FOCUS ON MOLECULAR PLANT-NEMATODE AND PLANT-INSECT INTERACTIONS

MPMI Focus Issue Overview

Sedentary plant-parasitic nematodes such as root-knot nematodes and cyst nematodes engage in a long-lasting and intimate relationship with their host plant. This interaction starts in the soil when freshly hatched infective juveniles of these microscopic roundworms are attracted to specific parts of a host plant root system. Little is known of what determines the attractiveness of host plant roots, but a mix of biochemical and structural cues from specific host tissues in the roots likely triggers invasive behavior in nematodes. In this focus issue, Fudali and coworkers show that the attractiveness of specific parts of the host roots to plant-parasitic nematodes is influenced by ethylene signaling in the plant.

Once inside a root, infective juveniles become sedentary near the vascular system, where they modify host cells into life-sustaining feeding structures that enable them to complete their development and achieve reproduction over the course of several weeks. These nematode-induced feeding structures function as a conduit between the nematode and the flow of nutrients in the plant's vascular system. The basis of the transformation of host cells into a feeding structure are modifications of the mitotic cell cycle that result in repeated multiplication of the host genome by endoreduplication (reviewed by De Almeida Engler and Gheysen). It is an amazing feat of evolutionary engineering that feeding nematodes can extract large quantities of nutrients from the modified host cells without causing significant damage to these cells. In all fairness, we are still just beginning to understand signaling processes that are directing the host cell transformation by nematodes and the complexity of the molecular changes that occur during this transformation (Narella et al., Curtis et al., and Replogle et al.).

For a long time, technical difficulties in the identification of effectors from plant-parasitic nematodes held back progress in our understanding of molecular nematode-plant interactions (reviewed by Hewezi and Baum). However, advances such as microaspiration of esophageal gland contents and the availability of genome sequences of plant-parasitic nematodes have accelerated progress in nematode effector biology. In a technical advance, Maier and coworkers describe a method to isolate entire gland cells from diverse nematodes, which represents the latest innovation in this field. Historically, nematode effectors have been considered instrumental in driving the molecular and structural changes in host cells during their transformation into feeding structures. To this end, several nematode effectors directly home in on the nucleus of host cells (Li et al.). The sheer size of the nematodes relative to the host cells and the drastic alterations of host cells they bring about make it difficult to believe that these endoparasites remain entirely unnoticed

by the immune system of a host plant. The contribution by Jaounnet et al. to this focus issue demonstrates that effectors play a critical role as suppressors of host innate immunity in enabling the extraordinary persistence of nematode infections in plants. The study by Nahar et al. further uncovers a mutually antagonistic interaction between brassinosteroids and the jasmonate pathway in host defenses to nematode infections.

Similarly to plant-parasitic nematodes, phloem-feeding aphids and other piercing-sucking (hemipteran) insects must establish close associations with their host plants in order to modulate plant cellular processes to promote feeding and reproduction. Electrical penetration graph monitoring allowed studying the feeding behaviors of these insects and distinguishing insect ingestion and salivation behaviors in intracellular and extracellular environments of various plant cell types. Salivation allows for delivery of effectors that suppress or evoke plant defense responses. In the last few years much progress has been made in the elucidation of effector candidates in aphids by using, for example, mass spectrometry analyses of saliva and dissected salivary glands and the development of bioinformatics pipelines and functional genomics tools. The latter enabled assessments of aphid effector functions in planta. As well, the expression of effector genes of hemipteran insects may be knocked down by RNA interference (RNAi) through injection of double-stranded (ds)RNAs into insect bodies and feeding dsRNA from transgenic plants (plant-mediated RNAi). The recent developments in effector research of plant-insect interactions have been highlighted in the current review of Rodriguez and Bos. Two papers further describe novel aphid effectors that modulate host responses to improve host colonization and aphid fecundity on host plants (Atamian et al. and Pitino and Hogenhout). Similar to plant-parasitic nematodes, the reproductive success of aphids on host plants will depend on their ability to suppress host innate immunity. Studham and MacIntosh's data suggest that aphids are able to suppress hormone-mediate immune signaling in susceptible plants but not in resistant plants.

In conclusion, this focus issue on molecular interactions between plants and different representatives of the animal kingdom sheds light on recent developments and offers a platform for exciting new data in this field. We are grateful to all the authors for their diverse contributions and for making this focus issue possible.

Guest Editors

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