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Deleterious Rhizobacteria: Future of Herbicides

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Rhizobacteria:

Rhizobacteria includes bacteria from the rhizosphere, root surface, and within the root. Growth of these bacteria in the rhizosphere is mediated by environmental conditions like soil chemical and physical characters, temperature, aeration, moisture availability *etc*. Rhizobacteria are aggressive colonizers (Plate 1.), their growth is stimulated by root-exuded organic compounds, and root cell lysates and secretions.

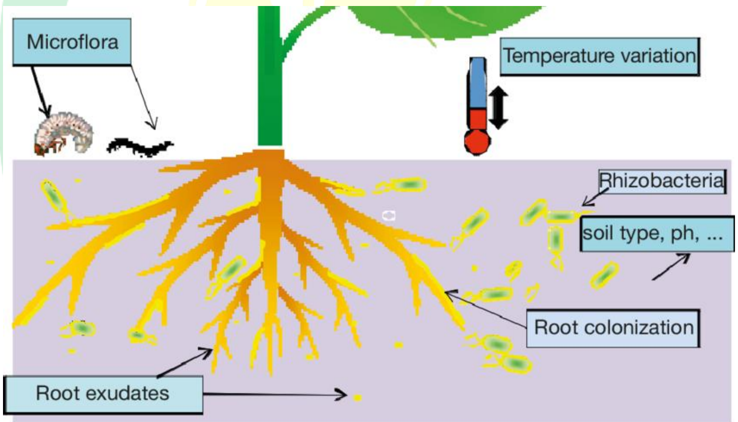
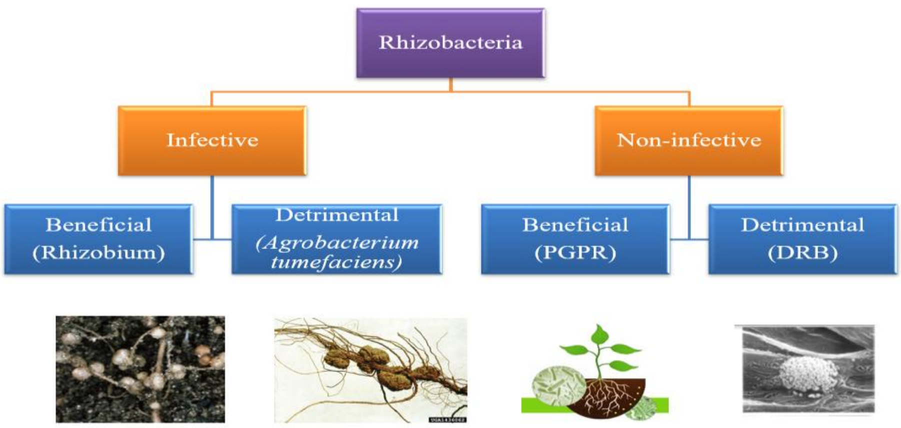


Plate 1: Rhizobacteria colonizing on roots of a plant.

Classification of Rhizobacteria



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Deleterious Rhizobacteria

Saprophytic bacteria that live in or on plant seeds and roots, surviving on organic compounds released by plant seed or root cells. The plant is not parasitized and vascular tissue is not penetrated by DRB like major or true pathogens, but seed tissues, root hairs, and the root tip are externally colonized; found intercellularly beneath epidermal cells and in intracellular spaces of root without inducing disease symptoms. Population densities of DRB are very high in soils and species include both beneficial and pathogenic organisms within the rhizosphere. Continuously cropped areas or perennial plants (trees, vines) that exhibit "replant disease" is due to DRB Ex: Citrus, Grapevine. Yield decline disease Ex: Sugarcane, Forest decline.

Development of growth suppression in plants

The association of high bacterial populations on the root surface of the host plant as a result of root exudation patterns, soil characteristics, other soil organisms, and management practises imposed on the ecosystem in which the plants occur is likely to result in growth suppression by DRB. It is well known that the diversity and functions of the rhizosphere's inhabitants, as well as the quality and quantity of the root exudates that define the degree of colonization, are what eventually determine how plants and microorganisms interact. There are few concrete examples of the numerous interacting factors that DRB uses to suppress growth. Rhizobacteria's ability to colonise roots and inhibit their development is influenced by soil environmental factors like pH, texture, organic carbon, and temperature (Fig. 1).

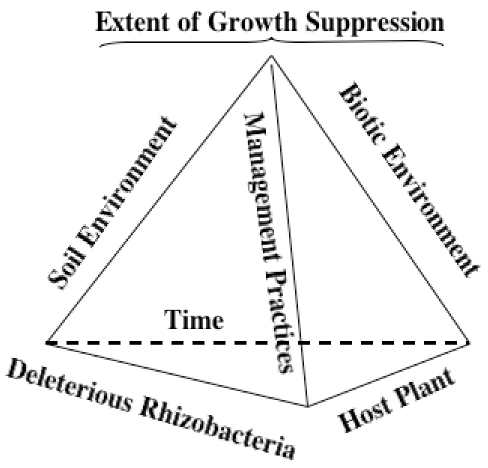

Fig. 1: Components and their interactions involved in plant growth suppression associated with deleterious rhizobacteria

Various factors affecting the activity of rhizobacteria

Soil characteristics, plant types, most virulent stage of bio agent growth must match with the susceptible host habit and active growth period of the host. The inhibitory effects of rhizospheric bacteria are due to the release of

- Enzymes,
- Growth regulators,
- Bacterial metabolites

Phytotoxic metabolites that inhibit plant growth

- **Indole-3-acetic acid (IAA)**
- **Ethylene**- Some rhizobacteria capable of producing high levels of ethylene have been investigated as germination biostimulants of seeds.
- **Hydrogen cyanide (HCN) -** By preventing cytochrome oxidase respiration, HCN has a negative impact on root metabolism and root development.
- **Phytotoxins:** Downy brome's root development was shown to be inhibited by a phytotoxin from Pseudomonas fluorescens strain D7. (*Bromus tectorum*)(Tranel et al., 1993).
- Pseudomonas spp. exopolysaccharides (EPS) induce wilting.
- **Nutrient Availability:** Producing a Mn shortage that causes wheat to become infected with *Gaeumannomycesgraminis* (Take-all disease).

