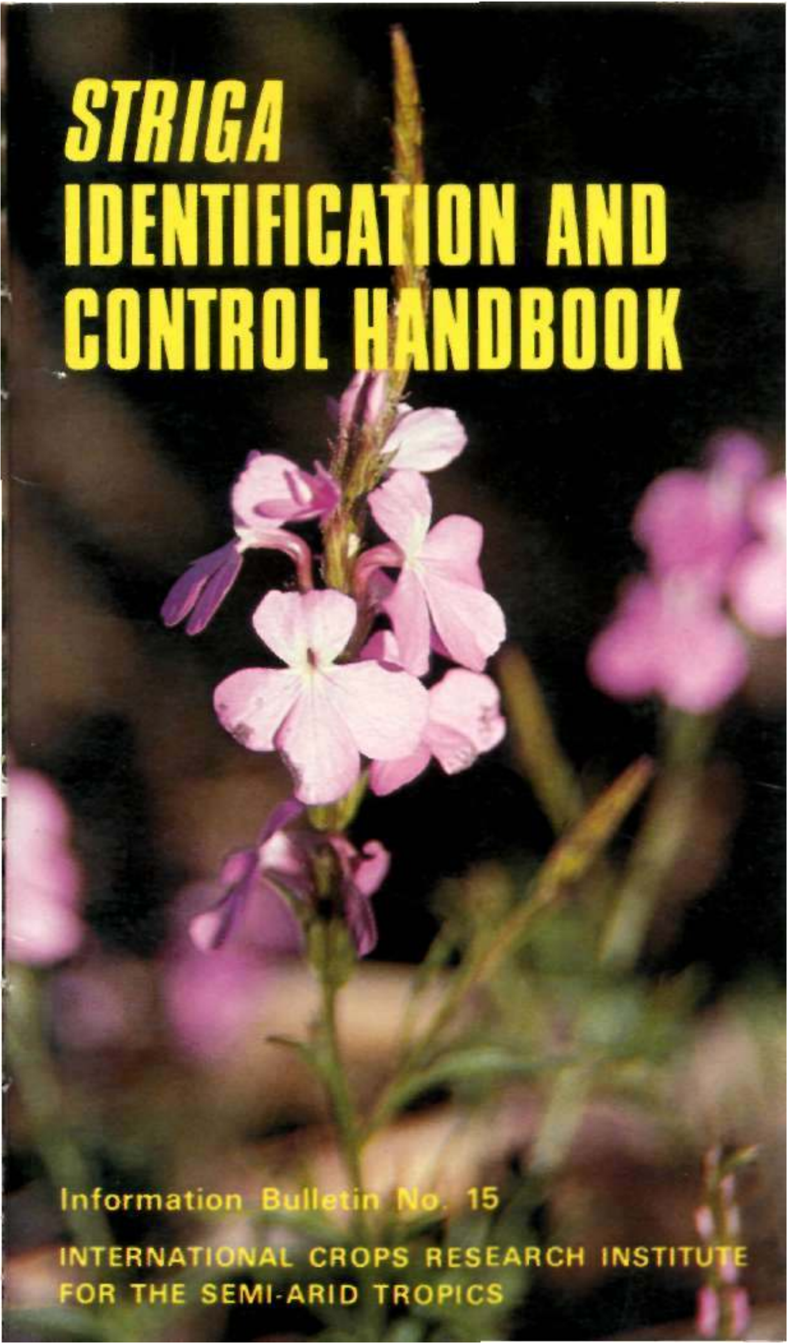

STRIGA IDENTIFICATION AND CONTROL HANDBOOK

Information Bulletin No. 15

INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS

Abstract

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Striga is a root parasite of many food crops. It causes serious yield losses throughout the semi-arid tropics. The purpose of this bulletin is to create increased awareness of the need to reduce such losses associated with *Striga* infestations. It describes the most important of the 25 species of the weed occurring in the world, their biology, and symptoms of attack. It also provides brief information about the options for controlling the parasite. A key is presented to assist in the identification of the seven most damaging species of *Striga,* and the text is supported by 34 illustrations in color.

