FOREWORD

Dr. Lytton J. Musselman, of Old Dominion University, has been in Sudan since the summer of 1982 on a Fulbright grant. Since he did not have adequate funds for travel and field research, INTSORMIL made modest funding available to him for support of field work.

This report covers his activities from September 1983 to April 1983. It includes all his activities funded by INTSORMIL, as well as work supported by other sources.

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STRIGA IN SUDAN

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Summary of work from September 1982 to April 1983. University of Khartoum.

Introduction.

The agricultural community of Sudan is well aware of the magnitude of the Striga problem in subsistence grains. The earliest work on Striga hermonthica was, in fact, done in Sudan. There are no doubt more scientists, students, and technicians working on Striga in Sudan than in any other country. All of this testifies to the importance of this parasitic weed in this country. Most work to date has naturally centered on control with little emphasis on the biology of the weed. Undoubtedly the most serious Striga species in Sudan is S. hermonthica. The impact of this species has overshadowed the fact that numerous other species of the genus Striga also occur in Sudan.

Most of the work reported here has not been completed and this report should be considered largely tentative and preliminary and should not be cited. I will value criticism and corrections.

Field work and technical assistance were supported in part from a grant from INTSORMIL. Field surveys in different parts of Sudan were greatly aided by WSARP, Plant Protection Departments, and Regional Ministries of Agriculture. Pot, laboratory and greenhouse experiments were conducted at the Faculty of Agriculture in cooperation with the U of K/ARC Striga project funded by IDRC. I have received supplies from the witchweed laboratory of the USDA. All of this support is gratefully acknowledged.

Objectives.

1. Collect seeds from as many different populations, hosts, and areas as possible for use in the screening work at U of K.

2. Field surveys.

3. Biology of S. hermonthica including floral biology, ecology, genetic interactions, albinism, host selection, variation, and insect interactions.

4. Examine other species of Striga.

Seed Collections. Seeds were collected from about ten different locations. Each collection has a voucher specimen. Seeds are stored at the Striga laboratory, Shambat with duplicate collections at the Striga laboratory, Weed Research Organization, Oxford, UK.

Field Surveys. I have omitted from this section my observations at Shambat, Abu Naama, and Wad Medani because S. hermonthica is well known and well studied in these places.

Adaref, Kassala Province. I visited this rain-fed area the second week of October. Sorghum is the main crop in this region and Striga is a very serious factor in yield reduction and is becoming increasingly more important due largely to intensive mecha-

nized farming. The farm I visited at Um Shagera, a village 9 km north of Gadaref consists of 32,000 feddans, 10,000 in sorghum. This an exceptionally large farm on cracking clay soils. The farmers estimate yield reduction at ca. 50%. Addition of urea (rate unspecified) helps suppress Striga. Striga first appeared in the area in 1972. Since that time, it has spread and increased immensely. In an attempt to obtain reasonable grain yields, farmers have planted some feddans of millet. The millet was from western Sudan and was apparently contaminated with Striga seed. These farmers use a unique control means. If Striga emergence is heavy, the field is disced when the sorghum is 70-75 cm tall. This is ca. 40 days after the sorghum has emerged and about 20 days after Striga emergence. A 20 inch disc is used. Obviously some sorghum is lost but the farmers claim that the yield is greater than if the field is left with Striga.

El Obeid and Kadugli. I visited El Obeid twice, the last week of October and the first week of November, both times in company with Mr. Sabir Barsom Safa, a Sudanese PhD student studying Striga at the University of London. On the second trip we drove from El Obeid to Kadugli and were able to collect Striga at several sites on the way.

Striga hermonthica is a serious problem in Kordofan on both millet and sorghum, both grains are grown on a large scale. Millet is grown on the lighter, more sandy soils and sorghum on the heavier clay soils.

In the El Obeid area I was told that Striga is more serious on millet, especially on very sandy soil perhaps due to lower fertility. The chief means of control, as in most of Sudan, is by hoeing. In the Kordofan shifting cultivation is practiced. In a typical rotation sesame may be grown the first year, millet the second and sorghum or sesame the third. Other means of control are early sowing or dry sowing.

Millet is very uncommon in the Kadugli area but sorghum is very widely planted and usually heavily infested with Striga. A third trip to Kadugli was taken in January. Much of the sorghum was harvested by this time. As commonly noted by other Striga workers, the parasite will mature on sorghum plants that have been cut. A few plants were still in flower on 8 January but most plants were dry.

Red Sea Hills and vicinity. I visited Erkowit, Suakin, and Port Sudan the last week of December. This is rainy season in the Red Sea Hills. Little sorghum is grown, millet being more common on the predominantly sandy soils. However, I was able to examine both sorghum and millet fields but without finding a single Striga plant. Most fields are small and the farmers told me that Striga is not a problem in their region.