Effects of combined mechanisms of action:

In the rhizosphere, coexisting strains with different mechanisms of action may work together to inhibit plant development.

Interactions with beneficial rhizosphere microorganisms

- Deleterious rhizobacteria negatively affect mycorrhizal development through reductions in spore germination and hyphal lengths of arbuscular mycorrhizae.
- Symbiotic nitrogen fixation in leguminous plants is inhibited by DRB by reducing nodulation capacity, inhibiting nitrogenase activity, and reducing rhizobial growth in the rhizosphere
- Deleterious rhizobacteria may be involved in inconsistent performance of selected PGPR by degrading the signaling compounds, that is necessary for root colonization and production of biocontrol compounds

Deleterious rhizobacteria as weed growth inhibitors:

- ✓ Nearly 300 herbicide-resistance weed species cause to use microorganisms as biological control agents.
- ✓ Potential control of wild radish found in vineyards in Western Australia (Vargas *et al.*, 2002).
- ✓ Strains of *Pseudomonas fluorescens* and *Xanthomonas campestris pv. poae*isolate JT-P482 has been commercialized as CAMPERICO for control of annual bluegrass (Imaizumi*et al.*, 1997).
- ✓ Inhibition of Seed Germination, Seedling Emergence, and Seedling Growth-cause 30% mortality in sprouting seedlings as well as delayed development in 68% of infected plants under laboratory conditions.
- ✓ Stunting of tap and/or lateral roots,reduced hypocotyl or coleoptile length, leaf chlorosis.
- ✓ DRB may be involved in blocking the plant-derived signaling compoundsincluding salicylic acid, jasmonic acid, and ethylene that are important in pathogen defense, which could render plants more susceptible to soil borne pathogens.

Table1: Examples of successful DRB's isolated and tested for effective weed control

Microbe(s) involved	Target weed(s)	Mechanism(s)	Observedeffects/comments
Streptomyces hygroscopicus	Barnyard grass	Antimicrobial and herbicidal activity due to hydantocidine production	Germination inhibition, significant reduction in stem, and leaf structure of

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			weed
Flavobacterium sp.	Sugar beet	IAA production	Decreased root elongation and increased shoot to root ratio
Enterobacter taylorae	Bindweed	IAA production	90.5% reduction in root growth, phytotoxic activity
Pseudomonas fluorescens	Leafy spurge	Auxin production to phytotoxic levels	Reduced cell membrane integrity, inhibited root growth
Pseudomonas syringae strain 3366	Corn spurry and fireweed	Phytotoxin production	Germination inhibition, reduced root, and shoot growth
Trichoderma virens	Several weeds	Rhizosphere competence and production of herbicidal compound viridiol	Reduced emergence and seedling growth of different weeds up to a significant extent

Management impacts on DRB activity

- Higher amounts of weed DRBs are supported by agronomic practises like perennial forage and pasture systems, organic farming, and mixed cropping systems.
- Weed-repelling DRB was present in higher concentrations in soils with high enzyme activity and a high percentage of water-stable soil aggregates.
- Cropping Systems: Depending on the makeup of their root exudates, various plant species choose particular rhizosphere communities.
- The prevalence of DRB occurrence in soil is influenced by tillage. Under conventional or decreased tillage, there are higher amounts of native DRB inhibitory towards the weeds jointed goat grass and downy brome.
- Pesticide application found that colonization of wheat roots by DRB (inhibitory *Pseudomonas* spp.) and resulted in extensive cellular and tissue damage when plants were treated with the herbicide mecoprop.

- A significant shift in endophytic bacteria detected in soybean roots was related to cultivation in soils with pre-plant glyphosate application.

Herbicide-pathogen interactions

- Herbicide effective on a weed causes weed more or highly susceptible to a pathogen.
- Herbicide lethal to a weed can improve the weed control efficacy of a pathogen at sublethal rates.
- Herbicides can be used together with microbial herbicide to increase the spectrum of weeds controlled in a field.
- Herbicides are able to reduce the amount of control obtained with a pathogen alone.

Constraints of using bioherbicides

- Low activity
- Limited spectrum of activity
- Poor survival of the introduced microbes
- Persistence of the suppressive compound
- Large-scale production
- Storage
- Formulation
- Shelf-life of the organism
- Delivery systems
- Avoiding injury to non-target organisms
- Interactions with chemical herbicides
- Regulations
- Commercialization
- Economic feasibility stabilization of high titers following fermentation
- Shelf life of formulations
- Achievement of viable delivery system
- Obtaining virulence of the product before reaching the target

Conclusion

Root colonization and growth inhibitionis often plant species or variety specific, which is intriguing from an ecological andmanagement standpoint. Deleterious rhizobacteria may have potential for use inpest management systems and in biological control. The dynamic and complexnature of DRB and their ecological interactions with other organisms will continueto be investigated to improve our understanding of this group. Strategies might then be developed to reduce crop suppressive DRB populations and enhance weedsuppressive strains. Further, rhizobacteria as bioherbicides or natural components ofthe soil microbial community may receive more consideration as major factors in restoring soil quality and biodiversity to ecosystems degraded through currentconventional cropping systems.

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