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Secondary Metabolites of Plants and their Impact on Nematodes

Nangki Tagi[1] Jisna George[1] and Ruthy Tabing[2]
[1]PhD Scholars Department of Nematology, College of Agriculture, Assam Agricultural University, Jorhat Assam
[2]PhD Scholars Department of Plant Pathology, College of Agriculture, Assam Agricultural University, Jorhat, Assam

SUMMARY

Plants produce a high diversity of natural products or secondary metabolites having important function in the protection against predators and microbial pathogen on the basis of there toxic nature and repellents to herbivores and microbes and are also involve in defense against biotic and abiotic stresses. These metabolites are also important for interaction between plants and other microorganism and are involved in survival of the plant in its environment.

INTRODUCTION

Plant roots produce a diverse and wide range of bioactive *secondary metabolites*, many of which are known to have defense compounds and no direct function in growth and development. In natural system plant faced a plethora of antagonist and thus posses extremely great number of defense mechanism by which they are able to cope with various kinds of biotic and abiotic stresses. Plant parasitic nematodes cause significant crop damage and yield losses worldwide . Currently, many nematicides have been banned or are being phased out because of environmental and human health concerns. Therefore, we need to focus on sustainable and alternative methods of nematode control to protect crops. And these Plant roots contain and release a wide range of bioactive secondary metabolites, many of which are known to have defense compounds. Hence, profound understanding of the root mediated interactions between plants and plant parasitic nematodes may contribute to efficient control and management of pest nematodes. chemical compounds act as either nematode attractants, repellents, hatching stimulants or inhibitors. But plant root metabolites regulate the expression of nematode genes.

Plant secondary metabolites can be divided into three major distinct groups-

Terpenes – terpenes constitutes the largest class of metabolites and are presumes to be largest involve in defense as toxin and feeding deterents.

Phenolic compound- phenolics synthesize primarily from products of the shikimate pathway and have several important defensive roles in the plant.

Nitrogen and sulphur containing compounds- they are thought to involved directly or indirectly in the defense of plants against microbial pathogen and number of them are thought to be involved in systemic induced resistance (SIR).

Mechanism of Plant Root Metabolites in Nematodes

Plants consist a sophisticated system of defenses against pests and pathogens that consists of both constitutive, pre-formed mechanisms and inducible immune responses which occur upon the attack of pathogens . Plant hormones are largely studied as defensive strategies against plant parasitic nematodes. The jasmonate (JA) plant hormones play a significant role during early plant defense against the nematode. Jasmonate also checks other plant hormones and defend the plants from nematode attacks. For example, plants treated with Me-jasmonate and ethephon (an ethylene analogue) made plants more defensive against the rice root knot nematodes *Meloidogyne graminicola* compared to untreated plants (Nahar et al., 2011). Salicylic acid (SA) application induced resistance to the clover cyst nematode *Heterodera trifolii* in white clover (Kempster et al., 2001), and to *Meloidgyne incognita*. Abscisic acid (ABA) plays a complex role in plant defense responses. While it promotes resistance in some plant–pathogen interactions, it enhances susceptibility in others (Lim and Lee, 2015). *Arabidopsis thaliana* root exudates were found to affect gene expression in *M. incognita* J2 larvae, prior to physical contact and penetration of the root (Teillet et al., 2013). But, the identity of the exudate compounds that elicit enhanced expression of these genes is still unknown. Phytoalexins are synthesized in response to bacterial or fungal infection or other forms of stress that help in limiting the spread of the invading pathogens by accumulating around the site of infection, appears to a common mechanism of resistance to pathogenic microbes in a wide range of plants. Many of these changes are linked to a rapid apoptotic response, resulting in death of one or a few invaded plant cells, known as the hypersensitive response (HR). Most plant families produce organic phytolexins of diverse chemistry.

