FEDERAL UNIVERSITY OF TECHNOLOGY
MINNA

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B.Sc., M.Sc., Ph.D.

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(Weed Science)

INAUGURAL LECTURE SERIES 21

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Introduction

My interest to study agriculture arose naturally from my growing up on the farm, my passion to study weeds was due to dearth of weed scientists in Nigeria, which is still probably the case today over two decades on, and my desire to work on *Striga* was premised on the enormous crop yield losses they cause to the helpless Nigerian farmer who is compelled to grow crops in *Striga*-sick field. Were there weeds in the beginning? No, in the beginning there were no weeds because humans were few and were hunter-gatherers before the advent of selection, domestication and cultivation of crop plants which started about 9500 BC. The sedentary nature of agriculture changed due to expansion in human population up to the carrying capacity of land which in turn also changed with time. Spore (2010) posited that the trend of world population is that it was five million when man first began farming, however today five million people are born every 10 days worldwide. Furthermore, from the beginning of agriculture it took about 10,000 years for the world population to reach its first billion, but the second billion was hit in 130 years in 1927 (Spore, 2010). Today, 84 years after, the world population is about 6.9 billion. Two pertinent questions to ask at this juncture are: Does food supply increase proportionately with human population? How can this massive number of people be fed? To my immediate domain, which has an annual population growth rate of about 2%, Nigeria is faced with the reality of feeding her teeming population which can result into crisis if the current situation is not properly addressed.

The food crisis in Africa is multidimensional. Apart from climatic factors that militate against crop production in any part of the world, weeds are the most important. The adverse effect of weeds is equal to that of all other factors combined and they cause about 30% yield losses in crops in developing countries. Furthermore, African farmers spend about 40% of their time removing weeds from their crops while their counterparts in the developed world spend less than 10% (Lagoke *et al*., 1991). Weed problems in the tropics have been compounded by recent climate change. Weeds can be classified on the basis of growth habit into free-living (autotrophic) and those dependent on other plants for survival are parasitic (heterotrophic). The problem of parasitic weeds in crop production differs significantly from that caused by other weeds because of the close biological association of parasitic weeds with the host crop plants which makes them special weed problems.

This lecture focuses on the parasitic witchweed (*Striga* spp.). The witchweed constitutes one of the most important biotic constraints to the production of cereal food crops in Africa and it can cause yield losses of up to 100% in cereals. *Striga* is one of the problems reducing crop yield and directly marginalizing capacity for crop production in Africa thereby threatening her food security.

Of the 40 witchweed species worldwide, 28 are found in Africa and of this number five species cause significant damage to crops. The centre of origin of *Striga* is Africa between the Semien Mountains of Ethiopia and the Nubian hills of Sudan (Ejeta, 2011). This area is also recognized as the centre of origin for sorghum and millet which are heavily parasitized by the weed. It is of great concern that all the five species of *Striga* causing serious damage to cereal crops are found in Nigeria. These are:

(I) *Striga hermonthica* (Del.) Benth.
(ii) *S. asiatica* (L.) Kuntze.
(iii) *S. aspera* (Willd.) Benth.
(iv) *S. forbesii* (Benth.)
(v) *S. gesneriodes* (Willd.) Vatke.

While the first four species attack cereal crops (rice, maize, sorghum, millet, hungry rice and sugarcane) the last one attacks leguminous crops (groundnut, cowpea) and *Striga hermonthica* is the most serious in sub-Saharan Africa. Why the name witchweed? The term "witch" in this context expresses the magical and mysterious manner in which the weed damages the host crop, even before it becomes visible above the ground. Across Africa farmers ascribe local names to *Striga* that so correctly translates to effects of humans under evil spirit attack. For example, it is called "wuta wuta" in Hausa language in Nigeria. While the weed is still underground it causes the crop to suddenly become sickly, obviously bewitched. *Striga*'s dramatic bewitching effect and dreadful affliction on crops is recognized by farmers more as a scourge. The *Striga* problem has been a major reason why crop productivity has remained at or below subsistence, leaving farmers with no way out of a situation that is only getting worse.

Description of the Witchweed

For you to appreciate the role I have played in the battle against the witchweed it is appropriate for you to know the characteristics of the weed. *Striga hermonthica* is the largest of the witchweed species, usually at least 30-40 cm tall. The flowers are very striking and beautiful, usually purple in colour but variable, but the plant is deadly in attack (Figure 1). Someone saw a field of sorghum heavily infested with *Striga* and remarked: "who planted these beautiful flowers in this bush?" A parasitic plant is one which depends on another for part or all of its nutrition. The weed attaches itself to the host crop plant through their roots and feed on the host nutrients from the soil and food from the atmosphere thereby causing the crop to be stunted in growth which leads to reduced yield. The witchweed is a hemi-parasite because it has the ability to partially manufacture its food, being chlorophylous. However, it is an obligate root parasite because it cannot establish and develop independently. It is a C3 plant of the Orobanchaceae (formerly Scrophulariaceae) family that parasitizes C4 monocotyledonous hosts of the Poaceae family. In this lecture the terms "*Striga*" and "witchweed" will be used interchangeably.

Fig. 1: The witchweed (*Striga hermonthica*) in flowering stage

Distribution of the Witchweed

The genus *Striga* (witchweed) is the most important of the parasitic weeds in the tropics in terms of spread and virulence. It was known as a serious parasitic weed in Africa, Asia and Australia before 1900 and it was discovered in Carolina, USA in 1956 (Ejeta, 2011). Economically important *Striga* species have broad distribution across Africa thereby leading to locally adapted races parasitizing particular crops. It is an ominous obstacle in the sahel and all the savanna zones of Africa where the bulk of the cereals are produced. M'boob (1991) indicated that 17 countries of Africa are seriously affected by *Striga* and another 25 experienced moderate damages from the weed. It extends from Cape Verde on the West Coast through central, eastern and southern Africa (Figure 2). Today, *Striga* is found in almost all regions of sub-Saharan Africa, except in areas where rainfall is too heavy or in high altitude areas where temperature may be too low for its development. Figure 3 shows approximate area of maize under *Striga* attack in some countries of Africa. The most important *Striga* spp. parasitizing cereal crop plants in some countries of Africa is shown in Table 1.

