide control. The highest rates of cinosulfuron i.e (0.2 and 0.4g/l) and all the rates of CGA 152005 reduced *Alectra* incidence on SAMPEA 7, while all the herbicide concentrations reduced *Striga* incidence on the variety. With the susceptible variety SAMPEA 7, only the highest concentration of the herbicide reduced *Alectra* incidence while all the herbicide concentrations reduced *Striga* incidence. No difference in *Striga* and *Alectra* incidence was observed among the resistant varieties IT90K-102-6 and IT89KD-245-1 which without seed treatment had low incidence. Similarly, all the seed treatments reduced the incidence of *Striga* and *Alectra* on the tolerant SAMPEA 6. While all the herbicide concentrations except cinosulfuron at 0.05g/l reduced incidence of *Alectra* and *Striga* on the moderately resistant IT81D-985. CGA 152005 and cinosulfuron at 0.2 and 0.4gl and 0.032 and 0.064g/l reduced both *Alectra* infestation and incidence compared with the corresponding low rates and the no herbicide control on cowpea. This agrees with the earlier report by Lagoke *et al* (1996a) that cinosulfuron at 0.2 and 0.4g/l and CGA 152005 at 0.032 and 0.064g/l applied as seed treatment resulted in a good control of the parasitic weeds in cowpea.

5.4 Correlation

The significant negative correlation of grain yield with the number of *Striga* at 11WAS, crop injury score at 3WAS, number of nodules at 9WAS, shoot and root dry weight at 9WAS and 1000 grain weight indicated that *Striga* parasitism reduced cowpea grain yield. Atokple *et al* (1991) reported similar observation that parasitism reduce cowpea grain yield. Yield reduction of upto 100% due to *Striga* has been reported to occur in cowpea depending on the level of infestation (Emechebe *et al.*, 1983).

The positive correlation observed between grain yield and weight of pods showed that the parameter is an important determinant of cowpea yield. The result agrees with that of Sule (1988) who also observed positive correlation between grain yield and other yield components of the crop including weight of pods. Similarly, increased nodulation caused by herbicide seed treatments in the cowpea varieties especially IT81D-985, which was least tolerant to the herbicides could be a hypersensitive reaction of the crop to herbicide injury. This is further confirmed by the negative relationship between nodulation and cowpea grain yield observed in the study. The strong negative relationship between cowpea grain yield and *Striga* parameter at 11WAS and at harvest could probably be explained by the fact that maximum *Striga* emergence occurred at 9WAS which probably caused serious damage at the critical grain filling stage of the crop.

Without ' ıfestation, the negative correlation of grain yield with leaf, shoot and root dry weight at 9WAS and number of days to 50% flowering indicated that there was a reduction in grain yield as a result of competition between various plant parts, vegetative and reproductive, for assimilates following phytotoxicity by the herbicide seed treatments on the crop. The positive correlation observed on grain yield with leaf number at 9WAS, stand count at harvest, weight of pod, 1000 weight and crop injury score indicated that these parameters are critical determinants of cowpea grain yield especially without weed stress.

CHAPTER SIX

SUMMARY AND CONCLUSION

Trials were conducted in the laboratory, screen house and farm of the Institute for Agricultural Research, Ahmadu Bello University, Samaru (11° 11' 07°) in the Northern Guinea savanna of Nigeria during the 1994 dry and 1995 wet seasons to evaluate the acetolactate synthase (ALS) inhibitor sulphonyl - urea herbicides, cinosulfuron and CGA 152005 for the control of parasitic weeds, *Alectra vogelii* Benth and *Striga gesneriodes* (Willd.) vatke in cowpea (*Vigna unguiculata* (L.) Walp). The treatments consisted of five cowpea varieties (IT81D-985, SAMPEA 6, SAMPEA 7, IT90K-102-6 and IT89KD-245-1) and 10 herbicide seed treatments, cinosulfuron at 0.05, 0.1, 0.2 and 0.4 CGA 152005 at 0.008, 0.016, 0.032 and 0.064 g/l as well as the no-herbicide control of dry and water soaked seed planting. The treatments were laid out in a completely randomized design (CRD) in the laboratory and screen house and split plot design in the field.