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STRIGA
IDENTIFICATION AND CONTROL HANDBOOK

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Contents

INTRODUCTION

Plants of *Striga* genus (Scrophulariaceae) are generally known as witchweeds. The genus includes about 25 species, only a few of which are economically important, for instance *S. hermonthica, S. asiatica, S. gesnerioides, S. densiflora, S. euphrasioides, S. aspera,* and *S. forbesii* (in order of importance). Species range from almost completely parasitic to almost totally autotrophic. They attack several food crops, mainly cereals, but also some broad-leaved crops such as cowpea. There is a wide range of wild hosts. Though precise crop loss estimates are difficult to make, complete crop failures caused by *Striga* have been recorded, and occur in many regions of Africa and India. Control of *Striga* could not only increase food production in *Striga*-infested land, but also bring back into cultivation land that was presently abandoned because of *Striga* infestation.

Unfortunately, *Striga* is still considered as a weed nuisance and not as the important agricultural pest it is. Though farmers whose plants suffer *Striga* attack recognize it as a primary yield-reducer of theirfood crops, the extent of the problem has so far not been realized by research and extension agencies and their donors. As a result, there is a general lack of awareness of the problem. There is also some confusion in the identification of different *Striga* species. This handbook illustrates in color some of the economically important species and gives information about their distribution, host range, and control measures

BIOLOGY

Seeds

Striga seeds are produced in enormous numbers. Each seed capsule (Fig. 1) produces some 400-500 seeds, and each plant thus produces several thousands. They are generally dispersed by wind, water, cattle, and man. Seeds are minute, measuring about 0.2 x 0.3 mm (see center of Fig. 2; for comparison maize seeds are shown, top, and sorghum seeds, bottom : x 3 magnification). All species of *Striga* have prominent ridges on the seed coat surface that can be seen under the microscope. The primary ridges are generally ornamented. Secondary ridges, which run at varying angles between primary ridges, may lack ornamentation.

Germination

Striga seeds possess the remarkable capacity to remain viable in the soil for 15-20 years in the absence of a suitable plant host. The seeds are usually dormant for a few months after harvest before they acquire the capacity to germinate, but some samples have been shown to germinate more quickly than others. After this dormancy requirement is satisfied the seeds need a period of conditioning. This may last some 10-15 days under optimum moisture and temperature conditions before they respond to a germination stimulant produced by the young host root. The seeds have to be very close to the host root (within 10 mm and preferably within 3-4 mm) to be stimulated. At favorable temperatures of 30-35°C, seed germination occurs within 24 hours (Fig. 3 : x 25).

Figure 1

Figure 2

Figure 3

Haustorial initiation

There appears to be chemotropic behavior that assists the parasite in making contact with the host root. On contact with the root, the tip of the radicle transforms itself into a haustorium (arrowed in Fig. 4), apparently due to a chemical secretion from the host root known as the haustorial initiation factor.

Attachment

The radicle of the *Striga* seedling secretes enzymes that assist in its penetration of the host root. The xylem of the parasite then establishes connections with that of the host, thus completing the successful establishment of the parasite on the host (Figs. 5 and 6). Certain species of *Striga* can produce adventitious roots that form secondary haustoria. Thus the parasite becomes connected to many roots of the host within a short time.