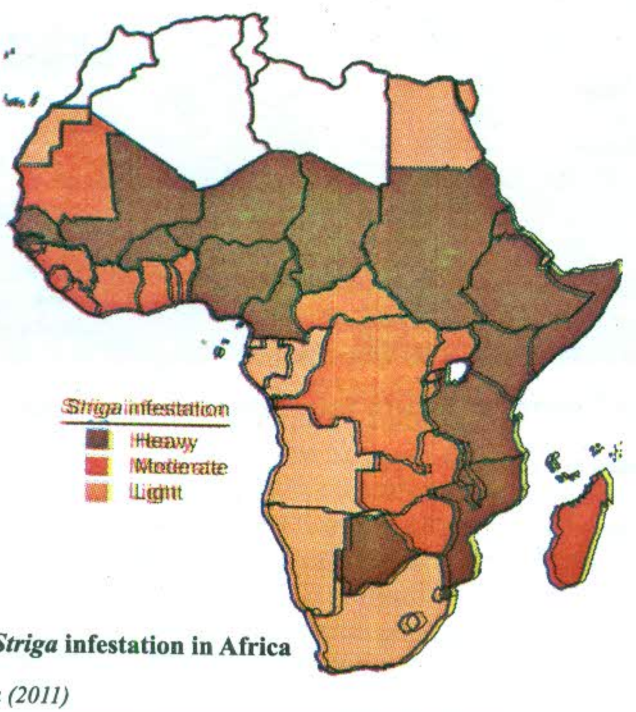

Fig. 2: Level of *Striga* infestation in Africa

Adapted from Ejeta (2011)

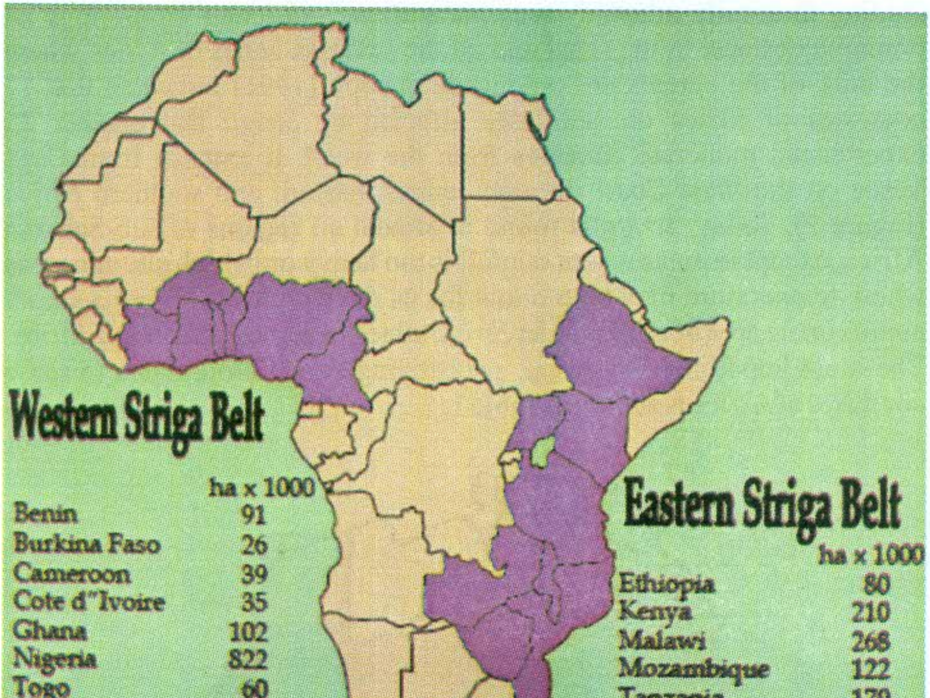

Fig. 3: The Western and Eastern *Striga* Belts of maize in Africa

Adapted from AATF (2006)

Table 1: Distribution of the most important *Striga* species attacking cereal crops in Africa

Striga species	Host crop	Some Countries found
Striga hermonthica	sorghum, millet, maize, upland rice, sugar cane, hungry rice	Benin, Burkina Faso, Cameroon, Chad, Egypt, Gambia, Ghana, Kenya, Mali, Namibia, Niger, **Nigeria**, Senegal, Tanzania, Togo, Uganda
Striga aspera	maize, millet, sorghum, upland rice, sugarcane, hungry rice	Benin, Burkina Faso, Cameroon, Cote dIvoire, Ethiopia, Gambia, Malawi, Mali, Niger, **Nigeria**, Tanzania, Togo
Striga forbesii	maize, sorghum, sugar cane	Botswana, Cameroon, Ethiopia, Kenya, Malawi, **Nigeria**, Tanzania, Togo, Uganda, Zimbabwe
Striga passargei	maize, sorghum	Mali, **Nigeria**, Cameroon
Striga asiatica	Maize, millet, sorghum, upland rice	Angola, Benin, Burkina Faso, Botswana, Cameroon, Cote dIvoire, Egypt, Ethiopia, Ghana, Kenya, Malawi, **Nigeria**, Senegal, Sudan, Tanzania, Togo, Uganda, Zaire, Zimbabwe

Adapted from M'boob, 1991

In Nigeria *Striga* occur in the sahel and savanna zones as far as the derived savanna zone of Ogun State which constitute about one-third of the size of the country and the major areas of food production (Figure 4). The weed is found in 19 states of the country in addition to the FCT. Furthermore, the spread of the weed has increased due to erratic rainfall, intensive land use and use of farm machinery. The major spread of witchweed is mainly through transport of contaminated crop grains and livestock. There is a near perfect ecological overlap between areas of *Striga* infestation (Figure 4) and areas of food insecurity in Nigeria. The area is characterized by low rainfall and infertile soils. The impact of *Striga* is therefore worsened on crops that grow under moisture and nutrient stress conditions. Past survey indicated that *Striga* was present on 94% of the farms and *S. hermonthica* was the most predominant species occurring on 77% of the farms in Nigerian savannas (Lagoke *et al*., 1990) (Figure 4). Dugje *et al*. (2008) observed that *Striga hermonthica* population per hectare increased in the order Sudan savanna > northern Guinea savanna > southern Guinea savanna.

