BIOLOGY AND MANAGEMENT OF SOYBEAN CYST NEMATODE

SECOND EDITION

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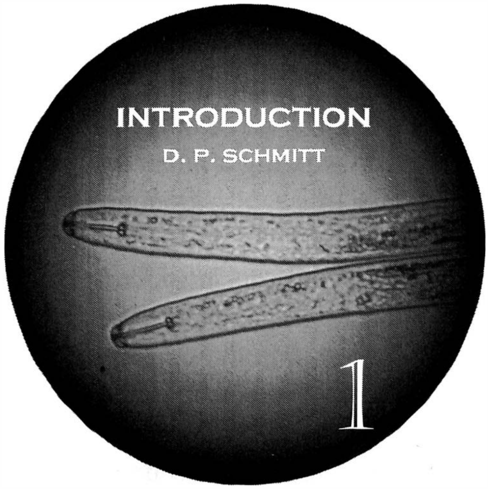

During the 2002-2003 growing season, 193.5 billion kg of soybean seed (*Glycine max*) were produced globally from 81.4 million hectares (American Soybean Association, 2003). The seed in turn from this crop were used for dozens of products such as animal food, human food, ink, biofuel, disease control, weight loss products, milk replacement, hormone replacement, cooking oil and lubricants (American Soybean Association, 2003; Food and Agriculture Organization of the United Nations, 2002). Total world protein meal consumption in 2002 was 187.6 billion kg with 70% (131.8 billion kg) being derived from soybean (American Soybean Association, 2003). Similarly, about 93.2 billion kg of vegetable oil was consumed in the same year with the soybean share of this market constituting 32%. Biodiesel consumption was 56.7 million liters in 2002 and is one of the uses of soybean that is likely to expand greatly over the next few years.

For soybean production to remain profitable at current prices or even at somewhat higher prices, it is crucial to optimize yield in relation to input costs (Council for Agricultural Science and Technology, 2003). Soybean cyst nematode (*Heterodera glycines* Ichinohe) is one of a number of factors that influences that relationship between cost and return. It has been suppressing yields, reducing profits and remains one of the most economically important pests of soybean. Assuming a mean loss of 3%, based on the conservative use of crop loss estimates compiled by numerous scientists (Wrather *et al.*, 2001), the direct loss from the nematode is over US$1.1 billion annually. Considering direct and indirect costs associated with managing soybean cyst nematode, the losses are probably more than double the conservatively derived direct economic loss.

Numerous aspects of the biology of the nematode (See Chapters 4-8) enable this organism to be a successful and highly damaging pathogen. Effective management (See Chapters 9-11) is essential for soybean production to remain profitable or even sustainable. Successful manipulation of populations of soybean cyst nematode to minimize crop damage is based on understanding its behavior. History certainly shows that major advances have taken place in the management of the nematode (See Chapter 2). Yet, in spite of these effective management programs, the nematode continues to spread and cause damage throughout most areas of the world where soybean production is intense. Thus, more activity in biology and management research is needed. Parallel educational programs are crucial to promote effective management and to encourage growers to adopt those effective management strategies. Underscoring this management are the economic aspects involving numerous direct and indirect costs (Khan, 1972; Mumford and Norton, 1984) (See Chapter 3).

Management of soybean cyst nematode is predominantly accomplished using resistant soybean cultivars and crop rotation. The successful utilization of these methods relates to predicting the behavior of soybean cyst nematode. Such predictions depend upon a detailed, factual database about the organism and a sound synthesis and interpretation of that data (See Chapters 4-6). This point is important because soybean cyst nematode exhibits a high level of specialization for a parasitic life style. Some of these adaptations include a narrow host range, variation in virulence phenotypes (classified as races and more recently as HG Types), synchronization of host and parasite life cycles and long-term survival. Adaptations for survival, such as the cyst stage and diapause, have allowed this nematode to be effectively disseminated to many and diverse habitats.

Reliable sampling and assay procedures for soybean cyst nematode are crucial for making management decisions (See Chapter 6). Sampling needs to be conducted in a manner that provides a reasonably accurate and precise assessment of the population density of the nematode. These assays provide numbers, such as numbers of nematodes per unit of soil, for interpreting the assay data and predicting damage and crop loss. Presently, most methods of interpretation are static and do not account for the dynamics of the agroecosystem.