Nutrition

Once established, the parasite becomes a metabolic sink for the carbohydrates produced in the host, thus depriving the host of some of its photosynthates. The effect of *Striga* on the host, however, is more than just the removal of water, assimilates, and other nutrients. Recent studies at the University of Reading, UK, have shown that, as a result of *Striga* infestation, growth inhibitors in the host are increased and growth promoters are decreased (suggesting an explanation of the damaging effects of *Striga* on the host). Young *Striga* seedlings are completely parasitic on the host while they are subterranean and, at this stage, cause maximum damage to the host. On emergence from the ground they develop green leaves (Fig. 7) that produce their own photosynthates. However, there is a con-

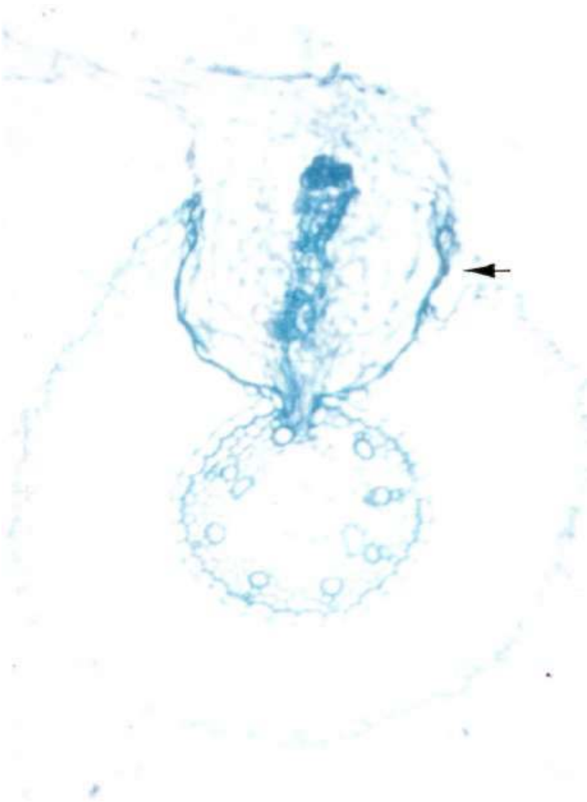

Figure 4

Figure 5 a: Sorghum root b: *Striga* initial
c: *Striga* haustorium

Figure 6 a: *Striga* leaf initial b: Subterranean *Striga*

Figure 7

tinued flow of carbohydrates, water, and minerals from the host.

Life cycle

After germination and attachment, *Striga* takes a few weeks to emerge, depending upon the depth of the seed in the soil. After emergence, it takes about 4-10 weeks to complete its life cycle. Thus, 2-4 months are required from germination to seed-setting. It is often observed that *Striga* can complete its life cycle on the crop stubble after the harvest of the host.

STRIGA SPECIES

The economically important *Striga* species are all annuals. The genus is characterized by opposite leaves and irregular flowers with a pronounced bend in the corolla tube (see Key to the main *Striga* species, pp. 26-27).

1. *Striga asiatica* (L.) Kuntze (= *S. lutea* Lour. = *S. hirsuta* Benth. = *S. coccinea* Benth.)

S. asiatica is a self-pollinated species with established morphological differences among strains (morphotypes) present in different geographical regions of the semi-arid tropics. In India, it is usually white-flowered (Fig. 8). In Indonesia several distinct forms have been observed, including one with pale-pink flowers (Fig. 9) and another with yellow flowers (Fig. 10). A yellow-flowered variant was also found in North Carolina in the USA, Upper Volta (West Africa), and in South Africa. In South Africa the species has bright red flowers with a yellow color on the undersurface of the corolla (Fig. 11) and, in the USA, a deep red flower (Fig. 12).

Distinguishing features. Plants of this species are extremely variable, slender erect herbs, scabrid-pubescent or almost glabrous, with glandular pubescent buds. Calyx-lobes subulate, calyx distinctly 10-ribbed, usually hispid; corolla tube up to 10 mm long, glandular pubescent, and corolla 5-10 mm diameter; bracts linear-lanceolate, about 5 mm long.

Distribution. It is widespread in the semi-arid tropical regions of Asia, southern Africa (from Lake Victoria in Tanzania to South Africa), and is also established in North and South Carolina, USA. Additionally, it has been recorded from northern tropical Africa, but rarely as an agricultural problem.

