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Striga's Status as a Plant Parasite in the United States

Striga asiatica (witchweed) is one of several parasitic plants of the Scrophulariaceae family that for years have plagued man in his production of agronomic crops (Fig. 1). *S. asiatica* and its sister plants *S. hermonthica, S. gesnerioides,* and *S. euphrasioides* have long been known throughout the Old World tropics, Africa, India, and much of the tropical and subtropical climatic zones (Fig. 2). These parasitic weeds have been reported to cause more crop damage than any other pest on the continent of Africa.

Because witchweed parasitizes roots (Fig. 3), it may be characterized as the silent reaper, undramatically robbing the crop of nutrients and moisture. The damage is far in excess of what might be expected based on the biomass of the parasite. The interference with movement of nutrients and moisture through the root system plus the strong indication of some metabolic toxicant have devastating effects on the host crop, often causing severe to total yield loss.

First Quarantine Against a Weed

S. asiatica was identified as growing in an area of eastern North Carolina in 1956 and has subsequently been found on some 153,960 ha in southeastern North Carolina and northeastern South Carolina. With the aid of A. R. Saunders (8), the leading authority on *Striga*, the potential devastation to corn, sorghum, rice, and other gramineous crops in the United States was recognized. The decision was made to impose a federal quarantine on the infested area. Because weeds were not legally recognized as pests, the quarantine was imposed under the Plant Quarantine Act, with witchweed considered a "parasitic disease" of corn. Both North Carolina and South Carolina imposed state quarantines to regulate intrastate movement (Fig. 4). This was the first quarantine action taken against a weed. However, it was not until some 17 years later that Congress, by passing the Federal Noxious Weed Act of 1974, established a procedure for protecting the United States from such devastating weeds of foreign origin as *Striga*.

The imposition of federal and state quarantines (10,11) provided a mechanism to prevent the spread of witchweed out of the infested area. All equipment, commodities, and material must be free from seed or soil before leaving the infested area; this is achieved by fumigation, washing, or other means of cleaning. This most successful regulatory program has been accomplished by a dedicated staff of federal and state regulatory officials and by constant input from extension, vocational agricultural, and news media personnel. Credit must also go to the farmers and agribusiness people of the area who have done their part.

Although witchweed has been found on more than 150,000 ha in 38 counties in

Fig. 1. Witchweed infestation of cornfield. (Right) Close-up of the parasitic weed.

the eastern Carolinas, that area is basically the same as the original infested one. To date, witchweed has been eradicated from some 8,700 ha in eight counties, and these areas have been released from quarantine.

Research Facilities Are Set Up

Soon after witchweed was found and its adverse effects on American agriculture determined, research facilities were established within infested areas—at Whiteville, North Carolina, and near Dillon, South Carolina—to develop the methodology for containing and eventually eradicating witchweed from the United States.

Early work focused on developing control methodology, with some attention given to basic research on the parasite-host relationship. One finding was that witchweed could produce up to a half million microscopic seeds per plant. Work by Saunders (8) indicated these seeds could maintain viability in the soil for up to two decades. The seeds germinate only if chemically stimulated by a constituent in the root exudate of host plants.

Controlling and Devitalizing

Two other general areas of activity are involved in eradicating witchweed from the United States: 1) controlling growth, development, and reproduction of the plant and 2) devitalizing seeds in the soil.

A versatile and diversified herbicide program has been the primary mechanism for controlling the growth and development of witchweed. The program is administered and funded by the U.S. Department of Agriculture Animal and Plant Health Inspection Service, Plant Protection and Quarantine. States conduct cooperative activities. Much of the weed control activities by farmers directly benefit the eradication effort.

Early in the program, 2,4-dichlorophenoxyacetic acid (2,4-D) was the chemical of choice for controlling witchweed in corn (9). Because the infested area includes large acreages of crops susceptible to 2,4-D—ie, cotton, soybeans, and tobacco—the research station at Whiteville designed special high-clearance sprayers equipped with low-pressure whirl-chamber nozzles. With this equipment, herbicide damage rarely occurs outside the target area.

