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ARBUSCULAR MYCORRHIZAL FUNGI (AMF): BIOPROTECTANT OF PLANT HERBIVORE INFESTATION

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Changing climatic pattern and modern agricultural practices leads increasing the pest and insect attack of important agricultural crops. Arbuscular mycorrhizal fungi (AMF) have a symbiotic association with the plants which improves the plant by nutrient mobilization and priming the Defense against various environmental stresses. AMF changes the morphology (trichome density, tissue hardness) and physiology (antioxidant enzymes, primary and secondary metabolites) of the plant which enhanced defense during herbivory. In this article, we reviewed the importance of AMF defense priming upon herbivore attack.

Agriculture is one of the important sectors of growing food demand globally. Controlling the insect pest attack in agriculture crops is important for healthy crop cultivation and maximum production. In India pest attack alone causes crop losses of 15.7% annually. Arthropod pest alone destroys 18-20% of annual production worldwide (Sharma et al.2017). Changing climatic pattern and modern agricultural practices lead to increasing the insect pest attack. Deutsch and Tewksbury(2018) reported crop losses increased to 10-25% because of the temperature increase. About 30-35% of annual crop yield in India get lost because of the pest according to P.K. Chakrabarty, Assistant director-general, Indian council for agricultural research. Control the insect pest with the use of chemicals leads to environmental problems. In this case, using biological methods to control/reduce insect pest is eco-friendly.

Importance of AMF in Agricultural Ecosystem

AMF is a ubiquitous soil fungi belonging to phylum Glomeromycota, which have a symbiotic association with more than 80% of terrestrial plant species (Meier et al.2018). These biotrophic fungi alter plant root system and improve the uptake of nutrients, primarily phosphate and some micronutrients from the soil (Jung *et al.*2012). The mycorrhizal

Volume 2 – Issue 9
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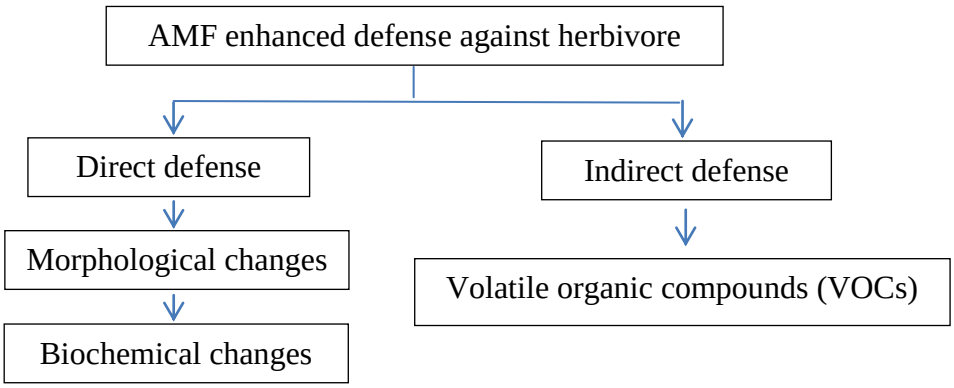
association also increases the photosynthetic activity of plant and AM fungi hyphal network helps to absorb the soil moisture (Kumar et al.2020). However, changing agricultural cultivation pattern and modern agricultural practices reduce the mycorrhizal inoculum in the field. Additionally, mycorrhiza had less attention for high input agricultural crops because of little benefits to heavily fertilize agricultural ecosystem. In spite of this, mycorrhiza has a huge attractive role. AMF colonization alters the plant physiology and gene expressions. This leads to acquiring resistance/tolerance against various biotic and abiotic stresses by crops (Montesinos - Navarro *et al.*2019).

Mycorrhiza Priming Defense in Plant upon Herbivory

Plants undergo various biotic stresses, including herbivore attack. Upon herbivore, attack plant develops both constitutive and induced Defense against herbivore. Mycorrhiza not only improves the plant growth by nutritional mode, but it also increases the Defense of plant by non-nutritional mode. AMF improves the plant resistance against insect by improving nutrient uptake, altering the plant morphology, physiology and by producing volatile organic compounds (VOCs) (Jung et al.2012).



Direct Defense

Morphological Changes

The modified structure of the plant is the first line of Defense against insect pest. Plant special structures like thorns, stings, sticky resins and trichomes provide physical Defense against insect (Taggar & Gill, 2012). Trichomes are an important physical barrier against insect, which is increased in mycorrhizal colonized plants. Glandular trichomes are other types of trichomes which secrete secondary metabolites like alkaloids, flavonoids,

Volume 2 – Issue 9
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www.agriallis.com

terpenoids which are poison and repellent to the insect pest. Tissue hardness is other types of Defense. Hardening of leaves reduces the palatability of insect pest. Enhance the leaf hardness by lignin, cellulose, suberin and callose, small organic molecules (phenolics) provide mechanical Defense against insect feeding and penetration (War *et al.*2018).

Biochemical Changes

Upon herbivore attack, mycorrhizal plant produces enhanced levels of antioxidant enzymes like lipoxygenases, polyphenol oxidases, and peroxidases and phenylalanine ammonia-lyase. Reallocation of food resource is another important method of Defense against the insect. Apart from this mycorrhizal plant produce improved level of secondary metabolites, hormones (jasmonic acid) and anti-nutritional protein upon insect attack (Jung *et al.*2012).

Indirect Defense

During environmental stress, the plant has produced divers VOCs for plant protection and signalling molecules to communicate among nearby plants. It is an indirect method of plant Defense against biotic stress, which attract the natural enemies of insect. This defensive volatiles attract the parasitic and predatory insects that are natural enemies for the herbivore (Chen, 2008).

Conclusion

Arbuscular mycorrhiza is one of the key bioagents for controlling insect pest and also improves the plant by nutritional mode. Priming Defense of mycorrhizal plants upon herbivore reduces the infestation percentage. But the level of Defense and positively or negatively regulation of Defense, depends on the type of insect and mycorrhizal species.

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Volume 2 – Issue 9
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