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

Host range. Almost all cereal crops: sorghum, pearl millet, maize, finger and foxtail millet, and upland rice; also sugarcane, *Paspalum,* and grass weeds—for example *Digitaria sanguinalis.*

Host specificity. Sorghum- and millet-specific strains of S. *asiatica* have been reported from India.

2. *Striga hermonthica* (Del.) Benth. (= *S. senegalensis* Benth.)

S. hermonthica (Fig. 13) is a cross-pollinated species. Pollination is effected by insects, including butterflies (Fig. 14) and moths that suck nectar from the base of the long corolla tube. Bee-flies (Bombyliids) are often found visiting the flowers to feed on pollen, but may not be effective pollinators. Long-tongued lepidopterans are considered as the most likely pollinators. Cross-pollination results in a continuous variation in this species whereas, in *S. asiatica,* the spontaneous mutations may be fixed by self-pollination. In *S. hermonthica* wide variation has been recorded for plant type, corolla shape, size, and color (Fig. 15). White-flowered plants are occasionally seen at very low frequency. They are probably spontaneous recessive mutants.

Distinguishing features. Erect herb reaching a height of 0.5 m; flowers bright pink; calyx distinctly five-ribbed; corolla tube 11-17 mm in length, bending characteristically at an angle immediately over the tip of the calyx.

Distribution. Widespread in the semi-arid zones of northern tropical Africa from 5°S up to 20°N latitude. From east to west it is distributed across the width of Africa. It is not reported from other places in the world, except the southwest Arabian peninsula.

Figure 13

Figure 14

Figure 15

Host range. Sorghum (Fig. 16), pearl millet (Fig. 17), maize, upland rice, finger millet, sugarcane, and several wild grasses in fallow lands and field bunds.

Host specificity. At least two crop-specific strains exist in West Africa. One is specific to pearl millet in the drier zone north of latitude 13°N, where it does not parasitize sorghum (Fig. 18). The second strain found in the north Sudanian zone, around latitude 12°N, attacks sorghum but not pearl millet. Maize, however, appears to be generally susceptible to this species.

3. *Striga densiflora* Benth.

Striga densiflora is relatively less important as a species compared with *S. aslatica* and *S. hermonthica,* and is often mistaken for the white-flowered *S. asiatica. S. densiflora* found on grasses is short (up to 0.2 m), while on sorghum and maize it can reach a height of up to 1 m.

Figure 16

Figure 17

Key to the main *Striga* species

1a. Calyx ribs 5 2

1b.

2a. Leaves scale-like; rarely exceeding 5 mm in length. Corolla variable in color: white/mauve/pink/ purple, 3-5 mm across; densely branched parasite on cowpea but usually less branched forms on other hosts........ *S. gesnerioides*

2 b Leaves green, 20-60 mm long: 3

3a. Corolla white, 3-10 mm across; anthers bluish-black; plants sparsely branched, drying bluish . . . . *S. densiflora*

3 b. Corolla pink/mauve, 8-15 mm across 4

4a. Corolla tube about equal to calyx in length (ca 10 mm) bent immediately above calyx; bracteole 2-3 mm wide . . . . *S. hermonthica*

4b. Corolla tube 8-10 mm long, distinctly longer than

5a. Calyx ribs 10 or more, but never more than 5 extending to tips of calyx lobes, remainder stopping at the sinus; corolla 5-1 0 mm across;

5b. Calyx ribs 15, three meeting at the tip of each calyx lobe 6

6a. Leaves narrowly lanceolate, 3-8 mm wide without teeth; corolla white, 5-10 mm across; seeds 0.5 mm long . . . . *S. euphrasioides*

6b. Leaves broadly lanceolate 10-15 mm wide, coarsely toothed; corolla salmon-pink (rarely yellow),

Figure 18

Distinguishing features. Robust, little branched, and erect herb; aerial parts profusely hairy, green or purple, turning dark blue on drying; flowers densely arranged on the inflorescence (hence the name *densiflora);* flowers bright white; calyx five-ribbed (unlike *S. asiatica* that has 10 ribs). Another distinguishing feature is the anther color, which is creamy white in *S. asiatica* and dark blue in *S. densiflora.* Seeds are similar in size to *S. asiatica* but usually are darker brown with the narrow end blunt rather than pointed. Figure 19 shows a comparison between plants of *S. densiflora* (on the left), and *S. asiatica* (right).

