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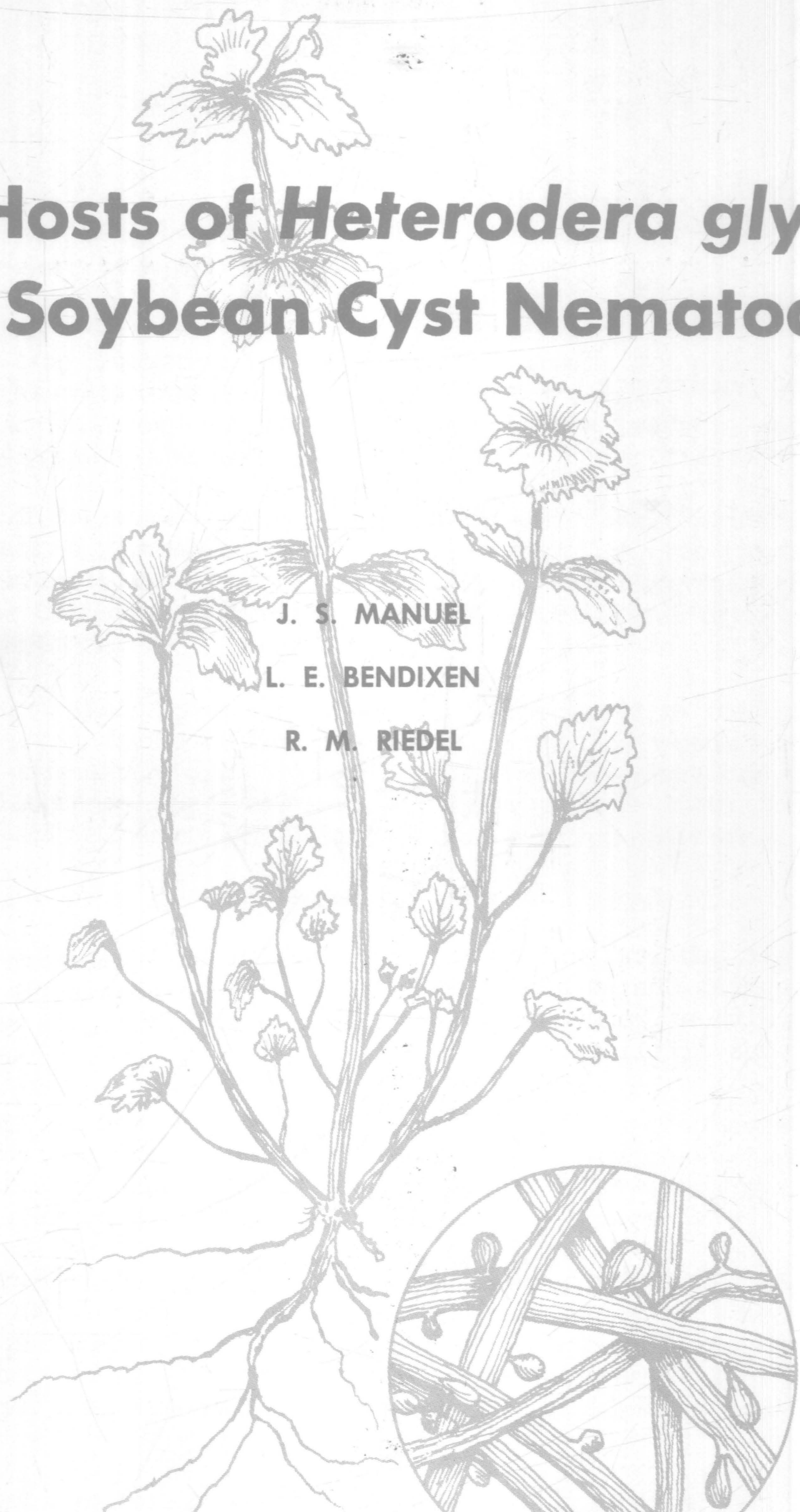

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WEED HOSTS OF HETERODERA GLYCINES: THE SOYBEAN CYST NEMATODE

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Introduction

Weeds are misfits. They are unwanted plants, ever present throughout the agricultural calendar. They interfere with man's activities and are significant negative factors in crop production.

Weeds restrict crop production by competing directly with crop plants for the essentials of growth, such as light, water, mineral nutrients, and carbon dioxide. They lower profitability of crop production by lowering the market quality of farm products, increasing cost of production, and reducing land value and water utilization.

