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Technical Bulletin

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SIGNIFICANCE OF VAM FUNGI TO PLANT ESTABLISHMENT IN MINE LAND REVEGETATION PROJECTS

The Mine Site

One of the most challenging type of revegetation project is the mine site. Mining generates a variety of mineral wastes that are brought to the surface and replace the original topsoil. These wastes are very different from normal topsoils in their biological, chemical and physical attributes. Successful revegetation on such waste materials depends on various soil factors such as the amount of organic matter, fertility, pH, water-holding capacity, physical properties (non-cementing), temperature and microbial activity.

The surface material left after most mining activities will not support the health of plants and soil microbes, so it must be ameliorated with the addition of organic matter or other soil amendments in order to achieve successful revegetation. These amendments should provide organic and inorganic nutrient sources and enhance the development of fully functional soil microbial communities. Functional microbial communities are composed of a complex of species that differ in their environmental tolerances, physical requirements and habitat adaptations.

Healthy Soil Microbial Community Includes VAM Fungi and Rhizosphere Bacteria

Vesicular-arbuscular mycorrhizal (VAM) fungi are major components of a healthy soil-plant microbial community. These fungi are among the most ubiquitous soil organisms found in established natural plant communities. They form root symbioses with a broad range of plant species (grasses, flowers, forbs, shrubs, and the majority of trees) and contribute to plant growth and survival by reducing on-site stresses associated with deficiencies in organic matter, fertility, water, aeration, soil structure, erratic pH, salt, toxins and heavy metals. There are many studies reporting on the occurrence of VAM on naturally-occurring plants growing in mining wastes of different ages. Unfortunately, most operational revegetation practices ignore the importance of mycorrhizal fungi in plant community dynamics. As a result, such practices and have had limited success in establishing sustainable plant communities, and are characterized by repeated replanting, sharply limited selection of usable plant species, and expensive maintenance.

Other important members of the microbial community are soil and root bacteria. Rhizosphere bacteria, important contributors to healthy plants, are associated with

nonwoody roots and mycorrhizae and improve their function. These free-living bacteria not only decompose organic matter and release beneficial minerals, but they also non-symbiotically fix atmospheric nitrogen, solubilize insoluble minerals, reduce certain root diseases, and produce growth regulators that promote plant growth.

Weedy, Nonmycorrhizal Pioneer Plants Remain Too Long on Disturbed Sites Lacking VAM

In semi-arid and arid areas, weedy annuals that first appear on mining wastes are typically nonmycorrhizal plants, that is, plants that are not dependent on mycorrhizal fungi for their growth and survival. Initial attempts to re-seed an area using plant species requiring VAM may be unsuccessful because of the scarcity of VAM fungal spores found in the disturbed soils. The natural introduction of VAM fungal spores to mining wastes occurs by blow-in (dust storms), insects and small animals...a very slow process requiring decades. VAM fungal spore densities found on vegetated mining wastes of various ages (1 to 31 year old) in Wyoming never reached levels of spores found in adjacent, undisturbed vegetated sites. Many scientists agree that with low VAM spore density in the soil, the resulting plant community will be dominated by nonmycorrhizal weedy plants. Progress towards a more diverse community including mycorrhizal plant species will be significantly delayed. Observations on the pattern of plant succession in arid and semiarid habitats indicate that VAM play a major ecological role in the composition and stability of the plant communities. This subsequently affects the various processes critical to forming a stable ecosystem.

The successful re-enty of VAM fungi into mining waste soils will depend on several things, including the nearby presence of mycorrhizal-dependent plant species (i.e. the majority of plant species), the initial level of VAM fungal spores, the harshness of the waste material, soil conditions, and time. It is clear that VAM fungi, as well as the other attributes needed to support a microbial community, are inherently important in the establishment and maintenance of a permanent and healthy plant community.

Stockpiling Topsoil Kills Off VAM Fungi

Most operational revegetation practices include the application of topsoil to the site prior to planting. Topsoil is initially high in VAM fungal inoculum produced on roots of the original plant communities. However, the topsoil used in revegetation projects often comes from commercial stockpiles. Stockpiling topsoil for 1 to 3 years will decrease VAM fungal inoculum to less than 10% of it’s original density; longer storage can reduce survival to near zero. Therefore, application of VAM fungi inoculum may still be necessary even when natural topsoil is used.

Absence of VAM Leads to Poor Survival of Introduced Vegetation

The absence of VAM accounts for the poor survival of plants used to revegetate overburden dumps resulting from mining, especially in arid regions. VAM fungi improve the ability of desired plant species to compete with weeds, and increase

the speed of changeover from the weed stage to a stable diverse plant community. Considerable research has been published showing the lack of viable VAM fungal inoculum on overburden dumps in arid and semiarid regions. VAM fungal inoculation will improve plant productivity on these dumps by increasing drought tolerance of plants (essential in arid regions) and mineral availability, which are the main limiting factors in plant establishment on these dumps.

VAM are Essential Partners for Achieving Sustainable Vegetation

In natural semiarid and arid habitats, VAM occur on most plant species growing in semi-natural grasslands, tall-grass prairie, short-grass steppe, alpine and tundra grasslands and in the savanna of the Serengeti. They are also extensive in shrub-land plant communities, high-elevation sagebrush communities, and in plant communities in high-elevation cold deserts, the Chihuahuan Desert, the Sonoran Desert and the deserts of Asia. Much research has been published on the improvement in water relations and growth of plants by VAM fungi. Drought tolerance appears to be related to improved mineral nutrition and increased membrane permeability of plants with VAM.

Modern Methods Allow for Mass Production of VAM Fungi for Revegetation

There are many scientific publications showing the beneficial effects of VAM on various plants species growing in mining waste on semiarid and arid lands. These reports are based on small scale studies performed in small on-site plots or in greenhouses and usually involved only a few dozen plants per study. Until very recently, large-scale demonstrations or operational level applications of the VAM fungal technology for establishment of plants on mining wastes has not been possible because of the lack of effective inoculants. We are now able to mass-produce spores of selected species of VAM fungi that are proven effective on mining wastes in the USA. These spores can be pelletized with beneficial bacteria for direct field operational application. The spore pellet technology for establishment of direct seeded grasses, flowers, forbs and shrubs and the technology to custom-inoculate seedlings of native trees and shrubs in nurseries are now operational for mined land revegetation with PHC Reclamation, Inc.

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