Distribution. *S. asiatica* and *S. densiflora* are found together in some parts of India. Mixed populations of the two species are often seen in sorghum fields in Maharashtra, Karnataka, and Gujarat states in India. In other parts of India *S. densiflora* is found on wild grasses.

Host range. Sorghum, maize, millets, and wild grasses.

4. *Striga euphrasioides* Benth. (= *S. angustifolia* (Don) Saldhana)

S. euphrasioides is less parasitic than the previously described species, being capable of germination and possibly even of growing to an advanced stage in the absence of the host (though there is disagreement on this).

Distinguishing features. Small erect herb reaching a maximum height of 0.45 m; white flowers in long lax terminal spikes (see Fig. 20, center; on the left, *S. asiatica;* right, *S. densiflora);* calyx 15-17 ribbed, unlike other species; capsule walls much stronger; calyx remains with the spike for a considerable time after seed dispersal. Seeds are distinctly larger (0.3 x 0.5 mm) with more elaborate sculpturing.

Figure 19

Distribution. India and Burma.

Host range. Sorghum, maize, sugarcane, upland rice, and grass weeds.

Figure 20

5. *Striga aspera* (Willd.) Benth. (= *Euphrasia aspera* Willd.)

Distinguishing features. It is similar to *S. hermonthica* except that it is smaller, the major distinguishing characteristic being that the corolla tube has glandular hairs and extends beyond the tip of the calyx before it characteristically bends, whereas that of *S. hermonthica* is free from glands and the corolla tube bends abruptly over the calyx tip (see Fig. 21, right; on the left, *S. hermonthica).*

Distribution. Throughout West Africa and Sudan.

Host range. Upland rice, and wild grasses. Also, occasionally observed on maize, sorghum, and sugarcane. However, it is rarely an economic problem.

6. *Striga gesnerioides* (Willd.) Vatke (= *S. orobanchoides* Benth.)

S. gesnerioides is almost completely parasitic, and contains less chlorophyll than other species.

Distinguishing features. Distinctly different from other species. A large number of short branches arise from the ground level; compact (Fig. 22); grows to a height of 0.15 m; leaves scale-like; forms a very large haustorium with the host root, unlike other species (see Fig. 23 that shows a *S. gesnerioides* haustorium, arrowed right, attached to a cowpea root on the left); species shows variation in flower size and color: flowers usually bluish, pink, purple, or creamy white.

Distribution. From Cape Verde Islands through tropical and southern Africa and through the Arabian peninsula and western and southern India. Also found in Florida in the USA.

Figure 21

Figure 22

Figure 23

Host range. Cowpea, tobacco, *Euphorbia,* hairy indigo *(Indigofera hirsuta)* (Fig. 24), *Jacquemontia tamnifolia,* and other weedy Convolvulaceae, and the weedy legume *Tephrosia pedicellata.* A wide range of other hosts are reported.

Host specificity. The forms parasitizing cowpea, tobacco, indigo, and *Tephrosia* have each been shown to be specific to these hosts.

7. *Striga forbesii* Benth.

It is rarely an economic problem.

Distinguishing features. Erect, simple or little-branched herb growing to a height of about 0.5 m; flowers pink (Fig. 25), scarlet, or yellow, 10-20 mm diameter; corolla tube 20-25 mm long, sparsely pubescent. This species can be distinguished from *S. hermonthica* by the presence of two flowers only open on each inflorescence, the salmon-pink colored corolla, and lobed leaves.