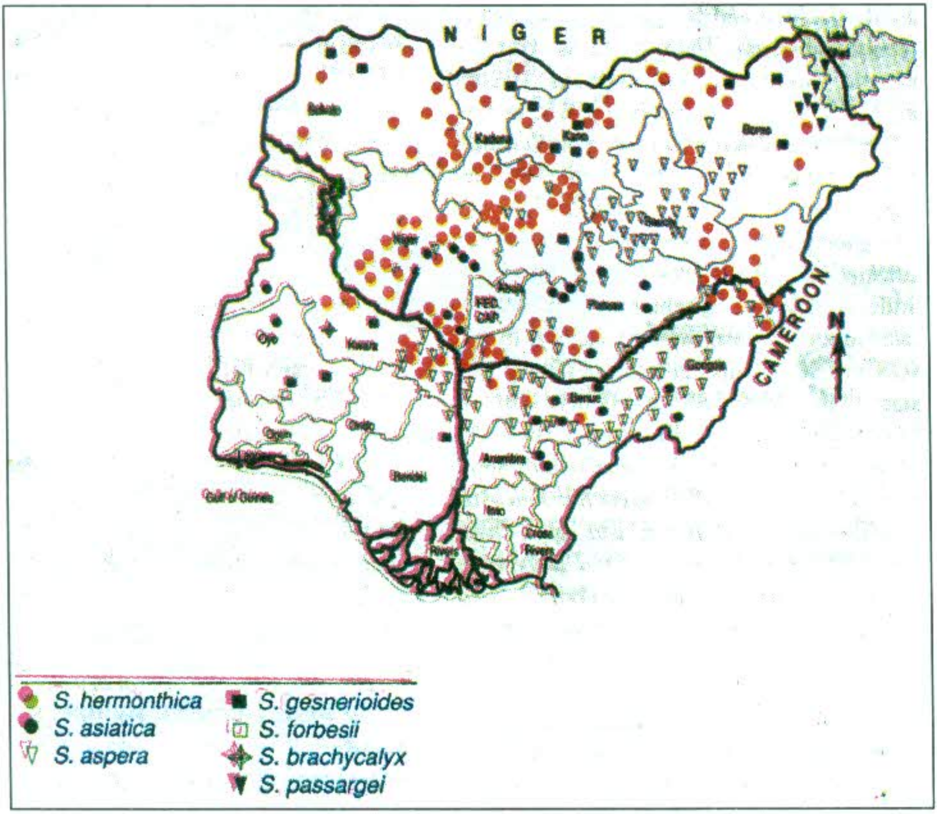

Fig. 4: Map of Nigeria showing distribution of *Striga* species

Adapted from Lagoke, et al., 1991

Why the *Striga* Problem?

In Africa some degree of ecological sustainability was ensured through the practice of crop rotation and shifting cultivation during which the soil regained its fertility naturally. However, anthropogenic factors mainly increase in human population as pointed out earlier, and land tenure systems have forced farmers to adapt a more intensive cropping system. The population growth has created pressure on available farm land thereby forcing crop production systems to marginal and poor soil fertility lands. The land is therefore cultivated continuously in order to meet the food demands of the ever increasing population. Consequently, crop production is practiced with no or shortened fallow periods. However, in the past long fallow periods was used as a means of allowing the soil to regain its fertility, hence controlling *Striga*. Today, the reverse is the case as intensified land use with little or no external amendments accelerates soil fertility depletion and hence, increased *Striga* problem. Where problems of *S. hermonthica* are most severe in sub-Saharan Africa, 94% of the area under cereal production is cultivated with one of its host crops (FAOSTAT, 2011).

Secondly, there is exchange of crop seeds between farmers through which *Striga*-contaminated seeds are exported from one place to another. This has been known to be the major source of *Striga* dissemination.

Economic Importance of Witchweed

Striga posses an ominous obstacle to the African continent that is struggling with food security as it affected the livelihood of more than 300 million people (Mboob, 1991). Lagoke e*t al*. (1991) posited that *Striga* infests 40% of arable land in the African savanna region and two-thirds of the 73 million hectares devoted to cereal production in Africa were affected by *Striga*. Furthermore, AATF (2006) noted that it infested 2.5 million hectares of maize in 15 countries of Eastern, Southern and Western Africa accounting for 92% of infested maize fields. However, the hectarage of land under maize production infested by *Striga* was put at four million (Anon, 2011a). Nearly 100 m ha of the African savanna are infested annually with the witchweed and more than half of African farmers recognize that *Striga* infestation is on the increase on their farms (Ejeta, 2011).

Hard data on crop yield losses due to *Striga* are difficult to compute because of the variation in degree of infestation in an area. However, yield losses from *Striga* attack ranges from a small percentage to complete crop failure depending on crop species, crop variety and severity of *Striga* infestation. New Agriculturist (2011) estimated crop losses due to witchweed in Africa to be above US $7 billion. Over US $1 billion losses per year was estimated for *Striga* infested maize alone in Africa (AATF, 2006); a major cause of food insecurity in the region. An article in the Nigerian Tribune Newspaper (1999) entitled "*Striga*: Competing with man for food" aptly describes this situation.

In Nigeria based on an average grain loss of 39% caused by *S. hermonthica* on sorghum, an estimated annual loss of US $ 93.6 million would be incurred (Lagoke, 1990). The author also put estimated yield losses for both sorghum and maize to *S. hermonthica* to worth US $ 250 million per annum. Furthermore, farmers are unable to grow their choice crop on *Striga* infested field and are usually forced to abandon heavily infested fields thereby contributing, in no small measure, to food insecurity in the country.

Norton (1991) stated that "FAO will continue to consider the *Striga* problem as one of the priorities to be solved in Africa." Similarly, Okonkwo (1990) noted that the International Council of Scientific Unions (ICSU) Committee in Rabat, Morocco in 1989 listed *Striga* among the 18 natural disasters of Africa. In addition, Jonny Gresisel referred to the witchweed as "millennium" weed because "it is of global widespread distribution that is uncontrollable with affordable agronomic techniques".

Biology and Ecology of Witchweed

Okonkwo (1991) stated: "to succeed in an attack against an enemy you should learn as much as you can about your enemy's resources before you decide on your strategy and launch an attack." This therefore leads me to the biology and ecology (resources) of witchweed which makes it intractable to control. The life history of *Striga* is adapted to that of its host and the host-parasite relationship starts in the soil.

The seeds of the witchweed are microscopic (0.25-0.35 mm long and 0.12-0.20 mm wide) with ridges on the seed coat. I have discovered that about 1, 000 seeds of *Striga* weigh approximately 0.01 g while Okonkwo (1991) put the weight of one seed at averagely five millionth of a gram. AATF (2006) observed that one *Striga* plant can produce more than 50,000 seeds in one season and some of them can remain dormant in the soil for up to 20 years. The seeds will germinate only when they receive a signal (exudates called strigol) released from the host root growing nearby. After germination, the signal from the host root induces the *Striga* root to form a penetrating apparatus called haustorium. The haustorium is a specialized organ that connects the weed to the xylem of the host root which enables the *Striga* plant to develop and grow to the soil surface. The haustorium after penetrating the root of the host crop allows it to feed on the host crop by withdrawing water and mineral nutrients from the soil and carbon from the atmosphere. In view of the large number of seeds produced by *Striga* only those that are close (about 10 mm) to the host root germinate, the other seeds lie dormant in the soil and germinating seeds that cannot get contact with the roots of the host crop die within 4-6 days. The large number of seeds produced increases the chance of their germination and finding a suitable host.

