MICROBIOLOGY ASSOCIATED WITH THE VETIVER PLANT

Settha Siripin
Maejo University
Chiang Mai, Thailand

Introduction

The major determinants of agricultural productivity in the tropics are climate and soil fertility. A number of climatic zones can be identified and these change more with topography than with latitude. The fertility of soil in the tropics varies, being heavily influenced by the nature of the parent rock. Many tropical soils are derived from very ancient parent rock and are highly weathered and leached, with consequent problems of nutrient deficiencies, or of acidity and associated toxicities. Soils in the tropics are low in nitrogen and phosphorus levels, and yet they continue to support most of the world's rice, cassava, sugarcane, oil palm and rubber production with virtually no addition of fertilizer.

The discovery of associative nitrogen-fixation system in the tropical grass has changed, the view of plant and soil microbiology interaction. In many tropical countries, vetiver can grow and survive without nitrogen and phosphorus fertilizer application, especially in the infertile soil. What or where is the nutrient source for vetiver growth and development? It was believed that the soil microbes are mostly effective and are associated with vetiver. Many heterotrophic microbes have been found in the soil surrounding roots, known as the "rhizosphere soil", in which bacterial growth is stimulated. Microorganisms often invade the surface tissue of roots, where they may cause a number of plant link for nutrient transport between the plant and soil, while the roots excrete soluble organic carbon compound, "polysaccharide", for soil microbial metabolism and adaptation. The soil microorganisms associated with vetiver root are nitrogen-fixing bacteria, phosphate-solubilizing microbes, mycorrhizal fungi and cellulolytic microorganisms.

Soil Microorganisms Associated with Vetiver

Two major groups of microorganisms are found to be associated with vetiver. They are bacteria and fungi.

The Bacteria

Nitrogen fixing bacteria: Many heterotrophic bacteria found in the soil are capable of fixing nitrogen. N_2 fixation is a biological process that some microorganisms produce nitrogenase enzyme which reduces the atmospheric nitrogen to biologically useful combined form of N-ammonia. Thus, N_2-fixation carried out by associative and free-living microorganisms in the rhizosphere of vetiver has been recognized to play an important role in nitrogen nutrient of vetiver. Diazotrophs belonging to diverse bacterial genera are *Azospirillum, Azotobacter, Acetobacter alicaligen, Bacillus, Beijerinckia, Enterobacter, Herbaspirillum, Klebsiella, Pseudomonas*, etc. Most of the N_2-fixing bacteria are present on the root surface, or are found in intercellular spaces, or in dead cells within the root.

Plant growth-regulator bacteria: Plant growth regulators (PGRs) are organic substances that influence physiological processes of plants at a very low concentration. PGRs include bacterial metabolites that affect plant growth; examples of PGRs are auxins, gibberellins, cytokinins, ethylene and abscisic acid. Many plant hormones (phytohormones), or their derivatives, can be produced by N_2-fixing bacteria such as *Azotobacter, Azospirillum, Bacillus* and *Pseudomonas*. Beneficial effects of these PGR bacteria have been attributed to biological nitrogen fixation and production of phytohormones that promote root development and proliferation, resulting in efficient uptake of water and nutrient, also antagonism against pathogens.

Phosphate-solubilizing bacteria: Several soil bacteria, particularly those belonging to the genera *Pseudomonas* and *Bacillus*, possess the ability to change insoluble phosphates in soil into soluble form by secreting organic acids, such as formic, acetic, propionic, lactic, glycolic, fumaric and succinic acids. These acids lower the pH and bring about the dissolution of bound form of phosphate. Tropical soils are generally low in phosphate which is readily available for plant growth. So the phosphate-solubilizing bacteria is very important for vetiver growth and development. Since plants utilize only inorganic phosphorus, organic phosphorus compounds must first be hydrolyzed by phosphatase enzyme which mostly originates from plant roots, through the action of fungi and bacteria.

The Fungi

Phosphate-solubilizing fungi: This group of fungi, belonging to the genera *Penicillium* and *Aspergillus,* can change insoluble phosphates in soil into soluble form that affects plant growth.