Weeds are one of the major limiting factors in soybean production throughout the world. The presence of weeds in soybean fields was reported to reduce crop yields by 40 to 60 %, depending upon the intensity of infestation (2). Annual weeds, especially grasses, cause the most damage. In the United States, the average yield reduction due to weeds in 28 soybean growing states was 12 % (23).

Another aspect of the crop-weed association, which is not so readily recognized and appreciated as a negative factor in crop production, is that of weeds serving as hosts of organisms adversely affecting crops. Populations of these organisms can be maintained or increased to high levels on the weed species which provide them food, shelter, and reproductive sites, enabling them to persist in the field when crop hosts are not present.

The Nematode

The soybean cyst nematode (Heterodera glycines Ichinohe) is reported to be the most damaging nematode attacking soybeans. Breth (3) reported that it is a potential threat to every soybean field in the United States. This nematode is the causal organism of the yellow dwarf disease of soybeans, a devastating disease capable of causing total crop failure (4).

The soybean cyst nematode is an endoparasitic worm. The second stage larvae enter the roots. Female nematodes protrude from the roots as small white lemon-shaped bodies. These small bodies are visible with the naked eye. Females turn yellow and brown upon maturity. Male nematodes are cylindrical in shape (21).

The mature female soybean cyst nematode produces about 600 eggs. She retains most of these but lays about 200 eggs in the gelatinous mass outside her body. When the female dies, the body wall becomes hardened cyst which protects the enclosed progeny through prolonged periods of adverse conditions. These nematodes derive their name from this cyst. Cysts remain in the soil after the death of the host plant and the enclosed eggs can survive for many years (3, 21).

The soybean cyst nematode can complete a life cycle in 23 to 27 days (8). Temperature is apparently an important factor. In Japan, the female nematode was reported to produce

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eggs in 24 days after entering the roots when the soil temperature was 74° F and in 41 days when the temperature was 64° F (11). In the United States, however, Skotland (20) reported that, at 75° F, female soybean cyst nematodes mature in 14 days and second generation larvae are produced in 21 days. In the southern states, five generations a season are possible (3).

Damage

High populations of the soybean cyst nematode in the field can result in significant reduction of soybean yield. It has been estimated that fields with established populations of the nematode can suffer yield losses as high as 50 to 80 % (19). Reported losses from this pest in 1974 in 4 states out of the 13 states infested in that year were estimated to be more than $23 million (16).

Soybean cyst nematodes lower yields by damaging the roots. The second stage larvae (the infective stage) penetrate the plant by puncturing the roots with their needle shaped mouth parts, the stylet, and move through the roots until they reach the conducting tissues, where they feed and mature.

To facilitate feeding, the nematodes induce host cells to provide specific feeding sites containing specialized nutritive cells or syncytia (5). The larvae inject a digestive enzyme into the conducting tissues that breaks down cell walls, resulting in the accumulation of cellular materials which clog the conducting tissues and interfere with translocation (3).

The above-ground symptoms of infected plants resemble those caused by other root pathogens, nutrient deficiencies, drought stress, poor drainage, or herbicide injury. Damaged areas in the field appeared as spots which may vary from a few square feet to several acres, with the most damage in the center (13). In highly infested fields, the plants are stunted and the leaves are yellow; in more severe cases, the plants die. To confirm infestation, diagnosis requires examination of the roots or soil and a microscopic study by a trained nematologist (7).

Distribution and Occurrence

The soybean cyst nematode was earlier known to occur only in East Asia (Japan, Korea, and Manchuria) but was later reported to occur also in other countries such as China, Egypt, Poland, Taiwan, and the United States (4, 16). In the United States, the soybean cyst nematode was reported to be present in 15 states. It was first discovered in the bulb growing areas of North Carolina in 1954. It was found in Missouri and Tennessee in 1956, in Arkansas, Kentucky, and Mississippi in 1957, and in Virginia in 1958. It was later found in Illinois, Indiana, Louisiana, Florida, Alabama, South Carolina, and Oklahoma. Its occurrence in Ohio was reported in 1980 and was suspected to have been introduced with tomato transplants obtained from states infested with the nematode.

Host Range

Early reports on the host range of soybean cyst nematodes were restricted to the family Leguminosae (4, 17, 20). Later studies, however, revealed a wide range of host plants (6, 8, 9, 18, 22). These included both annual and perennial crops and weeds.