The witchweed is completely parasitic before emergence and becomes semi-parasitic after emergence since it makes about 20% photosynthesis (Okonkwo, 1990). I have observed that first *Striga* shoot emergence above the soil surface is between 5-6 weeks after sowing the crop. The Author further observed that the weed derives 28-35% of its total carbon requirement from the host crop photosynthate thereby forming an additional sink for the host crop. Although *Striga* is chlorophyllous its rate of photosynthesis is low and dark respiration is high. Hence, the need for host carbon to support the growth of the parasite. In addition, the parasite shows a much greater rate of transpiration (loss of water from the leaves) than the host crop because the stomata are continually open, even in the dark and conditions of water stress (Okonkwo, 1990). It diverts its host's nutrients to itself so efficiently that its effect on the host is highly debilitating.

The major vehicle for *Striga* seed dispersal is crop seeds. Most African farmers grow their own seed by saving grain from previous crop. There is a significant activity of seed exchange among farmers and grains distributed as food are often contaminated with *Striga* seeds.

Striga Effects on Host Crops

Affected crop plants display a range of symptoms including chlorosis (Figure 5), necrotic lesions, stunting and wilting (Figure 6). They look unhealthy. These lead to reduced plant height, biomass and crop yield which is variable, depending on the extent of investigation. The growth of an infected host crop is reduced and its architecture markedly altered. The shoot growth of the host crop can be reduced by about 65% depending on the degree of severity of attack. This is because infected host crops experience reduced photosynthetic activity by about 60% and secondly the overall efficiency of photosynthate fixation is reduced by about 32% (Stewart *et al*., 1991).

Fig. 5: ***Striga hermonthica*** **attack on maize plant**

Fig. 6: *Striga hermonthica* attack on sorghum

Research on Witchweed

Early research into the problem of witchweed started in South Africa in 1930s, the second centre was East Africa, also in 1930s and the third was in West Africa (Nigeria) in 1960s and in 1964 at IAR, Zaria (Okonkwo, 1990). The devastating effect of the witchweed was recognised by various African governments which have led to several interventions that include:

(i) All-Africa Government Consultation on *Striga* control meeting in Maroua, Cameroon on 20-24 October, 1986 to promote active collaboration for *Striga* research and control activities.

(ii) The Pan-African *Striga* Control Network (PASCON) was established at the FAO/OAU workshop on *Striga* control in Africa in Banjul, Gambia in December, 1988. The membership of PASCON increased from the four founding Nations to 27 countries affected by *Striga* in 1991.

(iii) In view of the widespread and wide-scale damage done to grain crops by *Striga* world-wide interest by international organizations has been focused on research on controlling the weed in the context of Africa. Examples of such organizations are:

(a) Institute of Arable Crops Research, Long Ashton Research Station, UK.

(b) Purdue University, USA since 1984.

(c) Universite Pierre et Marie Curie Paris, France, mid 1984.

(d) Royal Tropical Institute, The Netherlands.

(e) The FAO, Rockefeller Foundation and USAID provided funds for research.

The Department for International Development (DFID), UK provided about US $1,000,000 in March 2001 for a period of three years (Chikoye *et al*., 2006). Recently, a four-year grant of US $6.75 million from Bill and Melinda Gates Foundation was given to IITA, Ibadan in 2010 for evaluation of four approaches to controlling *Striga* in Africa (Anon, 2011b) and it is hoped that by the time the project ends in 2014 about 250, 000 farmers would witness 50% increase in maize yields (NewVision, 2011).

Although significant advances have been made in *Striga* research, the progress has been slow due to lack of significant investment into research and control (Ejeta, 2011). The *Striga* problem has become too big for any resource commitment by national programmes of many developing countries. That notwithstanding, there have been several, albeit intermittent, international investments into *Striga* research. Despite these efforts and availability of control technologies the weed has remained uncontrollable and is increasing.

The Witchweed as a Tactical Enemy

The witchweed has developed over time, thus making it intractable and difficult to control, especially in developing countries. Some of the factors that have led to the "strength" of the enemy are:

(a) It has a high fecundity and longevity of seed reserves, i.e. production of numerous seeds which can remain dormant in the soil for 15-20 years and thereafter become viable. The seed bank is of several generations as new supply of thousands of seeds is added yearly to an already enormous seed bank.

(b) Natural crossing between witchweed species results into new strains, hence high variability even within the same locality, thereby leading to hyper virulent *Striga* populations, and therefore worsening the situation. A crop plant therefore has to be resistant to the great genetic diversity of strains within each *Striga* species.

(c) Broad geographic distribution leads to local adaptations. The weed has infested a wide ecological areas thereby leading to physiological specialization. This implies that *S. hermonthica* strains that infect a crop in one place may be different from that affecting another crop in another place.

(d) It has a preference for erratic rainfall and thrives on degraded soil which is the case with most soils of tropical Africa. The weed is exquisitely adapted to the climatic conditions of the tropical savannas.

(e) It does not only parasitize crop plants, but also grass weeds such as goosegrass (*Eleucine indica)*, itchgrass (*Rottboellia cochinchinensis),* *Paspalum scrobiculatum*, *Brachiaria* spp., etc. (Figure 7).

(f) There is no single effective method for its control for now.

Fig. 7: Witchweed (*Striga hermonthica*) (with purple flowers) growing on host weeds

Striga Control Measures

Since *Striga* problem is primarily in subsistence farming systems, control measures must be low-cost and practical. For control measures to be successful there should be a well coordinated effort that involves priority setting, capacity building, farmer empowerment and commercial investment. Devising measures to control the weed is based on the axiom that in any battle "one has to know the enemy and assess his strength before one attacks." Tackling the witchweed is therefore two-pronged: biology and control. A better understanding of the enemy was due to researches that focused on the biology of the weed and its association with its hosts. Till today, no single control option on its own has been found to be sufficiently effective in controlling the witchweed. Integration of various control measures has proved to be a better approach.

Striga control is slow because of the very many seeds in the soil; hence control measures adopted have to be practiced for several years. There are four major methods of *Striga* control namely: cultural, chemical, breeding and biological. I did not have the wherewithal to use the last three methods of control even though the intellectual ability and will were there. My line of action therefore was culturally based, using the tact farmers are already familiar with. Cultural methods of controlling *Striga* are: host crop seed treatment, sowing date, intercropping, crop rotation and transplanting. Most of these control practices are not only effective in *Striga* control, but also increase soil fertility and build up soil health. However, they need to be repeated for several years before their impact can be seen in significant reduction in *Striga* infestation and subsequent increase in crop yield. For example, it took over 40 years to contain *S. asiatica* in two counties of Carolina, USA with an expenditure of over US $250 million (Ejeta, 2011). The most important objective in *Striga* management is the prevention of seed input in the seed bank. Therefore, in any of the cultural control options the goal is to deplete *Striga* seed bank in the long run and satisfactory crop yield under *Striga* infestation in the short run.