Other herbicide treatments have been and are still being developed for the program. Paraquat (4) is used extensively as a based-directed application in corn. The dinitroaniline herbicides, such as trifluralin, control witchweed as well as grass, and oxyfluorfen (Goal) (7) kills on contact and provides residual preemergence control. We now have herbicides that directly control witchweed or eliminate all host grasses in all conceivable situations. In addition, such farm

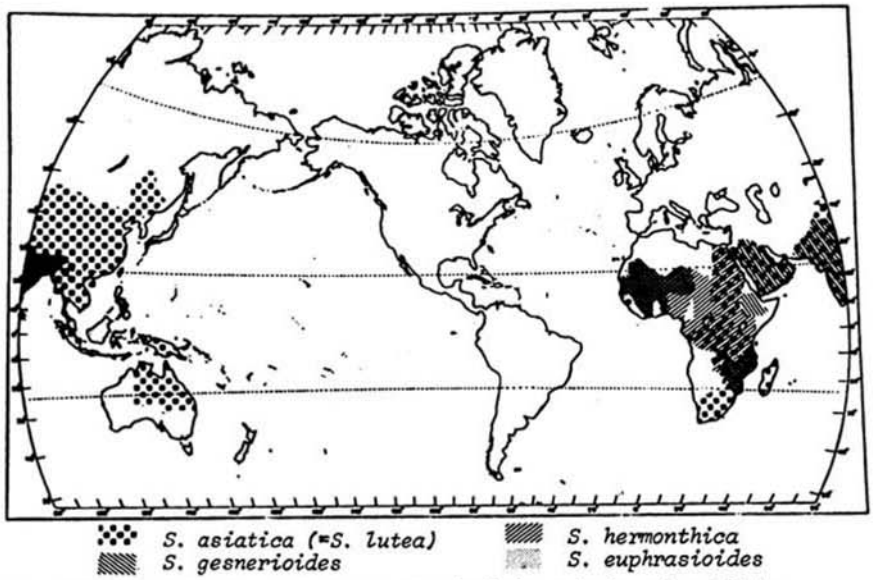

Fig. 2. World distribution of four most economically important species of *Striga*.

Fig. 3. Witchweed parasitization of corn plant roots.

Fig. 4. Under witchweed quarantine, movement of regulated articles from shaded areas into or through unshaded areas is restricted. Regulation is total for completely shaded counties and partial for incompletely shaded counties.

practices as using early-maturing corn varieties and field tillage immediately after early harvest have drastically shortened the control season and significantly reduced the cost of the program. By controlling grass in infested lands planted to nonhost crops, the farmer deprives witchweed of a host and contributes to the control effort.

Preventing the growth of witchweed in the United States is possible but costs money, and current funding for witchweed control does not permit the necessary level of activity on all infested areas.

Eliminating or devitalizing witchweed seeds in the soil is crucial to a successful eradication program. The development of an artificial "seed stimulant" was an objective of early research, and through this effort the natural stimulant was isolated, identified, and named "strigol" (1).

Identification of the natural stimulant has led to a great deal of synthesis research to produce biologically active analogs. Strigol was chemically synthesized by Heather, Mittal, and Sih (5) but is not considered practical per se as a soil treatment. Other scientists, including Johnson et al (6), have synthesized analogs of strigol, but all these analogs are still in various stages of development. Further work on these synthetic stimulants is warranted, especially for their potential benefit to Africa and other infested areas.

Coincidental with the identification of strigol, Egley and Dale (2) showed that ethylene gas was highly effective in inducing germination of preconditioned witchweed seeds. (As used here, preconditioning refers to a physiological condition in which mandatory temperature and moisture regimes have been met and the seed will germinate in response to a chemical stimulant.) With this discovery, major effort was devoted to determining the potential for practical use of ethylene (3) and to developing the methodology for field application. It was established that ethylene injected 15–20 cm into the soil at the rate of 1.6 kg/ha during May through July would diffuse more than 1 m from the point of injection and initiate the suicidal germination of all preconditioned seeds in this zone. Special equipment, similar to that for applying anhydrous ammonia, was designed for field application of ethylene. A single application, properly done, can reduce the witchweed seed population of a site by greater than 90%, and three applications in sequential years, along with an escape plant control program, can eradicate witchweed. An ethylene treatment costs less than $25/ha, but because funds are

limited, less than 3% of the total affected area is treated annually.

Time to Complete the Task

At the present time we have a quarantine and regulatory program that has succeeded in restricting witchweed to its original area, even though the pest will grow anywhere in the United States where corn is grown commercially. We have herbicide treatments and agronomic practices that can prevent growth, development, and seed production. We have ethylene and fumigation treatments that can deplete viable seeds in soil. We have specialized equipment with which to safely and effectively apply these treatments. We have an ongoing research program to enhance efficiency and to ensure that technology stays ahead of the treatment program. The small area in the eastern Carolinas is the only place in the Americas where this Old World menace to agriculture is known to occur. The crops threatened by this parasite are valued at more than $20 billion annually, with the crop loss potential in the hundreds of millions. It appears the time is right for some serious attention to completing the task of eradicating witchweed from the United States.

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