International Maize and Wheat Improvement Center
Centro Internacional de Mejoramiento de Maíz y Trigo

STRIGA WEED CONTROL WITH HERBICIDE-COATED MAIZE SEED

BACKGROUND

What is* Striga*? The witchweed *Striga* decimates maize, millet, sorghum, upland rice and Napier throughout sub-Sahara Africa. From the high plateau of East Africa where peasant farmers struggle to survive on tiny fields of maize, to the arid savannas of northern Nigeria where they rely on sorghum, African farmers today are fighting a losing battle against the *Striga* scourge. *Striga* is nevertheless more than just an unwanted weed growing in fields meant to produce food. In addition to draining photosynthate, minerals and water, *Striga* does most of its damage to its host through phytotoxins before the weed emerges from the soil. *Striga* is a parasite plant that survives by literally sucking nutrients out of the crops that African farmers use to feed their families. *Striga* exerts its toll on crops by inserting a sort of underground hypodermic into the roots of growing plants, siphoning off water and nutrients for its own growth. Above ground, the crop withers, and grain production is reduced (**Figure 1**).

Figure 1. Maize plants bewitched by *Striga* in western Kenya.

Striga flowers and sheds seeds within the life cycle of its host. Seeds are tiny (< 0.3 mm) and one plant can produce 50,000–200,000 of them. At typical infestation densities of 20 plants/m^2, annual increases in the size of the *Striga* seedbank in soil are tremendous. Moreover, unless stimulated to germinate, seeds may remain dormant and viable in the soil for up to 20 years. *Striga* inflicts most damage on the crop before the weed emerges from the soil. Attachment may occur as early as 2 weeks after germination of maize, depending on the size of the *Striga* seedbank in the soil and the exudation of germination stimulant by maize roots in the vicinity of *Striga* seeds.

What is the impact of Striga? *Striga* infestation is a consequence of monocropping with cereals, which host the parasite, and declining soil fertility, which weakens the host plant to *Striga* attack. As a result of these cropping practices, *Striga*-infested areas have developed very high levels of long-lived *Striga* seeds in the soil with only some breaking dormancy each season when stimulated by crop exudates. Each season every year, infestation by *Striga* becomes worse, contributing to the downward spiral of poverty that in bad years in Africa can lead to starvation. Yield loss due to *Striga* damage ranges from 20-80%; complete yield loss is not uncommon. *Striga* infests an estimated 20 to 40 million hectares of farmland cultivated by poor farmers throughout sub-Saharan Africa. The tiny seeds are carried in run-off, eroded soil and contaminate traded seed to infest an ever-increasing area. In Kenya, an estimated 75,000 ha of land are infested with *Striga* (80 % of farmland in Western Kenya). Every year *Striga* damage to crops accounts for an estimated US$7 billion in yield loss in sub-Saharan Africa, and affects the welfare and livelihood of over 100 million people.

Why have alternative methods of Striga control not had impact? *Striga* control methods have been researched in Africa for over 50 years and have focused on agronomic practices, host plant resistance and herbicide applications. While many are effective, none of these methods has been widely adopted by farmers for several reasons: (i) their benefits are seen only in the medium to long-term since effects build slowly over several seasons, (ii) they require an understanding of *Striga* life-cycle which farmers usually lack, (iii) they require rotating land out of maize when population pressure requires intensification of land use for food production, (iv) while host plant resistance exists, the gains are inadequate and ineffective under high levels of infestation, and (v) conventional 'over-the-top' herbicide applications are prohibitive in cost and ineffective since damage is done before *Striga* emerges from the soil.

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CIMMYT is an international, non-profit, agricultural research and training center dedicated to helping the poor in low-income countries. We help alleviate poverty by increasing the profitability, productivity, and sustainability of maize and wheat farming systems.

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A NEW APPROACH

In order to be effective, technologies must control *Striga* before crop yields are affected and deplete the *Striga* seedbank to control further yield losses. Therefore, methods that act before or during *Striga* attachment will be the most effective in preventing the damaging effects of the weed. In the African small farmer context, the method must also be inexpensive and fit well into his present cropping systems including intercropping or rotations with sensitive crops.