My Role in the Battle against the Witchweed

Host Crop Seed Treatment

Maize seeds treated with *Parkia biglobosa* (locust bean) pulp at the rate of 4 kg to 25 kg maize seed soaked overnight in 1.3-1.8 L of water delayed *Striga* shoot emergence by 14 days, reduced its density by 58-62% and number of witchweed shoots flowering than the untreated maize seeds. In addition, the maize plant was significantly taller and produced greater grain yield of over 80% than that treated with *Parkia* pulp without soaking in water (Kolo and Mamudu, 2008).

In another study, Kolo and Nkonchoson (2003) observed that maize seeds soaked overnight in boiled and cooled *Parkia* seed effluent effectively controlled *Striga* infestation (Figure 8) thereby increasing maize grain yield than the control (Figure 9). The effluent is usually thrown away after cooking the seeds in the process of making a local food seasoning condiment. Similarly, maize seed dressed with *P. biglobosa* seed coat ash prior to sowing expressed 25-34% more grain yield than the non-treated one (Kolo *et al*., 2005). The objective here was to improve on the earlier work by processing the *Parkia* material into a patented seed dressing product. Ma *et al*. (2004) found several Chinese herbs extracts to have inhibited or induced *S. hermonthica* seed germination in laboratory studies. Furthermore, we observed that the resistant maize variety performed much better than the susceptible one when grown under *Striga*-sick condition.

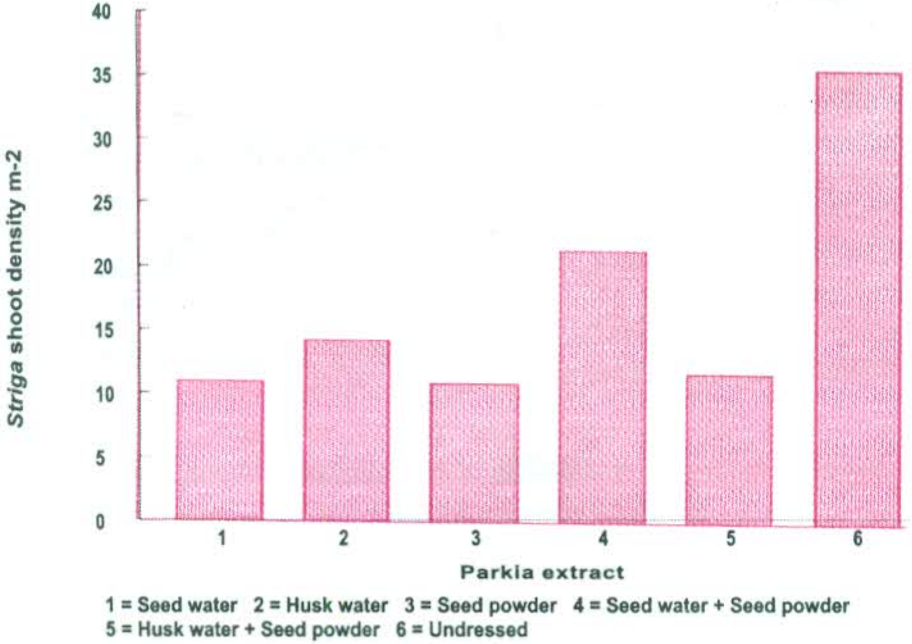

Fig. 8: Effect of maize seed treatment with *Parkia biglobosa* extract on *Striga hermonthica* shoot density.

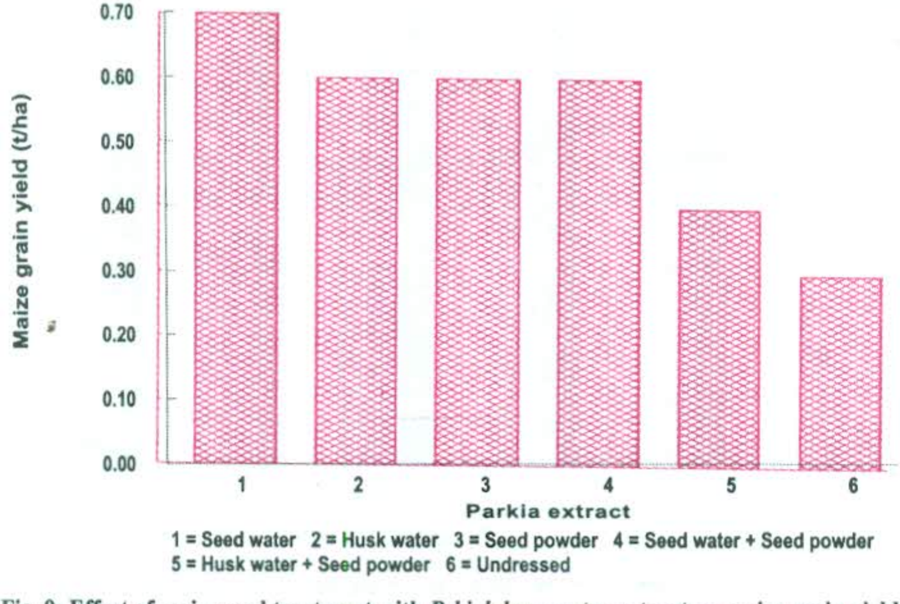

Fig. 9: Effect of maize seed treatment with *P. biglobosa* water extract on maize grain yield

Manipulation of Sowing Date

Delayed sowing of sorghum (31 July) significantly reduced the number of days to *Striga* shoot emergence by 50% over those sown earlier (21 June) in all the sorghum varieties tested (Figure 10). However, late sown sorghum consistently and significantly increased the number of *Striga* shoot density, but significantly had higher grain yield (Kolo, 2007). Therefore, early maturing sorghum varieties can be sown late in order to avoid witchweed attack, however crop grain yield should not be compromised. It was also observed that the *Striga* resistant sorghum variety KSV-8 (SAMSORG 14) significantly delayed *Striga* shoot emergence and out yielded the susceptible varieties.