In the study, it was apparent that cowpea varieties IT90K-102-6 and IT81D-985 were highly sensitive to the herbicide seed treatments evaluated as reflected in depression in seed germination, poor stand establishment as well as high injury and low crop vigour score with and without parasitic weed inoculation in the screen house. The nodulation of the cowpea varieties was also lower than the maximum obtained with IT89KD-245-1 with and without parasitic weed infestation. Variety IT90K-102-6 also produced lower leaf dry matter than the appropriate maximum throughout the trials. Cowpea variety SAMPEA 6 produced higher number of leaves and number of pods than all the other varieties with and without parasitic weed infestation. Cowpea variety SAMPEA 7 produced the least 1000 grain weight with and

without parasitic weed infestation while IT89KD-245-1 produced the heaviest seeds with and without parasitic weed infestation. The number of days to 50% flowering varied between 42 and 63 days with SAMPEA 6 having the highest number of days with and without parasitic weed infestation. Variety SAMPEA 6 produced higher cowpea grain yield than SAMPEA 7 and IT81D-985 only with parasitic weed infestatuion. The grain yield of SAMPEA 7 was also lower than those of all the other varieties. Generally, SAMPEA 7 supported the highest number of *Alectra* infestation and incidence at all stages of growth except at 9WAS when SAMPEA 6 was comparable. IT89KD-245-1 and IT90K-102-6 however supported lower number of *Alectra* and incidence than IT81D-985. Similarly, *Striga* emergence and incidence was higher on SAMPEA 7 and SAMPEA 6 than other varieties. The delayed on varieties IT81D-985 and IT89KD-245-1 and IT90K-102-6 compared with SAMPEA 6 and SAMPEA 7 although all the varieties did not differ significantly or the number of days to *Alectra* emergence.

The herbicide seed treatments significantly injured cowpea and depressed the vigour, growth and nodulation of cowpea, CGA 152005 at 0,064g/l caused significantly higher injury score of cowpea with *Alectra* infestation and the same herbicide at 0.032 and 0.064g/l without parasitic weed infestation than the corresponding lower concentrations and no herbicides controls. Similarly, the higest rates of the two herbicides CGA 152005 at 0.064g/l and cinosulfuron at 0.4g/l resulted in lower vigour score than their corresponding lowest concentration in the screen house with and without inoculation. Some herbicide seed treatments induced leaf production in cowpea. Cinosulfuron at 0.4g/l and CGA 152005 at 0.032 and 0.064g/l in the screen house as well as cinosulfuron at 0.05 and 0.1g/l and CGA

152005 at 0.032g/l in the field caused higher leaf production than the no herbicide controls. The nodulation of cowpea was depressed by cinosulfuron at 0.2 and 0.4g/l and CGA 152005 at 0.016 to 0.064g/l with parasitic weed infestation. All the herbicide seed treatments deppressed leaf dry weight at 6WAS while cinosulfuron at 0.05 and 0.1g/l did not at 9 WAS in the field . Similar results were obtained with the shoot dry weight except that cinosulfuron at 0.2 and 0.4g/L did not depress the parameter with parasitic weed infestation. CGA 152005 at 0.032 and 0.064g/l also reduced root dry weight of cowpea significantly compared with the no herbicide control.

With parasitic weed infestation, CGA 152005 at 0.064g/l produced significantly higher cowpea grain yield than cinosulfuron at 0.05 and 0.1g/l, CGA 152005 at 0.008 and dry planting control as a result of effective reduction of parasitic weed infestation.

Cinosulfuron at 0.2 and 0.4g/l and CGA 152005 at 0.032 and 0.64g/l significantly delayed the emergence of *Alectra* in the screen house and the to parasitic weeds in the field. The herbicide seed treatments significantly reduced the number of emerged and unemerged *Alectra* in the screen house. The number of emerged *Alectra* decreased with concentration of the two herbicides while their highest concentrations supported similar number of *Alectra* shoot. Cinosulfuron generally deppressed the number of unemerged *Alectra* than CGA 152005.

Generally, herbicide seed treatments reduced *Alectra/Striga* shoot count and incidence compared with the no-herbicide treatments in the field. CGA 152005 at 0.032 and 0.064g/l

caused more effective reduction of *Alectra* infestation than the other herbicides treatments. Planting of water-soaked seeds resulted in *Alectra* shoot count comparable to that caused by cinosulfuron at 0.05g/l and higher than all the other seed treatments. All the herbicide seed treatment supported lower *Alectra* emergence than the dry planting control at harvest. Similarly *Striga* infestation throughout and incidence until 11WAS were significantly reduced by the herbicide seed treatments. *Striga* emergence was higher on the plants of dry planting compared with cinosulfuron at 0.4g/l and CGA 152005 at 0.016 to 0.064g/l at 10WAS.