Distribution. Throughout West and East Africa, South Africa and Madagascar.

Host range. Maize, sorghum, rice, and *Setaria sphacelata.*

SYMPTOMS OF *STRIGA* ATTACK

In severe infestations symptoms of *Striga* attack generally become observable even before the *Striga* emerges from the soil. Both *S. asiatica* and *S. hermonthica* cause stunting of the host shoot and failure of panicle forma-

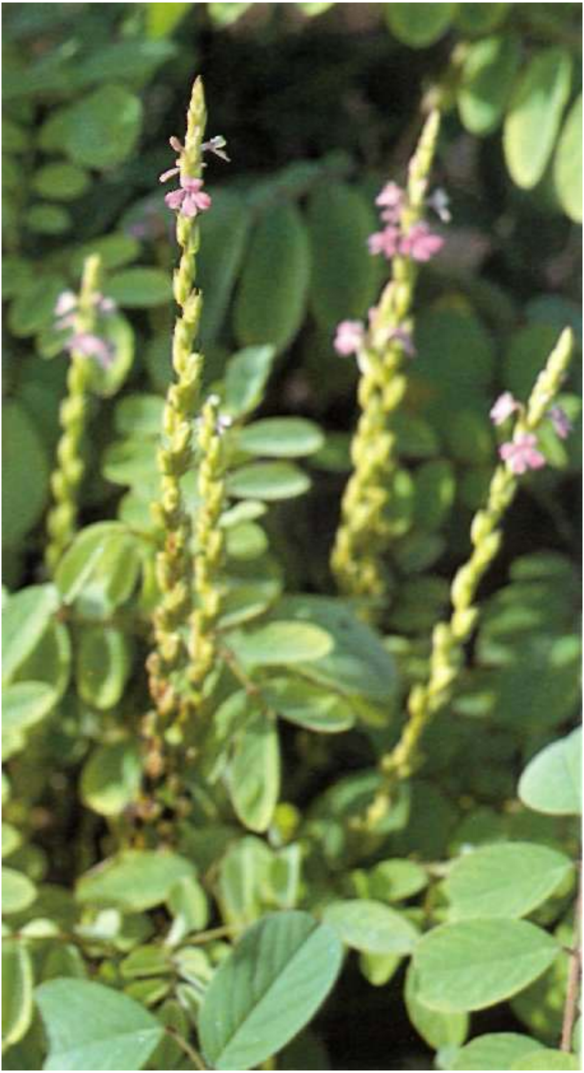

Figure 24

Figure 25

tion, but other symptoms are different for the two species. *S. asiatica* attack induces symptoms similar to those induced by drought-like leaf wilting (Figs. 26 and 27) and leaf rolling, even though the soil is saturated with moisture. *S. hermonthica* does not generally cause drought symptoms but does cause chlorotic lesions (Fig. 28). These may not always be clear and are quite often confused with leaf diseases. *Striga* may completely destroy the host if drought occurs because drought adds to the water stress already created by *Striga. Striga* attack can be very serious on millets because millets are generally grown on lighter soils under low and erratic rainfall, and the attack can lead to a complete loss of yield. Sorghum may also be badly attacked on lighter soils with low rainfall (Fig. 29), but show less damage in high-rainfall areas, probably because of high soil fertility and moisture that favor good crop growth and also discourage *Striga. S. gesnerioides* can be a very serious parasite of cowpea, causing chlorosis and then severe wilting and collapse under drought stress, very often leading to complete crop failure.

CONTROL MEASURES

No single control measure currently available can provide complete control, and many of those listed below have limited applicability on small farms. The identification, breeding, and distribution of resistant varieties are by far the most important research and developmental activities recommended, but other agronomic control measures should be exploited wherever feasible.

