Geophysical Research Abstracts, Vol. 7, 10847, 2005
SRef-ID: 1607-7962/gra/EGU05-A-10847

Bioremediation of water repellency

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Introduction

Water repellency in soils occurs on more than 5 million hectares of sandy soils in western and southern Australia and can seriously reduce agricultural production. It is caused by the formation around the sand particles of a skin of hydrophobic substances derived from plant waxes and their biodegradation products. Kaolinite clays have been used successfully to remediate repellency, but because of the large amounts required this practice is only economic if clays are on site. Wetting agents are expensive but have been used in confined areas such as turf grass. As an alternative strategy, bioremediation of water repellency through biodegradation of waxes by bacteria was investigated.

Wax-degrading bacteria were isolated from soils and other sources rich in microorganisms. Woolwax, a complex mixture of fatty acids and alcohols was used to select bacteria capable of metabolising hydrophobic compounds. Of the stable isolates (37) two-thirds were actinomycetes known for their ability to metabolise a wide range of complex organic compounds. The most efficient isolates (mainly *Rhodococcus* spp) were also the most prolific producers of biosurfactant which facilitates the degradation of waxes associated with particles by emulsifying the waxes.

Inoculation of water repellent soils, under controlled conditions in the laboratory, with the most efficient wax-degrading isolates resulted in a significant decline in water repellency. However, inoculation of soils in the field did not result in improvements in soil wettability, possibly due to competition from natural microflora, adverse environmental conditions or relatively low inoculant numbers.

Wax-degrading bacteria were isolated from soils including water repellent soils. Therefore an alternative strategy was to stimulate these organisms. But first the soils had to be wet to support microbial activity. Under irrigation, a gradual decline in water repellency was observed over time. However, under dryland farming conditions, wetting up of water repellent soils was slow following the advent of winter rains in the Mediterranean climates of south western and southern Australia. Following farmer observations, lime was investigated as a mechanism to increase the rate of water infiltration into water repellent soils particularly following opening rains at the beginning of the season. The addition of lime resulted in significant reductions in water repellency in the laboratory and in the field both under irrigated and rainfed conditions. In the laboratory, there was initially a rapid reduction of repellency (indicative of a physical impact) followed by a gradual decline in repellency (indicative of a biological change). In the field, particularly in rainfed systems the changes in repellency were more gradual. The mechanisms of lime on water infiltration are not certain. It is likely there are physical (fine particle effects), chemical (pH, Ca^{++}) and biological impacts. Estimation of numbers of wax-degrading bacteria in soils showed at least a 10-fold increase in lime treated soils compared with the controls, supporting, at least in part, that a biological mechanism is involved.

In conclusion, soils (including water repellent soils) contain bacteria capable of degrading waxes that cause water repellency. The activities of these organisms are severely limited by lack of soil moisture but managements that increase water infiltration encourage their activity. The results suggest that lime may provide a viable alternative for increasing the wettability of soils by promoting microbial activity by bacteria responsible for wax degradation, resulting in more consistent plant germination and establishment, and increased crop yields.