Wau, Bahr Al Ghazal Province. I visited Wau at the end of January during the dry season. I saw no crops in the field. However, Mr. Joseph Ramdan, Senior Inspector of Agriculture for the province told me that Striga is very serious throughout much of Bahr Al Ghazal. Control is almost entirely through shifting cultivation.

Equatoria. I toured Eastern Equatoria the second half of March in the company of M. O. Beshir. In the test plots of the Project Development Unit at Yei I found Striga hermonthica on upland rice, finger millet (Eleusine coracana) as well as sorghum. The Director General of Agriculture for the southern region as well as personnel of the Project Development Unit told me that Striga is becoming a serious problem in larger schemes.

Floral Biology. One of my main interests is in the floral biology of Striga hermonthica. Much of this work remains to be accomplished during the 1983 Striga season.

The nectar of S. hermonthica contains a surprisingly high concentration of sugars. Observations with a hand held refractometer indicate a sugar level of about 35% sugars. This is a significant finding when considering floral visitors and their role in pollinations.

Unlike any other species of Striga that has been studied, S. hermonthica corollas remain open for more than one day. Field observations at Shambat in December show that individual corrollas remain open from eight to 15 days. It is not known, however, how long the stigma remains receptive.

The amount of nectar in December ranged from 0.67 uml to 2.68 uml/flower.

The number of capsules that developed as a percentage of the number of flowers ranged from 3% to 35% in December observations.

Ecology and Host Specificity. While S. hermonthica is a very well known weed in sorghum and millet, little attention has been paid to the native habitat and hosts of this parasite. In general, it appears that S. hermonthica must be present in a given area for some time before it is able to attack native grasses.

At various sites in Gezira and Blue Nile Provinces, weedy grasses at the margins of sorghum fields were parasitized. Such hosts include species of Rottboellia, Brachiaria, Cymbopogon, Ophiuros, and Cenchrus. In such cases, S. hermonthica was always depauperate being only a few cm tall, sparsely branched and with few flowers.

The situation in the Kadugli region appears to be much different. Here S. hermonthica is a part of the grassland flora. Plants are tall, robust and appear similar to those that are weeds in fields of sorghum. This phenomenon deserves closer scrutiny as it lends credence to the theory that S. hermonthica is part of a plant guild, including Sorghum spp., that centers in the Nuba Mountain region. In other words, this region may be a center of dispersal for this species.

The existence of sorghum and millet strains of S. hermonthica is well known. Seeds of each strain were planted with reciprocal hosts. The sorghum strain grew on millet but not the millet on sorghum. Likewise, Striga from wild grasses in the Kadugli region grew on sorghum but not on millet.

Genetics. Little is known about the genetic systems of S. hermonthica despite the value of such information in a host breeding system for resistance.

Strains of millet and sorghum Striga have been crossed with seed produced and planted on reciprocal hosts. This has not yet emerged.

White flowered forms of S. hermonthica are found at a very low frequency. Seeds of white flowered forms were planted. The F_1 gave an approximate ration of 3:1 for pink: white flowers although there is some evidence for incomplete dominance.

Albinism. Albino plants of S. hermonthica were found at Shambat and observed until they died before flowering. However, a single flowering albino plant was found near Sennar. Pollen from this plant was used to make crosses. Some seed was present on the albino. The maintenance of an albino line would be a very useful research tool as all material used for nutrition would have to come from a host plant.

Insect Interactions. Under this heading I am considering floral biology and insects that may have potential in biocontrol.

Floral visitors were collected at Gadaref, Wad Medani, Abu Naama, El Obeid, and Kadugli as well as Shambat. Such observations are highly season dependent and the list presented here may represent only one group of floral visitors/potential pollinators.

Lepidoptera
- Pieridae
  - Catopsilia florella Fabricius
  - Pinacopteryx eriphia Godart
  - Colotis protomedia Klug
  - C. halimede Klug
  - Belenois aurota Fabricius
- Nymphalidae
  - Junonia orithya L.
  - Cynthia cardui L.
- Hesperiidae
  - Borbo sp.? gemella Mabille

This survey is in general agreement with the only other published information on floral visitors (Musselman et al. 1983) except that no bee-flies were observed as in West Africa. Striga hermonthica would appear to be an important food plant for these adult lepidopterans. Larvae of Junonia orithya were common as herbivores of S. hermonthica in Kadugli. Without these floral visitors, most of which are considered to be probable pollinators, no seed would be set. This correlates well with the low percentage of capsules that develop in Shambat in the winter as previously stated. (3% to 35%)

Herbivorous insects on S. hermonthica. Three insects were found eating Striga, the coleopteran (weevil) Smicronyx umbrinus Hustache and two lepidopterans, the butterfly Junonia orithya, mentioned above and a well documented feeder on Striga species, and the microlepidopteran Stenoptilodes taprobanes Felder.