Figure 26

Figure 27

Figure 28

Figure 29

Resistant cultivars

The breeding of cultivars that are not parasitized, or are only lightly parasitized by *Striga,* offers a practical control measure. A few resistant cultivars of sorghum have already been identified. N-13 from India, and Framida (Fig. 30) from South Africa, for example, have good levels of resistance. Other useful cultivars include SPV 103, an improved cultivar from India, and IS 9830, a low-stimulant variety from Sudan. Tolerance (capacity to yield well in spite of a high *Striga* infestation) has been exhibited by several local and improved cultivars of sorghum. Very little information is available on breeding for resistance to *Striga* in maize, pearl millet, and cowpea. However, preliminary results indicate that there is genetic variability for host plant resistance in pearl millet, and that Serere 2A-9 is less susceptible. Host resistance to *Striga* is not believed to exist in maize because it is not native to Africa. In preliminary cowpea trials, two varieties, Suvita-ll (Gorom Gorom local from Upper Volta) and TN-121-80 (an improved local from Niger), have exhibited a satisfactory level of resistance to *S. gesnerioides.* Crop varieties resistant to *Striga* at specific locations can be requested from the authors.

Striga-pulling by hand

It is not practical to hand-pull dense infestations but sparse infestations can be hand-pulled before *Striga* flowers. This practice prevents the production of *Striga* seeds. Such hand-pulling should continue beyond crop harvest, if necessary. The crop stubble should also be uprooted or burned to prevent the continued growth and seeding of the parasite.

Figure 30

Rotations

Crop rotation offers good potential control wherever it is practicable. Rotation with trap crops (crops that germinate *Striga* seed but are not parasitized) such as cotton, sunflower, groundnut, and some other legumes not only reduces the *Striga* seed reservoir in the soil but also increases cereal yields because of beneficial rotation effects. A break in the continuous cultivation of sorghum with a trap crop, even for 1 year, has been found useful in reducing *Striga* build-up, but not very effective when infestation is already severe.

Nitrogen fertilizer

The exact timing and form of nitrogen application are not critical, the essential requirement being that the crop absorbs it and responds, Very high levels are needed to suppress *Striga* altogether, but levels recommended for *Striga-free* crops are likely to be highly beneficial in delaying *Striga* emergence and reducing the damage caused. An application of 20% urea as a directed spray on emerged *Striga* plants can kill the plants by scorching and thus reduce its seed production.

Herbicides

No herbicide can provide a perfect selective control of *Striga.* But, where 2,4-0 can be safely used in the cereal crops, it may at least partially prevent emergence when applied at about the time of *Striga* germination, or it may kill emerged parasites when applied later. Other herbicides such as linuron, bromoxynil, and ametryne have been suggested for directed spot-spraying in mixed crops where it would not be safe to use 2,4-D.

Germination stimulants

Ethylene gas, and some synthetic analogues of natural germination stimulants, can be effective in triggering "suicidal" germination of *Striga* seed in the soil. Ethylene is being extensively used in the USA, but the technique has not yet been developed for use elsewhere.

Biocontrol

Practical biocontrol techniques are yet to be developed, but potentially useful organisms include the following.

a. The gall-forming weevil (*Smicronyx umbrinus*) that lays eggs in the flower buds (see Fig. 31 showing damage on *S. hermonthica).* The grubs (Fig. 32: x80) feed on the ovules and effectively reduce seed production, sometimes by 70-80%. In *S. gesnerioides,* galls may be formed in the stem as well.

b. The butterfly *Precis* (= *Junonia)* species whose larvae feed on leaves, buds, and capsules of many *Striga* species (Fig. 33).

c. A range of fungal diseases, including *Fusarium equiseti* that causes girdling of the stem and varying degrees of damage, including the abortion of seed capsules or a complete kill of young plants (Fig. 34).

Integrated control

While any of the above approaches may not be adequate on their own, combinations of two or more control measures can make a significant impact.

Figure 31

Figure 32

Figure 33

Figure 34

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