Nematodes are obligate parasites and not all cultivated plants are suitable hosts. Their numbers decline if they are not located in areas or transported to areas where there are suitable hosts. In the absence of the cultivated hosts, weeds serve as alternative hosts (12). Studies conducted throughout the world have confirmed that weeds serve as hosts of nematodes which threaten cultivated crops. Odihirin and Adesida (14) reported that in Nigeria, species in more than 20 plant families served as hosts for root-knot nematodes

(Meloidogyne spp.). Nematode populations increased during the dry season after the annual crops were harvested. In the southern United States, nutsedge (Cyperus spp.) has been found to be a factor in maintaining damaging populations of many nematodes (10, 15).

Sixty-six weed species belonging to nine plant families were reported suitable hosts of the soybean cyst nematode (Table 1). Species classified in the family Leguminosae were the most numerous, followed by Scrophulariaceae. These nine plant families are: Capparidaceae, Caryophyllaceae, Cruciferae, Geraniaceae, Labiatae, Leguminosae, Phytolaccaceae, Portulacaceae and Scrophulariaceae.

Observations reported by Riggs and Hamblen (18) indicated that Linaria canadensis, Penstemon digitalis, and Verbascum thapsus of the family Scrophulariaceae maintained relatively high populations of the nematode. Cardamine parviflora var. arenicola and Geranium maculatum maintained significant numbers of cysts and increased the nematode population. Portulaca oleracea and Stellaria media failed to increase adequately the nematode population. However, the lower number of cysts recovered from them would prolong survival of the nematode infestation during an extended absence of more favorable hosts.

Apparently the capacity of the nematode to maintain and reproduce in different weed species varies. Although a given weed species may not be as suitable a host as the crop or other weed species, the nematode may survive in such species and maintain a low population. It is significant that a particular weed has the potential to serve as a reservoir for the nematode in the absence of more suitable hosts. The weed can serve as a source of inoculum of the nematode for rapid infestation when soybeans or other suitable host crops are planted.

The soybean cyst nematodes can spread rapidly in a variety of ways, such as use of contaminated seeds and other planting materials, movement of farm machinery and other implements, and natural agencies. Seeds may be contaminated with small balls of soil, called peds, at harvest. Peds from infested soils may contain cysts. The cysts in the peds contain the larvae and can survive normal seed storage (3, 16).

Cysts may be found in the mud adhering to farm implements, machines, workmen's shoes, or other mud carrying items which may be transported to other areas. Wind, run-off water, livestock, and wildlife may carry cysts into clean areas. Water fowls and other birds feeding in infested fields may pick up cysts and carry them to other sites. Cysts can pass through the digestive systems of birds and swine and still remain alive (7, 8).

Control of pests possessing such remarkable endowments for spread and survival as the soybean cyst nematode obviously cannot be accomplished through a conventional, single, direct approach such as localized soil fumigation, seed treatment, use of resistant varieties, and crop rotation. Application of nematicides to the soil reduces nematode population, but it is very expensive and has not proven effective year after year because cysts are generally not affected (8). Seed treatment is not practical. Chemicals and heat treatments that kill the larvae in the cysts also kill the crop seeds. The use of resistant varieties and crop rotation may provide satisfactory means of control. However, physiological races of this nematode exist and varieties of soybean resistant to one race may not necessarily be resistant to other races. Long term crop rotations of 3 to 4 years with non-host plants reduced nematode population, but to be effective, suitable weed hosts must also be eradicated (7).

In a situation such as this, a comprehensive integrated crop protection approach is essential. Obviously there is a need to develop and adopt an integrated multidisciplinary approach to pest control if the fight against crop pests is to be waged most effectively and successfully.