The large genetic variability of soybean cyst nematode must be considered in assessing and interpreting population census data. The genetic composition of soybean cyst nematode populations determines the vulnerability of the crop to damage (See Chapters 4 and 6). The threshold for damage will vary with the damage potential of the HG Type because some HG Types of the nematode are more damaging than others. An additional component of this complex relationship of nematode aggressiveness and crop response is the level of resistance of specific soybean cultivars to specific populations of the nematode. In spite of the present state of knowledge about these relationships, soybean yield losses are still relatively large.

Perhaps the most significant biological factor of soybean cyst nematode is its high genetic variability with regard to parasitism of resistant cultivars (See Chapter 4). In addition, selection pressure imposed on the nematode by resistant cultivars results in shifts from one HG Type to another. Another factor that favors the nematode is the high frequency of soybean planting in the cropping system. This minimal integration of nonhosts into the cropping system enables the nematode to maintain high population densities.

Because soybean cyst nematode is so damaging to soybean, focus is on management with little regard to the vast community of microorganisms associated with it. These communities consist of other nematode species, fungi, bacteria and many other taxa of organisms (Stirling, 1991). Polyspecific nematode communities that develop on soybean and other crops may modify the impact of each nematode in the community (See Chapter 6). Plant-parasitic species compete for nutritional resources and space. Microbivorous nematode activity, on the other hand, within communities, is probably beneficial (Barker and Koenning, 1998; Kloepper *et al.*, 1992; Taylor and Rodrìguez-Kàbana, 1999). A few organisms, especially fungi, attack soybean cyst nematode (See Chapter 11). To date, commercialization of these organisms as biological control agents has met with limited success. However, the impetus to develop commercial biological products to control soybean cyst nematode may be rising today with the heavy focus on protecting the environment and with concerns about growing plants that have been genetically modified using genetic engineering procedures.

Although soybean cyst nematode appears to be the primary causal agent of the disease of soybean, most of the damage is probably due to multiple causes (See Chapter 7). There are many factors operating under field conditions that involve numerous direct and indirect interacting components to form a web with the plant at the center (Wallace, 1973). Considering the fact that many organisms are interacting with each other under the influence of the soil environment, losses attributed to soybean cyst nematode are probably a consequence of these numerous interacting factors (Barker and McGawley, 1998). Consequently, efforts to characterize and understand the complex interrelationships of microorganisms, the environment and edaphic factors are warranted.

Even though the soybean plant is responding to all of the biotic and abiotic factors operating within its environment, soybean cyst nematode has a major and dominant affect on the crop. In response to all phases of infection, pathological changes occur in the plant (See Chapter 8). Most of these pathological changes in the plant involve modifications in root morphology and molecular changes, leading to the disruption of normal plant functions. The responses are different in susceptible and resistant soybean cultivars. The economic impact of this plant disruption is low seed yield.

Farmers grow soybean for economic gain. To assure economic success of the farm enterprise, management of soybean cyst nematode is directed at protecting the profit margin. The options in the soybean production system are limited to those that are low cost and effective because the crop has a low cash value. Resistant cultivars have provided the greatest return for growers in infested land since the cost of seed usually does not differ between resistant and susceptible cultivars. Development of productive cultivars resistant to soybean cyst nematode is a major goal of soybean breeding programs (See Chapter 9). Breeders are presented with the challenge of having to develop cultivars that are resistant to a wide range of HG Types. Fortunately, new techniques, such as molecular tagging of soybean cyst nematode resistance genes, should enable breeders to make major advances in developing new soybean cyst nematode resistant cultivars.

Successful utilization of resistant cultivars in the soybean production system depends on designing cropping systems that preserve the effectiveness of the resistant germplasm (See Chapter 10). An important component of a cropping system to manage soybean cyst nematode is crop and cultivar rotation. Crop rotation without obvious pests and pathogens, have consistently shown yield increases (roughly 10%) over continuous mono-cropping (Buchholz *et al.*, 1993). These returns are even higher on soybean cyst nematode infested land.

The goal of this book is to provide a comprehensive synthesis of soybean cyst nematode biology and management information.

The first three chapters are intended to be introductory and present important background information about the nematode, the soybean crop and the economics of managing soybean cyst nematode. Since an understanding of the biology of soybean cyst nematode leads to sound development of management programs, a major emphasis is placed in chapters 4-8 on providing a compilation of biological facts acquired by research and observations. Three chapters (Chapter 9-11) are management oriented. Chapters 9 and 10 focus on contemporary methods, whereas potential methods of controlling soybean cyst nematode are offered in chapter 11. In the final chapter, ideas and concepts for managing soybean cyst nematode are introduced for the readers and researchers to consider for possible testing and development. Ultimately, the objective is to have worldwide strategies for managing soybean cyst nematode in order to minimize damage and optimize soybean yield.

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