During the past five years CIMMYT, in collaboration with the Weizmann Institute of Science (Israel), with funding from the Rockefeller Foundation, has developed a unique product for *Striga* control in maize. It combines low-dose imazapyr (a systemic ALS-inhibiting herbicide) seed coating applied to imazapyr-resistant (IR) maize seed that leaves a field virtually clear of emerging *Striga* blooms season-long (**Figure 2**). Small quantities of imazapyr (as little as 30 grams) delivered in this manner act at the time of *Striga* attachment to the maize root and so prevent the exertion of the phytotoxic effect of *Striga* on the maize plant which usually occurs even before emergence of the *Striga* from the soil. Additionally, imazapyr that is not absorbed by the maize seedling diffuses into the surrounding soil and kills ungerminated *Striga* seeds. (Higher rates may be necessary to achieve full season control using later maturing maize varieties or where the season is longer.)

Figure 2. Low dose imazapyr seed coats on IR-maize give complete *Striga* control season long.

What are the added benefits for resource-poor farmers?

This technology has an enormous potential to contain the *Striga* problem on small-scale farms in Africa. The minute rates of seed-applied herbicide bring a technology within the financial reach of poor farmers with little resources to invest in alternative control options. Low-dose herbicide seed dressing on IR-maize also controls *Striga* without impacting sensitive intercrops when they are planted 10 cm or more from maize hills. This allows small-scale farmers to continue intercropping, at most with slight modification, while using maize seed treated to control *Striga*. Since the maize seed is treated, there is no need or added cost for spraying equipment, no possibility of off-target application and little chance of damage to sensitive intercrops. Furthermore, this technology delivers herbicide at rates of about 5% of those recommended for over-the-top herbicide applications, making it an affordable, low-cost solution for *Striga* control. With effective *Striga* control, the potential for returns on inputs such as fertilizers and other pest control products is greatly improved.

Table 1. Effect of imazapyr coated IR- maize seed on grain yield in *Striga* infested fields on station.

Herbicide	Herbicide Rate (grams/ ha)	Grain Yield (tons/ ha)
Control	0	0.93
Imazapyr	30	3.06
	45	3.39

Table 2. Effect of imazapyr coated IR-maize seed on *Striga* control and grain yield on farmers' fields.

Imazapyr rate (grams/ha)	*Striga* plants/m^2 12 weeks after planting	Grain yield (tons/ha)
0	23.2	0.55
30	4.0	2.50
45	1.4	2.72

What are the potential returns and market for the IR-maize technology?

Experiments on research stations and farmers' fields (**Tables 1 & 2**) have shown that low dose herbicide seed coating on IR-maize can **increase yields greater than four-fold** at an **effective cost of less than US$4 per hectare** (cost of herbicide added to other existing seed treatments). The added cost is equivalent to about 25-50 kg/ha maize yield depending on market prices, suggesting potential **benefit:cost ratios >25:1** even under the least favorable circumstances.

Precise estimates of the area of maize infested with *Striga* in sub-Saharan Africa are difficult to obtain. However, educated guesses based on extensive geo-referenced surveys in certain countries suggest a potential (maximum) annual market of about 40,000 tons of seed in Eastern and Central Africa, 35,000 tons in Southern Africa and 90,000 tons in Western Africa (based on seeding rates of 25 kg/ha) if all infested areas were reached. Even if only a fraction of these obviously optimistic projections were realized, the market is very significant indeed.

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THE FUTURE

IR-maize lines adapted to *Striga* infested agro-ecologies in sub-Saharan Africa will soon be available from CIMMYT. These lines are not transgenic; herbicide resistance is derived from a naturally occurring gene in maize originally identified by Pioneer International and made available to CIMMYT. Together with adapted IR-maize germplasm, CIMMYT has developed the herbicide seed-coating technology and appropriate rates for the humid mid-altitude ecology of western Kenya, and is testing the technology in other ecologies in sub-Saharan Africa. Our goal is to deliver this product to farmers in all major agro-ecologies in sub-Saharan Africa where *Striga* is endemic. To achieve this goal, CIMMYT is collaborating with BASF, producer of the imazapyr herbicide, to commercialize the technology and make it available to farmers. Seed producers are a vital link to the successful outcome of this goal. Interested seed producers are invited to contact CIMMYT-Kenya at the address below, and to see the benefits of this exciting new technology on farmers' fields.

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