Mycorrhizal fungi: Mycorrhiza (meaning fungus root) is the term used to indicate the symbiotic association between plant roots and fungus. There are two primary types of mycorrhizal fungal association with plant root: ectomycorrhiza and endomycorrhiza. Mycorrhizal plant increases the surface area of the root system for better absorption of nutrients from soil, especially when the soil is deficient in phosphorus. Yet another class of endomycorrhiza is known as vesicular-arbuscular mycorrhiza (VAM), which possesses special structures known as vesicles and arbuscular, the latter helping in the transfer of nutrient from the soil into the root system. These fungi are classified on the basis of their spore morphology into five genera: *Glomus, Gigaspora, Acaulospora, Scherocystis* and *Endogone.* Benefits of VAM associations include: (i) improved uptake of macro- and micro-nutrients, (ii) increased tolerance of stresses, and (iii) beneficial alterations of PGRs. These benefits result from fungal-root interactions, which are complex and dynamic. Many depend on physical, chemical, and biological composition of the soil.

Cellulolytic microorganisms: Dead and decaying parts of plants and animals contribute to the primary source of organic matter in the soil. In order of abundance, the insoluble chemical constituents of organic matter are cellulose, hemicellulose and lignin, while the soluble constituents are composed of sugars, amino acids, and organic acids. Other constituents are fats, oils, waxes, resins, pigments, proteins, and minerals. Soil microbes can utilize the ingredients of organic matter in the soil by feeding readily on soluble resources and rather slowly on insoluble forms. Residues of younger plant with more soluble nutrient materials are more easily metabolized than branches of old tree with relatively higher woody tissue containing lignin. The nutritional composition of the substrate to be composted is a selective factor in that nutritional requirements vary greatly among different organisms. Many bacteria prefer amino acid and other N-containing substrates, whereas many fungi and actinomycetes prefer carbohydrates. Bacteria can utilize C/N ratio of 10:1 to 20:1, whereas fungi can utilize a wider ratio of 150:2 to 200:1, or even higher for wood decay fungi. So the cellulolytic microorganisms which surround vetiver root are of great importance to build up or decrease the organic-matter content in tropical soil.

Antagonism fungi or fungi killer: Composted materials can also be benefited in the suppression of pathogens of horticultural and agricultural crops by microbial antagonism. In composted hardwood bark, the establishment of large population of *Trichoderma hamatum* and *T. harzianum* were strongly suppressive against damping-off caused by *Rhizoctonia, Pythium* and *Phytopthera.*

The Basic Research to Soil Microorganisms Associated with Vetiver in Thailand

Sunanthapongsuk et al. (2000) reported the study on soil microbial biodiversity in the rhizosphere of vetiver grass. The results revealed that the total soil microorganisms and cellulolytic microbes were in the range of 106 to 108 cells/g of dry soil. The amount of non-symbiotic nitrogen fixing bacteria and phosphate-solubilizing microorganisms varies from 101 to 104 cells/g of soil. The endomycorrhiza were 2.5 to 25.5 spores/100 g of soil. Most of microorganisms appeared in the areas of rhizosphere of the vetiver root. Soil pH and organic matter percentages affected soil microbial population.

Siripin et al. (2000) concluded that 35 isolates of N_2-fixing bacteria could be screened from the vetiver root. Each strain has different potential in N_2-fixing ability and has difference in physiology and morphology of the colonies and the cells. N_2-fixing bacterial inoculation increased vetiver growth and development, particularly by increasing lateral root number, root dry-weight, number of tiller, plant height, branch-root number, root dry-weight, culm dry-weight, and total plant dry-weight. N_2-fixing bacteria produced PGRs which are similar to IAA, IBA, and GA, and affected lateral root number and total biomass. The inoculated vetiver with mixed strains of N_2-fixing bacteria showed the highest N_2-fixing ability; 30 to 40% of N_2 in vetiver plant were derived from the atmosphere by using ^{15}N isotope dilution method for measurement of N_2-fixing ability.

Patiyuth et al. (2000) revealed that the N_2-fixing bacteria *(Azospirillum)* produced plant growth hormone, idole-3-acetic acid (IAA) at 30-40 ug/ml in the broth media. *Azospirillum* grew well outside and inside the vetiver root.

Techapinyawat et al. (2000) reported that VA mycorrhiza inoculated to vetiver significantly increased plant biomass and the nutrient uptake.

Conclusion

Soil microorganisms which are associated with vetiver exhibited diversity among bacteria, fungi, etc. All soil microbes share their survival and adaptation with vetiver. Thus, soil microbes associated with vetiver do not only produce nutrient sources for vetiver growth and development, but also induce plant growth hormones that affect vetiver directly. We need to know more answers about these associations.

References

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