TABLE 1.--Weed Hosts of Soybean Cyst Nematode

Plant Family	Weed Species	References
Capparidaceae	*Cleome serrulata*	Riggs and Hamblen, 1966
Caryophyllaceae	*Agrostemma githago*	Smart, 1964
	Cerastium vulgatum	Smart, 1964 Graham, 1977
	Stellaria media	Smart, 1964 Riggs and Hamblen, 1966 Graham, 1977
Geraniaceae	*Geranium maculatum*	Riggs and Hamblen, 1966
Labiatae	*Lamium amplexicaule*	Epps and Chambers, 1958 Riggs and Hamblen, 1962 Graham, 1977
Cruciferae	*Cardamine parviflora*	Riggs and Hamblen, 1966
Leguminosae	*Astragalus canadensis*	Riggs and Hamblen, 1962
	Astragalus corrugatus	Riggs and Hamblen, 1962
	Astragalus falcatus	Riggs and Hamblen, 1962
	Astragalus racemosus	Riggs and Hamblen, 1962
	Astragalus sinicus	Riggs and Hamblen, 1962
	Cassia tora	Smart, 1964
	Clianthus puniceus	Riggs and Hamblen, 1962
	Crotolaria incana	Riggs and Hamblen, 1962
	Crotolaria intermedia	Riggs and Hamblen, 1962
	Crotolaria lanceolata	Riggs and Hamblen, 1962
	Crotolaria mucronata	Riggs and Hamblen, 1962

Plant Family	Weed Species	References
Leguminosae (cont.)	*Crotolaria ochroleuca*	Riggs and Hamblen, 1962
	Desmodium ovalifolium	Riggs and Hamblen, 1962
	Desmodium salicifolium	Riggs and Hamblen, 1962
	Genista spp.	Riggs and Hamblen, 1962
	Glycine ussuriensis	Epps and Chambers, 1958
	Indigofera dosua	Riggs and Hamblen, 1962
	Indigofera parodiana	Riggs and Hamblen, 1962
	Indigofera sumatrana	Riggs and Hamblen, 1962
	Laburnum spp.	Riggs and Hamblen, 1962
	Lathyrus inconspicuus	Riggs and Hamblen, 1962
	Lathyrus sativus	Riggs and Hamblen, 1962
	Lathyrus tuberosus	Riggs and Hamblen, 1962
	Lespedeza bicolor	Riggs and Hamblen, 1962
	Lespedeza buerger	Riggs and Hamblen, 1962
	Lespedeza stipulacea	Riggs and Hamblen, 1962
	Lespedeza striata	Riggs and Hamblen, 1962
	Lotus angustissimus	Riggs and Hamblen, 1962
	Lupinus albus	Riggs and Hamblen, 1962
	Lupinus hartweggii	Riggs and Hamblen, 1962
	Lupinus mutabilis	Riggs and Hamblen, 1962
	Lupinus pubescens	Riggs and Hamblen, 1962
	Medicago arabica	Riggs and Hamblen, 1962
	Medicago hispida	Riggs and Hamblen, 1962
	Melilotus hirsuta	Riggs and Hamblen, 1962

Plant Family	Weed Species	References
Leguminosae (cont.)	*Phaseolus calcaratus*	Riggs and Hamblen, 1962
	Phaseolus lathyroides	Riggs and Hamblen, 1962
	Pisum elatius	Riggs and Hamblen, 1962
	Podalyria sericea	Riggs and Hamblen, 1962
	Psorolea bituminosa	Riggs and Hamblen, 1962
	Sesbania macrocarpa	Epps and Chambers, 1958
	Spartium junceum	Riggs and Hamblen, 1962
	Trifolium procumbens	Graham, 1977
	Trifolium semipilosum	Riggs and Hamblen, 1962
	Vicia angustifolia	Riggs and Hamblen, 1962
	Vicia hirsuta	Riggs and Hamblen, 1962
	Vicia lutea	Riggs and Hamblen, 1962
	Vicia tetrasperma	Riggs and Hamblen, 1962
Phytolaccaceae	*Phytolacca americana*	Riggs and Hamblen, 1966
Portulacaceae	*Portulaca oleracea*	Riggs and Hamblen, 1966
Scrophulariaceae	*Digitalis sp.*	Riggs and Hamblen, 1966
	Linaria canadensis	Riggs and Hamblen, 1966
	Penstemon albertinus	Smart, 1964
	Penstemon digitalis	Riggs and Hamblen, 1966
	Penstemon glaber	Smart, 1964
	Penstemon grandiflorus	Smart, 1964
	Penstemon polyphyllus	Smart, 1964
	Penstemon unilateralis	Smart, 1964
	Verbascum thapsus	Smart, 1964 Riggs and Hamblen, 1966