The number of days to first *Alectra* emergence was delayed by cinosulfuron at 0.4g/l and CGA 152005 at 0.064g/l compared with the lower rates. Similarly number of days to first *Striga* emergence was delayed by cinosulfuron at 0.2 and 0.4g/l and CGA 152005 at 0.032 and 0.064g/l comapred with the lower concentrations and the no herbicide controls.

The interactions of varieties and herbicide seed treatments on nodulation of cowpea at 3WAS and shoot dry matter at 3WAS with parasitic weed infestation, nodulation of cowpea at 6WAS, number of leaves at 3WAS, number of pod and number of days to 50% flowering without parasitic weed infestation was significant in the trial. With parasitic weed infestation SAMPEA 6 treated with cinosulfuron at 0.2g/l produced maximum number of nodules. SAMPEA 6, produced the highest shoot dry matter, when planted dry or soaked in water. Variety IT81D-985 grown from water soaked seeds and SAMPEA 7 from dry planting produced shoot dry matter comparable to the highest obtained with SAMPEA 6.

Without parasitic weed infestation the least number of nodules was produced by IT

90K-102-6 when planted dry or soaked in water compared with the other treatments while the variety produced the highest number of leaf per plant compared to all the other varieties when planted dry. Among the treatment combinations seed treatments of variety IT90K-102-6 with CGA 152005 at 0.016, 0.032g/l; IT89KD-245-1 with cinosulfuron at 0.05, 0.1 and 0.4 g/l and CGA 152005 at 0.008, 0.016, 0.032 and SAMPEA 6 treated with cinosulfuron at 0.1 to 0.4 and CGA 152005 at 0.008, 0.032 and 0.064g/l caused production of leaf comparable to the maximum. The highest number of pods was produced by SAMPEA 6 treated with CGA 152005 at 0.032g/l while the least number was produced by IT89KD-245-1 treated with CGA 152005 at 0.008g/l. Variety SAMPEA 6 had the maximum number of days to 50% flowering of cowpea. Seed treatments of cowpea with cinosulfuron at 0.1, 0.2 and 0.4g/l and CGA 152005 at 0.032 and 0.064g/l caused maximum number of days to 50% flowering. The grain yield of cowpea was negatively correlated with number of *Striga* at 11WAS, crop injury score at 3WAS, number of nodules at 9WAS, shoot and root dry weight at 9WAS and 1000-grain weight. The positive correlation observed between grain yield and weight of pods showed that the parameter is an important yield component and determinant of cowpea. Without parasitic weed infestation, the grain yield was negatively correlated with leaf, shoot and root dry weight at 9WAS and number of days to 50% flowering.

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Appendix 1: Pedigree/Origin of cowpea varieties evaluated

Varieties	Time to maturity	Photoperiod	Colour	Texture	Reaction to Striga/Alectra	Size of seeds	Pedigree/Origin	Growth habit
IT81D-985	late maturing	sensitive	white	rough	moderately resistant	large	IITA	prostrate
SAMPEA 7	Early maturing	insensitive	brown	rough	suceptible	medium	IAR	erect
SAMPEA 6	late maturing	sensitive	white	rough	tolerant	large	Nigerian local	prostrate
IT90K-102-6	Early maturing	sensitive	brown	rough	resistant	medium	IITA	erect
IT89KD-245-1	late maturing	sensitive	white	rough	resistant	large	B301 x local kananado	prostrate

Appendix 2: Total monthly rainfall, relative humidity, mean temperature, sunshine hours and evaporation during the period of green-house study, February to April, 1995 at Institute for Agricultural Research (IAR), Samaru.

Months	Relative humidity %	Temperature (°C)	Sunshine (hrs)	Evaporation (mm)
February	10.2	23.2	8.0	231.1
March	20.0	26.0	7.2	320.0
April	58.6	28.7	8.1	248

Source: Meteorological Unit, Institute for Agricultural Research, Samaru - Zaria.

Appendix 3: Total rainfall, maximum and minimum temperature, ralative humidity during the period of the experiment at Samaru in 1995.

Months	Days	Total rainfall (mm)	Temperatures (°C) Min.	Max.	Relative humidity 10.00hrs	16.00hrs
August	1-10	88.4	17.8	28.7	84.5	73.9
	11-20	73.6	19.8	29.1	82.8	73.1
	21-31	96.7	22.9	31.3	86.4	80.3
September	1-10	39.3	21.9	29.5	81.9	78.3
	11-20	80.5	18.9	29.4	81.6	68.3
	21-30	39.3	20.5	30.9	80.5	68.7
October	1-10	32.5	20.1	31.1	77.8	62.7
	11-20		18.7	32.6	71.2	74.1
	21-31		20.1	35.4	80.6	58.0

Source: Samaru meteological station

Appendix 4· Physico-chemical analysis of soil taken from experimental site (infested and uninfested field) during the period of the experiment at Samaru in 1995.

