C. Chattopadhyay and D. Prasad (eds),
Dynamics of Crop Protection and Climate Change

Influence of Climate Change on Predatory Soil Nematodes in Management of Plant Parasitic Nematodes

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Nematodes are microscopic, wormlike organisms and are one of the most abundant metazoans in soil. Nematodes play multiple and contrasting (positive and negative) roles in regulating productivity of plant-based production systems. Herbivorous nematodes feed on plant parts mostly on roots. Bacterial and fungal feeding nematodes are beneficial to crop growth because they help in enhancing the nutrient availability of crop plants. Predatory nematodes predate on plant parasitic nematodes; thus, have potential for biocontrol. Entomopathogenic nematodes are beneficial to crop production as they help in biological control of the insect pests of crop plants and reduce the consumption of chemical pesticides.

Classifications of Nematodes

Nematodes can be classified into functional groups based on their feeding habits, which can often be deduced from the morphology of their mouthparts (Figure 17.1).

In agricultural soils, the most common groups of nematodes are the bacterial-feeders, fungal-feeders, plant parasites, predators, and omnivores (Yeates *et al*. 1993). All these types of nematodes coexist in soil and contrary to their notorious image as hidden enemies of farmers; some nematode trophic groups play an important role in organic matter decomposition, mineral and nutrient cycling, and control of pests and diseases. Plant-parasitic nematodes cause crop losses worldwide and are among the most important agricultural pests, causing about 10-12% worldwide yield loss. The cost to world agriculture of nematode parasitism was estimated to be US $ 100-125 billion annually (Chitwood 2003). The damage due to nematodes is many a time a result of interaction between nematodes and other pathogens such as fungi, bacteria and viruses (Khan 1993; Son *et al*. 2009).

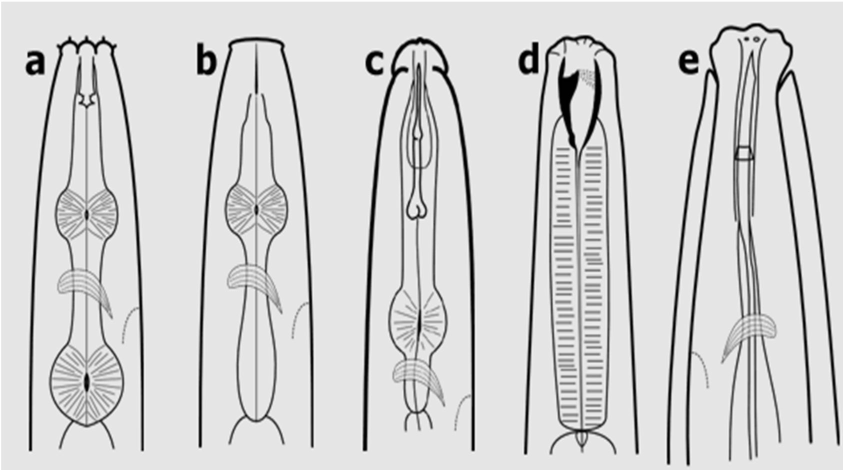

Figure 17.1 Classification of Nematodes into Different Feeding Groups Based on the Structure of Their Mouthparts. (a) Bacterial Feeder, (b) Fungal Feeder, (c) Plant Feeder, (d) Predator, (e) Omnivore. (Figure Courtesy of Ed Zaborski.)

The management of nematodes is more difficult than that of other pests because nematodes mostly inhabit the soil and largely attack the underground parts of the plants. Although chemical nematicides are effective, easy to apply, and show rapid effects, they have begun to be withdrawn from the market in owing to concerns about public health and environmental safety (Schneider *et al*. 2003). The search for novel, environment-friendly alternatives to manage plant-parasitic nematode populations has, therefore, become increasingly important. Several types of organism, including fungi, bacteria, viruses, protists, nematodes and other invertebrates have been found to parasitize or prey upon plant parasitic nematodes (Khan *et al*. 2005, 2007, 2008, 2009; Stirling 2014).

Biological control advocacy of predatory nematodes dates back to the early 20th century when Cobb (1917) speculated on their possible role in management of plant parasitic nematodes. Nevertheless, their potential has only begun to be studied in recent years. There has been widespread interest in using predatory nematodes to control populations of plant parasitic nematodes (Mankau 1980; Jairajpuri and Bilgrami 1990; Khan and Kim 2005, 2007; Stirling 2014). Yeates and Wardle (1996) introduced the dual function of predation by nematodes: Potential control of plant parasitic nematodes, and their important role in stimulating cycling of plant nutrients, which may enable plants to better withstand any nematode burden on their roots.

easy mass culturing due to their polyphagus feeding habits, and the inverse relationship with plant parasitic nematodes in soil and positive effect of climate change.

Prospects of using diplogasterid predatory nematodes in biomanagement of nematodes seem promising mainly because of their bi-phasic feeding, high rate of predation and fecundity, shorter life cycle, ability to perceive prey secretions and presence of resistance juveniles, and the high moisture and organic soil condition in which crops are generally grown. These nematode predators are likely to offer the most promising as augmentative agents in colonization effort in combination with cultural practices, such as cover cropping, green manuring, organic amendment, etc. However, implementation of this strategy as an effective means of nematode management will depend upon efficacy and long-term benefits to crop production. Greater research, development and extension efforts are required to identify and popularize this environmentally-friendly nematode pest management approach.

Research on impacts of climate change on soil nematodes has been limited, with most work concentrating on the effects of a single atmospheric constituent under controlled conditions. A few recent experiments have reported the response of herbivorous nematodes to elevated CO_2 beyond the trophic group level. Nevertheless, findings of these studies give an insight into the response of nematode trophic groups to climate change and its consequences to agricultural production. Nematodes reaction to rising CO_2 levels is complex, depending on trophic groups: no effect was reported on nematodes from prairie soil (Freckman *et al*. 1991), but numbers decreased in forest (Hoeksema *et al*. 2000), grassland (Hungate *et al*. 2000) and pasture soils (Yeates and Orchard 1993; Yeates *et al*. 1997; 2003). Higher CO_2 levels lowered the numbers of bacterial feeders, increasing fungal feeders and predators in forest (Neher *et al*. 2004) or prairie soils (Yeates *et al*. 2003). Responses of herbivorous nematodes to CO_2 enrichment were observed to be either neutral or positive but not negative. CO_2 induced changes in non-herbivorous nematode functional groups are highly variable. Investigations being carried out on Antarctic nematodes are also helping in demonstrating the correlation between nematode biodiversity and ecosystem functions under changing climate (Neher *et al.* 2004). More long-term studies in varied ecosystems under different cropping systems of particularly tropical regions are needed to critically assess the impact of climate change on predatory soil nematodes.

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