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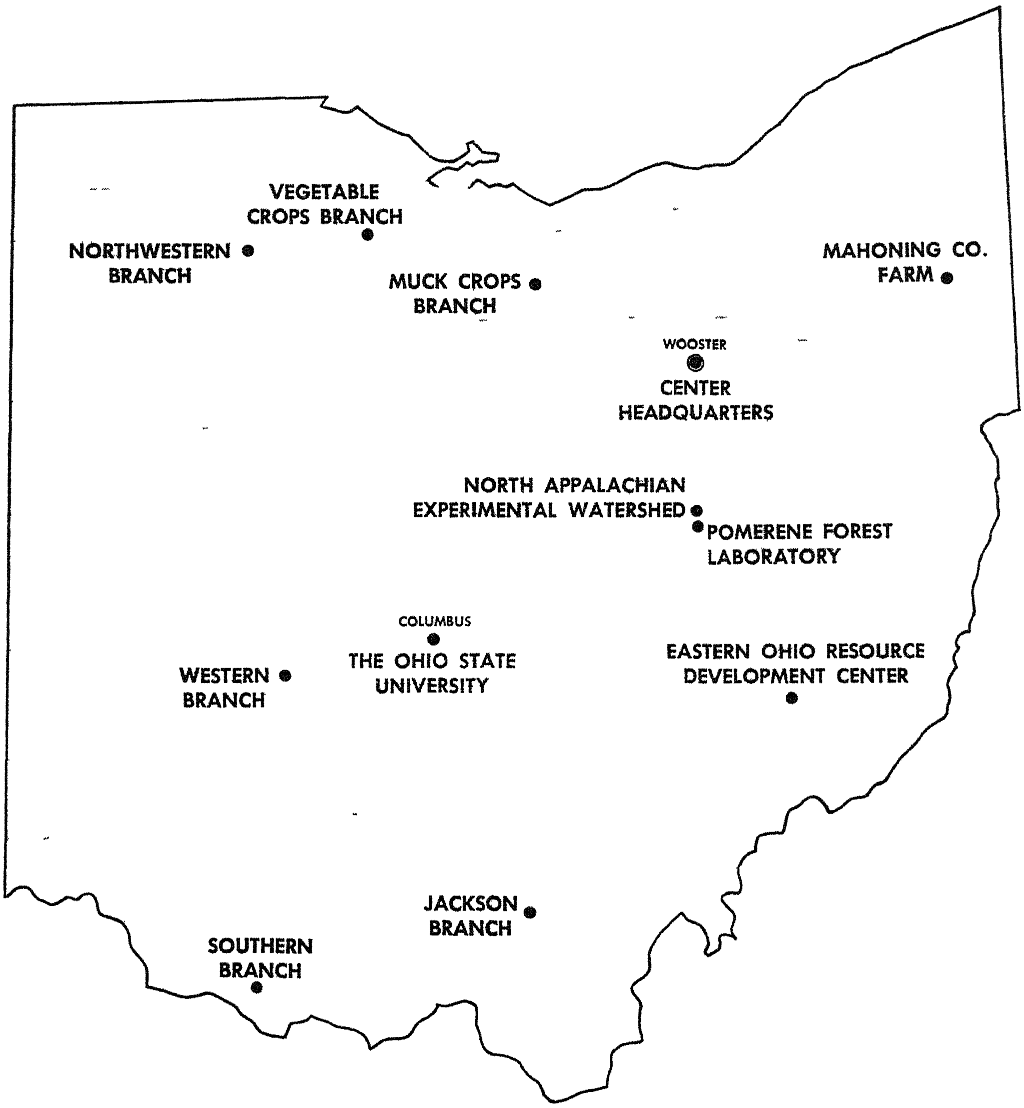

Ohio's major soil types and climatic conditions are represented at the Research Center's 12 locations.

Research is conducted by 15 departments on more than 7000 acres at Center headquarters in Wooster, eight branches, Pomerene Forest Laboratory, North Appalachian Experimental Watershed, and The Ohio State University.

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Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres

Jackson Branch, Jackson, Jackson County: 502 acres

Mahoning County Farm, Canfield: 275 acres

Muck Crops Branch, Willard, Huron County: 15 acres

North Appalachian Experimental Watershed, Coshocton, Coshocton County: 1047 acres (Cooperative with Science and Education Administration/Agricultural Research, U. S. Dept. of Agriculture)

Northwestern Branch, Hoytville, Wood County: 247 acres

Pomerene Forest Laboratory, Coshocton County: 227 acres

Southern Branch, Ripley, Brown County: 275 acres

Vegetable Crops Branch, Fremont, Sandusky County: 105 acres

Western Branch, South Charleston, Clark County: 428 acres