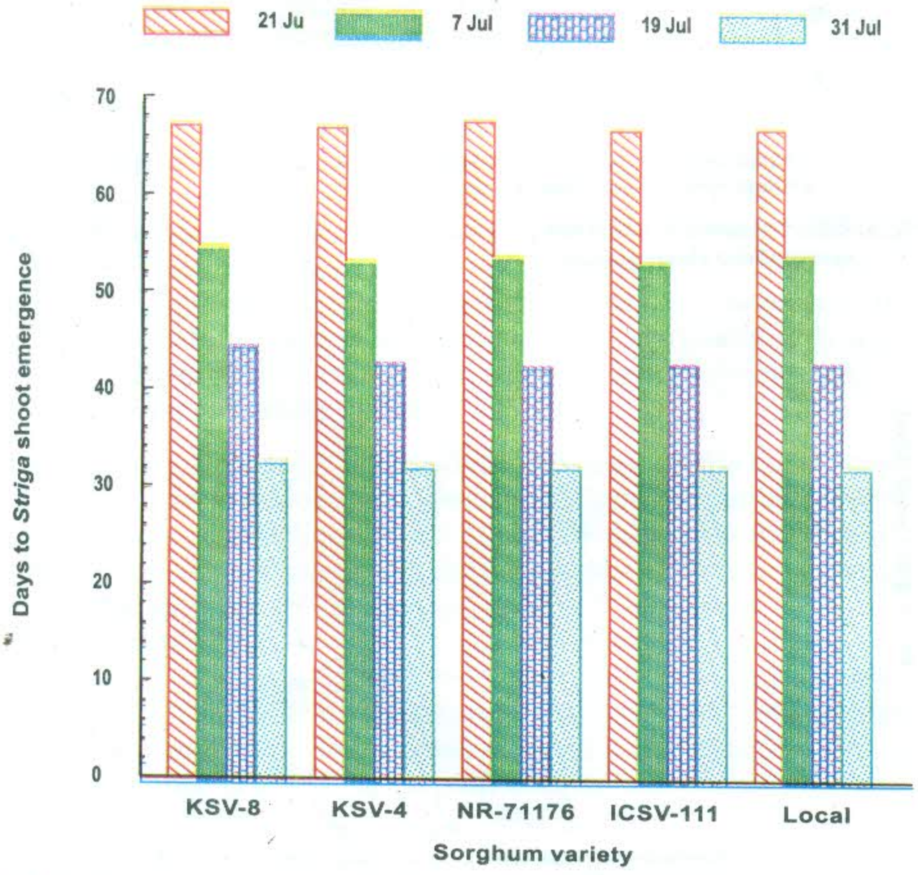

Fig. 10: Effect of sowing date and sorghum variety on days to *Striga* shoot emergence

Legume Intercropping

Intercropping is a common practice in Africa. The use of intercropping host crops with legume crops is to serve as trap whereby the *Striga* soil seed bank is depleted in the long run. The trap crop stimulates *Striga* seeds to germinate without being parasitized, a phenomenon known as suicidal germination. However, it was discovered that the species and varieties of the crops exhibit a wide variation in their ability to stimulate *Striga* seed germination. Kolo and Adamu (2007) noted that maize intercropped with groundnut (RMP 12) did better than that intercropped with cowpea (IAR 48). In a similar study, Kuchinda *et al.* (2003) observed increased maize grain yield when groundnut was intercropped with it than with soybean. Furthermore, Gworgwor (2000) and Dugje *et al.* (2003) found intercropping sorghum and millet with groundnut, respectively, to reduce *S. hermonthica* infestation compared with sole cropping.

We observed that susceptible maize variety TZB-SR showed significant higher *Striga* infection compared to the resistant ACR 97-TZL Comp 1-W and the latter gave 25-28% higher grain yield than the susceptible one. Also, Gworgwor (2000) noted that the resistant sorghum varieties supported fewer numbers of *Striga* shoots than the susceptible varieties. In addition, Kureh *et al.* (2006) observed fewer *Striga* shoots and higher grain yield in *Striga* resistant maize cultivar than the susceptible variety.

In a similar study Kolo and Lawal (2009) observed that sorghum interplanted with jointvetch (*Aeschynomene histrix*) (Figure 11) delayed *Striga* shoot emergence by about two weeks and reduced its density m^{-2} by about 60% thereby increasing sorghum grain yield by about 74% above the control.

Fig. 11: The level of *Striga* attack in sorghum interplanted with (Left) and without (Right) *Aeschynomene histrix.*

Crop Rotation

Crop rotation with trap and catch crops has been practised for *Striga* control. Catch crops are susceptible to *Striga* attack and thus become infected and subsequently destroyed before witchweed flowers. The type of crop cultivar grown has a direct influence on *Striga* infestation. The best practice is long term rotation of cereal crops with legumes or other crops not affected by *Striga*. Continuous cultivation of susceptible crops leads to disastrous levels of heavy *Striga* infestation and consequent build up of seed reserve in the soil. Our study shows that maize grain yield was 55% higher after two years of rotation of some food legumes (groundnut, cowpea and soybean) than that of one year rotation (Figure 12). However, the susceptible maize variety TZB-SR had significant higher *Striga* shoot count with 23% *Striga*-damage rating in the first year rotation compared with 15% in the second year (Kolo and Adamu, 2006). We also observed that soybean variety TGX 1448-2E, cowpea Dankurmi (local), and groundnut variety RMP 12 were better candidate legumes for *S. hermonthica* trap cropping by rotation than soybean SAMSOY 2, cowpea variety IAR 48 and groundnut UGA 2 (Figure 12). Kureh *et al.* (2006) noted that maize grain yield after one or two years rotation with soybean, cowpea or groundnut was 28-56% higher than yield in continuous maize or after natural fallow. In another study, Isah and Lagoke (2010) observed that two years rotation was more effective in reducing *Striga* parasitism on the host crops than one year.