Soil composition	Soil Depth (cm)			
	Soil depth 0-15 (cm)	infested field 15-30 (cm)	uninfested field 0-15 (cm)	15-30 (cm)
particle size (%)				
Sand	56	46	54	49
Silt	32	30	34	41
Clay	12	24	12	10
Soil textural class	Sandy	Loam	Sandy	Loam
Soil pH in water	5.7	5.8	4.6	4.7
pH in 0.0M $Cacl_2$	4.7	4.7	4.1	3.2
Organic carbon (g/kg)	4.5	4.6	3.9	0.4
Total Nitrogen (g/kg)	0.4	0.3	0.5	7.16
Available P (mg/kg)	8.39	5.65	8.91	
Exchangeable Bases (Cmol/kg)				
Sodium (Na)	0.10	0.13	0.03	0.05
Potassium (K)	0.0[c]	0.09	0.20	0.20
Calcium (Ca)	0.75	1.31	1.21	2.29
Magnesium (Mg)	0.34	0.75	0.39	0.56
Cation Exchange Capacity (Cmol/kg)	5.2	8.8	4.50	4.83

Appendix 5

Crop Injury Score

1 = No crop reduction or injury
2 = Slight crop discoloration or stunting
3 = Some crop discoloration, stunting or stand loss
4 = Crop injury more pronounced, but not lasting
5 = Complete crop destruction

Crop Vigour Score Scale

1 = Completely killed
2 = Moribund
3 = Only few green tissues present
4 = Definite growth reduction, severe toxity symptoms and less likely to survive.
5 = Definite growth reduction, severe toxity symptoms and less likely to survive.
6 = Distinguishable inhibition of growth and other injury symptoms.
7 = Distinguishable inhibition and slight discoloration/other injury symptoms.
8 = Distinguishable inhibition of growth.
9 = Slight discoloration and lower vigour/discoloration and necrotic spots.

Appendix 6: Gain in seed weight as a result of soaking and estimate of each chemical or water absorbed.

Varieties	Seed treatment									
	<----------Cinosulfuron (g/l)---------->				<----------CGA 152005 (g/l)---------->					
	0.05	0.1	0.2	0.4	0.008	0.016	0.032	0.064	H_2O soaking	Dry weight
IT81D-985	26	25	24	25	25	26	24	25	26	20
SAMPEA 7	22	22	21	22	22	22	23	21	22	15
KANO 1696	25	24	26	24	25	26	26	25	25	20
IT90K-102-6	22	21	22	22	22	21	23	21	22	18
IT89KD-245-1	26	26	24	26	2.	25	25	25	26	21

	Seed treatment									
	<----------Cinosulfuron (g/l)---------->				<----------CGA 152005 (g/l)---------->					
	0.05	0.1	0.2	0.4	0.008	0.016	0.032	0.064	H_2O soaking	Dry planting
IT81D-985	30.0	25.0	20.0	25.0	25.0	30.0	25.0	30.0	25.6	20
SAMPEA 7	22.2	22.2	16.7	22.2	22.2	22.2	16.7	22.2	21.6	18
KANO 1696	25.0	20.0	30.0	20.0	28.0	30.0	25.0	25.0	25.6	20
IT90K-102-6	22.2	16.7	22.2	22.2	22.2	16.7	16.7	22.2	21.0	18
IT89KD-245-1	23.8	23.8	14.3	23.8	23.8	19.1	19.1	23.8	21.0	21

BIOGRAPHY

A. PERSONAL INFORMATION

Name:	Chibiya Paul Shingu
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LGA and State:	Hong, Adamawa
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Post Address	Department of Agronomy Institute for Agricultural Research Ahmadu Bello University, Zaria.

B. SCHOOL ATTENDED

	Year	Qualification Obtained
CBM Primary School Mubi-Adamawa		FSLC
Govt. Sec. School Mubi	1975-1981	GCE 'O' Level
College of Agric. Samaru Zaria	1986-1987	Ordinary Diploma
University of Maiduguri, Borno State	1988-1992	B.Sc (Hons) Agric

C. WORKING EXPERIENCE

- Community High School, Otum, Saki	Class room teacher (Agric. Sci.)
- Department of Agronomy, IAR/ABU, Zaria	1995 till date

D. YEAR OF ADMISSION 1993/94

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