Effect On Nematode Movement

Many secondary compounds have signalling functions which influence the activities of other organisms, control their metabolic activities and co-ordinates the development of the whole plant. A variety of plant metabolites in roots and exuded from roots to the rhizosphere influence nematode behaviour, development, reproduction and even survival (Timper et al., 2006; Dandurand and Knudsen, 2016; Wang et al., 2018). Some metabolites thus facilitate plant parasitic nematode infection and damage, whereas others directly or indirectly reduce damage. Nematodes perceive their surrounding environment through chemosensory perception. Typically, plant parasitic nematodes locate their preferred host through root exudate signals (Bird, 2004). Many chemical gradients which exist around physiologically active roots will constitute “long distance attractants”, which help nematodes migrate towards root occupied soil volumes, whereas “short distance attractants” may help nematode navigation to individual roots of a host (Perry, 2005). Infective J2 larvae of root knot nematodes *Meloidogyne incognita* and *M. graminicola* take the most direct route to their preferred host, however, they take the longest route towards poor hosts, which indicates that specific root metabolites act as attractants and repellants, respectively, and influence the movement patterns of the nematodes to find their suitable host (Reynolds et al., 2011). Similarly , two studies (Kihika et al., 2017; Murungi et al., 2018) identify methyl salicylate as the most significant volatile attractant of *M. incognita* in the investigated Solanaceous plants. In a bioassay, salicylic acid attracted *M. incognita*, and dopamine attracted *Radopholus similis* (Wuyts et al., 2006).

Effect on Hatching of Nematodes

Plant metabolites influence on the interactions between plants, rhizosphere microbiomes, and nematodes. Host exudate induce cyst nematode egg hatching which involves exudate activation of genes in the dormant juvenile cyst nematode. Cyst nematodes (G*lobodera* spp. and *Heterodera* spp.) generally have a very narrow host spectrum, and as active infective juveniles only have limited storage energy they will starve and die within a relatively short period without access to a suitable host. However, the encysted, dormant eggs stay viable for years to decades, and are triggered to hatch and re-activate by host-specific hatching stimulants. Application of hatching stimulants in the absence of host plants is therefore a promising strategy for efficient reduction of cyst nematode populations. A number of hatching stimulants have been identified e.g. picrolonic acid, which induce hatching of *Heterodera rostochiensis* (Syn. *Globodera rostochiensis*), *H.glycines* and *H. tabacum* (Clarke and Shepherd, 1966), glycinoeclepin, which induces *H. glycines* hatching (Masamune et al., 1987), and solanoeclepin, sodium thiocyanate, alpha-solanine, and alpha-chaconine, which induce hatching of *G. pallida* and *G. rostochiensis* (Schenk et al., 1999; Byrne et al., 2001). Various studies on root knot, root lesion and cyst nematodes demonstrate that root exudates influence gene expression of pre-parasitic phase/early phase of nematodes. We know very little about the molecular responses elicited by nematode attractants, repellents, and toxins within the nematode body, but several studies demonstrate that root exudates regulate the expression of *flp* genes. *flp* genes encode FMRFamide-like peptides, a diverse group of neuropeptides, involved in nematode feeding, reproductive and locomotive behavior, and thus play a significant role in nematode chemotaxis. For instance, low concentrations (0.5–2.0 mM) of lauric acid from crown daisy (*Chrysanthemum coronarium*) root exudates attract *Meloidogyne incognita*, while higher lauric acid concentration (4.0mM) repels the nematode. This response is probably elicited by lauric acid’s concentration-dependent regulation of *Mi-flp-18* gene expression (Dong et al., 2014). Moreover, two other active compounds, namely palmitic acid and linoleic acid derived from castor root exudates, was found to repel *M. incognita* and inhibited the expression of *Mi-flp-18* and *Mi-mpk-1* (mitogen-activated protein kinase) genes in a concentration-dependent manner (Dong et al., 2018).

CONCLUSION

In natural system plant faced a plethora of antagonist and thus posses myriad of defense mechanism by which they are able to cope with various kinds of biotic and abiotic stresses. Plant secondary metabolites produces products that help in the growth and development of plants but are not required for the plant to survive. Secondary metabolites have important functions in plants. They protect plants from herbivores and against the attack from microbial pathogens. They serve as attractants (odor, color, taste) for pollinators and seed dispersing animals. They serves as agents of plant-plant competition and plant-microbe symbioses. The ability of plants to compete and survive is therefore profoundly affected by the ecological functions of their secondary metabolites. Therefore, we need to focus on sustainable and alternative methods of nematode control to protect crops. Plant roots contain and release a wide range of bioactive secondary metabolites, many of which are known to have defense compounds. Hence, profound understanding of the root mediated interactions between plants and plant parasitic nematodes may contribute to efficient control and management of pest nematodes.

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