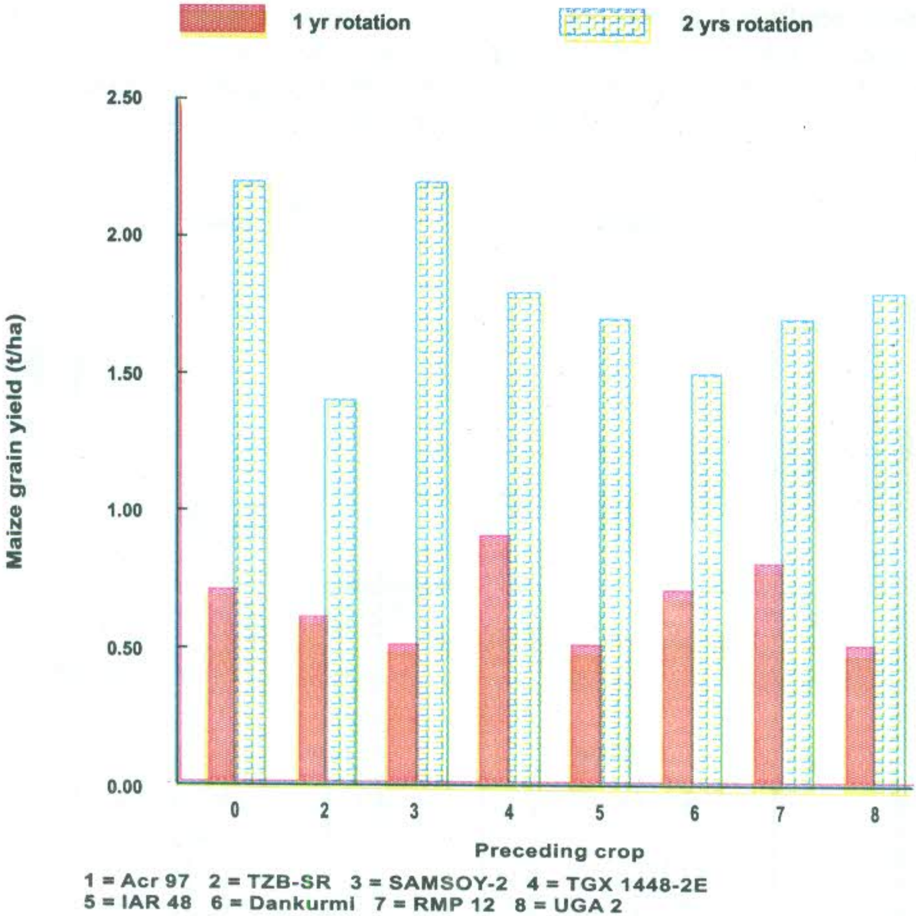

Fig. 12: Effect of crop rotation on maize grain yield.

Transplanting

Transplanting is a traditional practice in filling the gaps after crop emergence in sorghum and millet. However, this is not practiced with maize in Africa, probably because of lack of an appropriate technology. Transplanting a host crop is an effective method in *Striga* management because the crop seedling would be older and more resistant to *Striga* attack. Much work had been done in Nigeria in transplanting seedlings of sorghum against *Striga* attack, but not maize. Our study showed that maize can be transplanted by 15 days after sowing for avoidance of witchweed attack for higher grain yield than that sown directly. The more maize seedling transplanting was delayed the older their roots and the longer it took *Striga* roots to get attached to attack the host crop (Figure 13), the fewer the *Striga* shoot density (Figure 14) and the lower the yield beyond 15 days after transplanting (Figure 15).

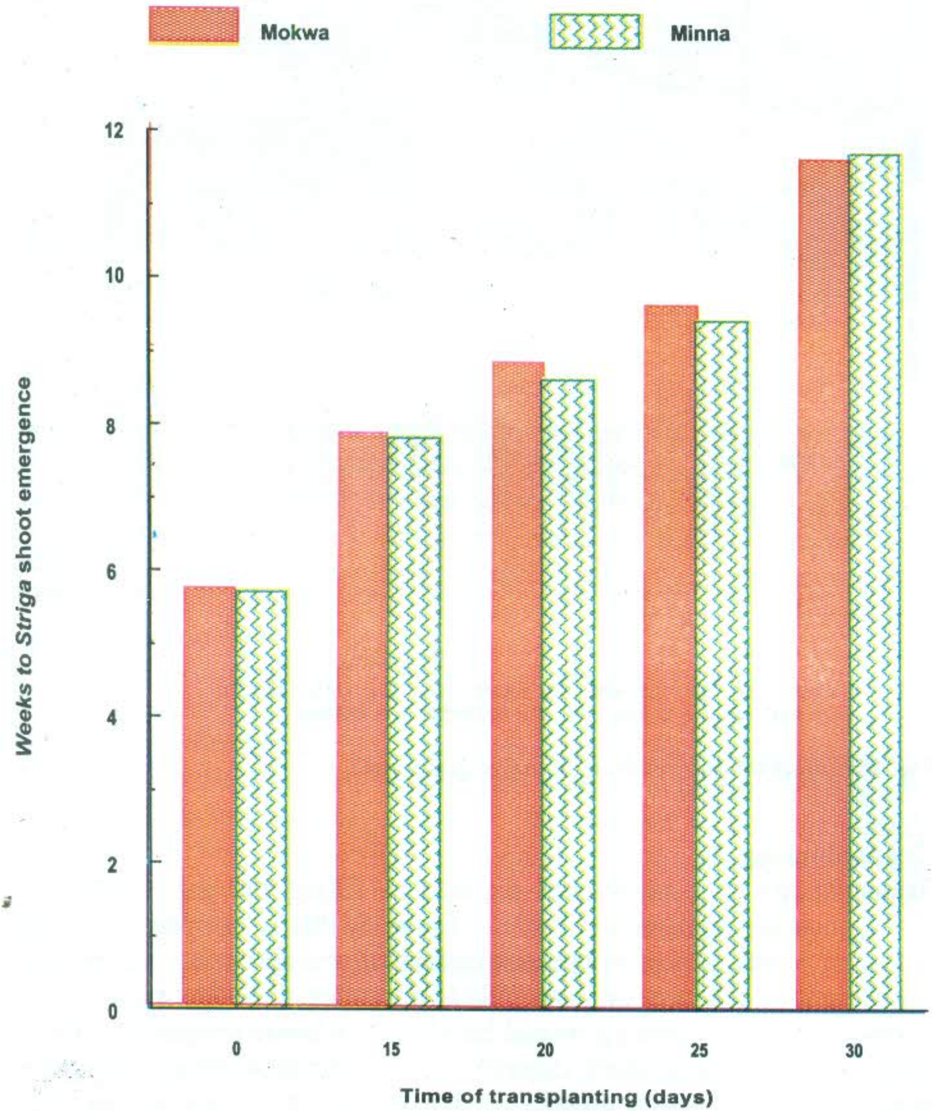

Fig. 13: Effect of time of transplanting maize seedling on weeks to *Striga* shoot emergence