Junonia orithya were most abundant at Kadugli but this could be attributable to the seasonality of the animal. It was also observed at every other location. In Kadugli, S. gesnerioides was also attacked by J. orithya.

Recently, Smicronyx has been suggested as a possible bio-control agent for Striga species. I found numerous animals at each site, except Wad Medani. At Gadaref and Kadugli the larval stages were abundant and I estimate that at least 10% of the population was infected. The adult lays eggs in the ovary in the late bud stage and the grubs develop in the developing ovary. A large percentage of the grubs were parasitized by the parasitic wasp Pteromalus semotus Walker (Pteromalidae) which is an ectoparasite of the Smicronyx eggs.

Stenoptilodes taprobanes is a specialized feeder on the stamens and stigma of S. hermonthica in the larval stage. This of course, renders the flower sterile and no seeds are produced.

All insects were identified by the Commonwealth Institute of Entomology and all insects were the first they had seen from S. hermonthica in Sudan (herbivores only). The diversity of insects specialized for S. hermonthica may lend further support to the hypothesis that Sudan is a center for distribution of the species. Because of the apparently long association between these herbivores and S. hermonthica it seems unlikely that these insects will have a role in the biocontrol of this parasite in Sudan.

Variation. Care was taken to collect specimens representative of the variability of the species including branching, height, color of flower, size of flower, corolla variation and leaf variation. This data is being included in the dissertation of S.B. Safa.

Striga gesnerioides. There are two strains in Sudan.

In the Kadugli region, S. gesnerioides is an abundant parasite on weedy Convolvulaceae in sorghum fields. The Kadugli plants are much branched and resemble those S. gesnerioides I have seen parasitizing cowpeas (Vigna unguiculata) in West Africa except for a different corolla color

A very different strain is found near Erkowit in the Red Sea Hills. This is much taller, sparsely branched, stems are burgundy in color (in contrast to the yellow green of the Kadugli strain), and very restricted in its host. It occurs almost exclusively on the tree Euphorbia abyssinica. The phenology of the two strains are also different.

Seeds of both strains were planted with crops which are known to be parasitized by this species including tobacco, cowpeas as well as weedy hosts. To date only the Kadugli strain has emerged and only on Meremia emarginata (Convolvulaceae).

Trap crops. Several crop species have been tested as potential trap crops, i.e., crops that will germinate S. hermonthica but will not support parasitism. To date, only cotton root exudate has germinated Striga seeds.

Other Striga Species in Sudan. I have begun a survey of literature and herbarium specimens to determine which species occur in Sudan. In addition to S. hermonthica and S. gesnerioides, both well documented parasitic weeds of economic crops. S. forbesii and S. asiatica are known from southern Sudan. (See further work).

Further Work.

Heritability of host specificity in millet and sorghum strains of S. hermonthica.

Genetic interaction (isolation) between S. hermonthica and other Striga species.

Distribution and host selection of S. asiatica and S. forbesii in Sudan.

Survey of the Striga problem in Southern Darfur and southern provinces.

Survey of trap crops.

Floral biology.

Effect of weeding methods on subterranean branching and shoot production.

Recommendations.

Establishment of a laboratory for determining amounts of Striga seeds in the soil in order to be able to evaluate control programs. The technology for this has been worked out and is regularly used by the USDA witchweed laboratory.

Some sort of quarantine is necessary in order to prevent the spread of Striga seeds to non-infested areas, especially large mechanized schemes. Likewise, some

simple method of cleaning millet and sorghum seeds is needed. (I am currently exploring this problem with Dr. Mick Turner, Seed Technologist at the Edinburgh School of Agriculture.)

The problem of "strains" needs critical attention including gel electrophoresis (alloenzyme analysis) to determine any genetic distance between strains.

A method of producing seed under controlled conditions is needed if germination responses are to be measured. In this way the role of environmental factors in the processes of after-ripening and conditioning can be accurately studied.

A simple method of sanitizing soil is needed to yield Striga free plots for growth loss studies.

While everyone agrees that Striga is a problem of national concern in Sudan, there is very little quantative data on how many hectares are actually infested. Data is also largely lacking on the severity of infestations. A national survey utilizing infra-red imagery could be a means for conducting such a survey. Much of the data currently available is based on very gross estimates due to the difficulty of surveying inaccessible areas.