Mini Review

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Soil organisms and microorganisms; their function as controllers of plant pathogens

Abstract

In this review we present how significant and important is the symbiosis between the plant and the organisms and soil microbiota, as well as the benefits it generates to achieve an ecological balance and safe food production. The interrelationships between soil microorganisms and plants have a positive impact on the soil ecosystem, an example are mycorrhizal fungi, which benefit by absorbing nutrients from the plant and help it to absorb minerals from the soil, to overcome water stress and provide root protection against phytopathogens. Another example is the diversity of fungi, bacteria and earthwormswhich have several muchanisms to keep plant pathogens in low populations. In this review we describe the way in which earthworms reduce phytopathogenic fungi. Finally, integrated crop management promotes competition and balance essential to maintain soil health and ensure food production.

Keywords: earthworm, *eisenia foetida*, mycorrhizal fungi, plant pathogens, symbiosis

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Introduction

Feeding the world's population is a priority issue, so that the 2030 Agenda for Sustainable Development of the United Nations includes within its 17 Sustainable Development Goals, the goal of *zero hunger*.[1] Achieving this is challenging, as plants are exposed to many conditions that affect growth and production. Pests and diseases are one of the biggest challenges crop producers face every year. In addition to this, emerging diseases constitute one of the greatest risks due to the devastation they cause in agricultural production.[2–5]

It is known that the excessive application of agrochemicals have an immediate effect on what is desired to achieve during agricultural production,[6] however, this is achieved with environmental consequences and damage to the health of agricultural workers and consumers. To produce the food demanded by the population without affecting natural resources, sustainable technologiesmust be used.

The soil, because it shelters a great biodiversity (Figure 1), is considered the basis for the production of healthy foods. Microbial diversity has several roles such as the solubility of minerals to make them more available to plants. For example, phosphate solubilizing bacteria contribute up to 50% of the solubilization of the element.[7] All this activity of microorganisms, promotes a fertile soil.

Another example is the benefit that mycorrhizal fungi provide to plants. Once micro and macroelements are solubilized by bacteria, these are transferedthroughout the hypha to the previously mycorrhized root. Phosphate transport enzymes from fungi and plants are involved in this process, each with specific functions.[8]

The protection against plant pathogens that mycorrhizal fungi confer on plants has been demonstrated.[9,10]

In the rhizosphere, microorganisms compete for space and nutrients,these confrontations can reduce the number of phytopathogens. Besides, mycorrhizae also stimulate the biochemical defense mechanisms of plants.[9] Mycorrhiza-plant interactions are self-regulating. When mineral nutrients are available, mycorrhiza colonization is reduced.[11]

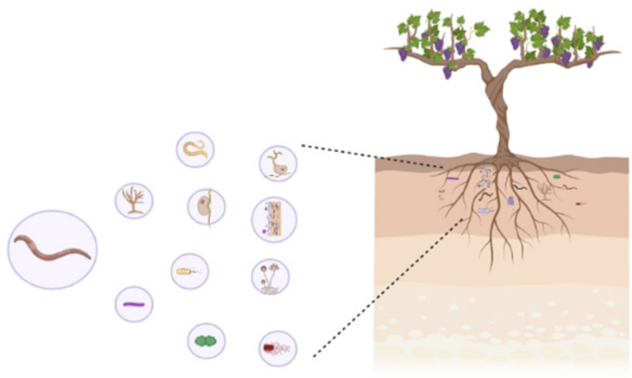

Figure 1 Eartworms and other microorganisms member of the soil ecosystem, each with a specific task.

Moreover, vermicompost has an essential role to promote life in the soil by improving the texture and promoting satisfactory levels of macro and micronutrients.[12] In addition, during vermicomposting, the Californian Red worm (*Eisenia foetida*) ingests organic matter which progressively decomposes and fragments. This matter is made up of microorganisms including a large number of fungi. The mucous substances yielded by earthworms have strong antimicrobial and antifungal activity.[13] Through their skin secretions and antimicrobial protein, they control microorganisms,[14] thus reducing the populations of soil plant pathogens.

The surface of the earthworm's skin contains antimicrobial peptides that protect it from the environment. Itdischarges peptides such as lysozyme through its skin, resulting in antimicrobial activity. In addition, the body wall and intestinal secretion have been shown to reduce *Fusarium oxysporum*.[13]

Earthworms feed on soils that contain organic materials, live microorganisms, and insects. Once the food is ingested, it is modified in the earthworm body to facilitate its absorption. When entering through the mouth, the material is swallowed by the pharynx which is a force pump (Figure 2). After that, the muscles contract and move the food up the esophagus. Then, it goes to the crop (which contracts more than the gizzard) where it is stored and moves towards the gizzard. This is a strong muscle that grinds the material into very small parts, where the enzymesecretion take part in breakingdown the products. The finely crushedmaterial goes through the digestion process in the intestine. Here more enzymes are added to aid the breakdown into simple molecules.[15] All this process achievespartially the elimination of plant pathogens.

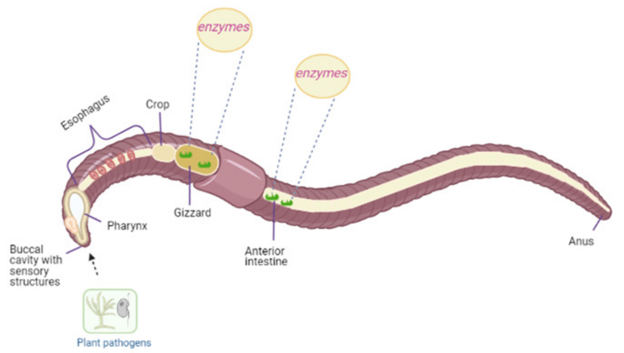

Figure 2 Earthworm's body organs, indicating decomposing enzymes production of ingested organic matter.

Once the organic material is ingested, it is swallowed by the pharynx. Then, the muscles contract and move the food up the esophagus. The food goes to the crop and moves to the gizzard that grinds it into small pieces mechanically as well as by secreting enzymes. Finely crushed material goes through the digestion process in the intestine where more enzymes are added.[15] Enzymes include protease, lipase, amylase, lichenase, cellulase and chitinase.[16]

Microbial populations in the soil are self-regulating, even the plant regulates the microorganisms in its rhizosphere. Thus, by adding microorganisms to the soil, they can be active for months or a year and disappear after that time. Chakravarty and Unestam[17] found that by incorporating the ectomycorrhizal fungus *Pisolithus tinctorius*, it protected *Pinus sylvestris* seedlings from the attack of *Fusarium moniliforme* and *Rhizoctonia solani*. This protection lasted for a year. It is very interesting to know the symbiosis in depth.The interaction begins through signals, and depending on the plant requirements and other factors still unknown, the microorganisms in the soil regulate themselves.

Conclusion

This review presents the significant and important activity of soil organisms and microorganisms for the plant benefit, focus on mycorrhizalfungi and earthworms. Both within their specialty, achieve by competition for space, or with physical and chemical mechanisms, reduce soil phytopathogens.Finally, we conclude that integrated crop management promotes competition and balance essential to maintain soil health and ensure food production.

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Conflicts of interest

The authors have no conflict of interest for this research.

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