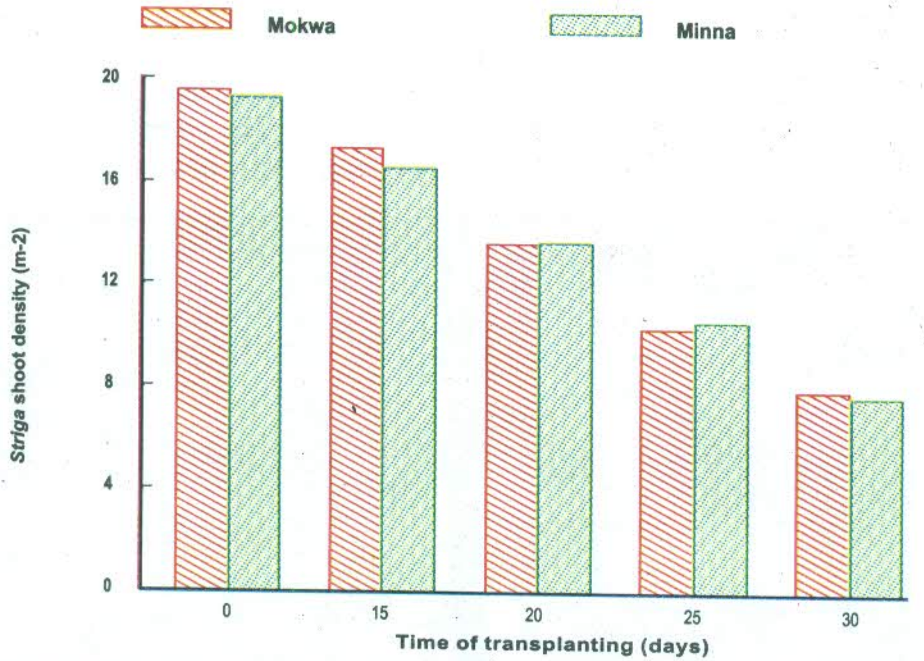

Fig. 14: Effect of time of transplanting maize seedling on *Striga* shoot density

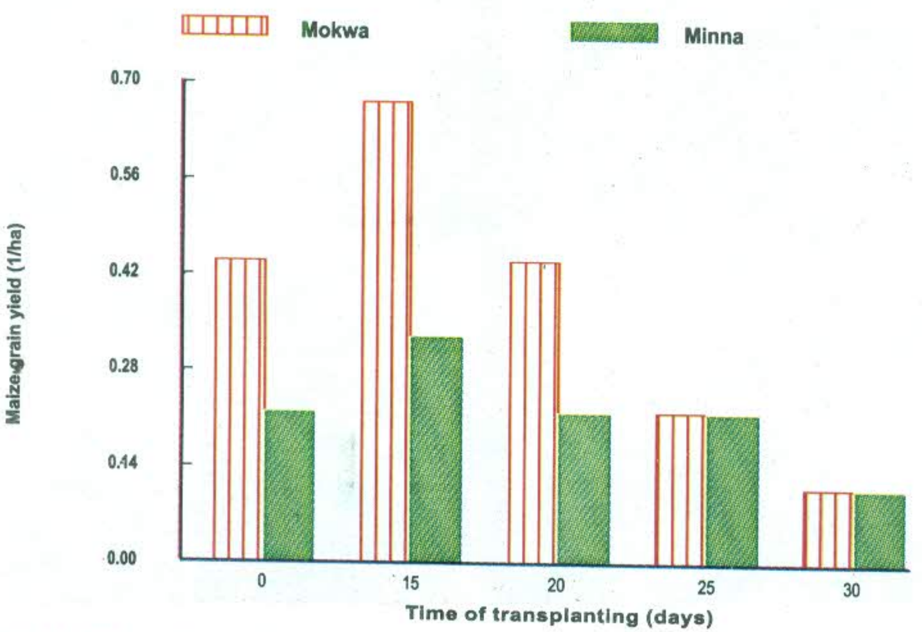

Fig. 15: Effect of time of transplanting maize seedling on maize grain yield

Managed Fallow

This is a concept introduced in areas of low soil fertility by planting leguminous trees and shrubs to enhance the nitrogen content of the soil in addition to provision of fuel wood and fodder. The use of jointvetch (*Aeschynomene histrix*) for this purpose is promising (Figure 16).

Fig. 16: A four month old jointvetch (*Aeschynomene histrix*) planted fallow

Winning the Battle against the Witchweed

Undoubtedly, the problem of *Striga* in Africa will become a disaster if it is left uncontrolled. It will turn an already precarious state of food production in Africa into a greater continental monumental crisis of food insecurity. In order to win the battle against the witchweed and keep its menace at bay the following is my thought:

A Weed Research Unit in the Agricultural Research Council of Nigeria should be established to characterize, map out and monitor *Striga* infestation and validate technologies for its control. This exists in India. In addition, it is to initiate and encourage research on witchweed among other notorious weeds.

Extension agents must be posted to the grassroots level so that farmers can see themselves as frontline cadres in the war against the weed. Production of weed science extension agents that will teach the adoption of *Striga* control technologies is inevitable. This must be done in a manner and language that the farmers can understand since they are generally recalcitrant to adopting new technologies. If farmers know their enemy it will make it easier for them to adopt effective control strategies.

Policy makers must know and view the threat posed by the witchweed as correctable which will be consistent with other emerging paradigms for Nigerian economic recovery including MDGs. A priority to the *Striga* problem must be given in the agricultural policies of the governments. This calls for concerted efforts to deal with the weed problem headlong. *Striga* eradication campaigns should be included in the agricultural agenda for rural development.

Governments should provide financial support for *Striga* research and extension programmes. Sustainable agricultural systems that enhance crop production with simultaneous reduction of the adverse effects on the soil environment are advocated.

Governments should establish and/or encourage functional seed production and dissemination programmes that will ensure certified high quality seeds to farmers. This will limit crop seed contamination with *Striga* seeds and hence, its spread. This was well explained in the 16th inaugural lecture of this University. Furthermore, the private sector, especially seed companies, should invest in production of *Striga* control products.

Conclusion

Research efforts to find solutions to *Striga* problem have been on-going since 1900s and although tremendous progress has been made in understanding its biology, ecology and control, effective control within the reach of resource-poor farmers is yet to be achieved. The panacea for the control of the witchweed is the integration of different environmentally friendly control measures that are economically feasible to smallholder farmers. Since the battle against the witchweed appears to be going on unabated, knowledge from biology, genetics, biochemistry and molecular biology have been used to offer insights to generate technologies to develop integrated control measures. Its control must be a concerted effort and regionally coordinated among the countries of Africa.

With the ever increasing African population, which may vary from one region to another, there is the need to accelerate a concomitant growth in crop production through effective *Striga* control in order to be food secured.

Hopefully, the Nigerian government and indeed the African State will arise with the prowess of the technologies available for *Striga* management today to conquer the scourge and avert disaster by winning the battle against the witchweed.

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I will not forget to say thank you to all of you seated here today to listen to me without which I could be considered to be under the influence of a witch.

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