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Water Repellency of Casuarina (*Casuarina equisetifolia* Forst.) Windbreaks in Central Taiwan

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Abstract.—Water repellent layer (WRL) in the Casuarina plantation near Taichung harbor in Central Taiwan is mainly due to the development of filamentous fungi. Not only are hyphae of the isolated fungi, the metabolites of fungi strongly hydrophobic, TCHC-5 and TCHC-20 are also significantly hydrophobic. Humic substances decrease the phosphorus fixation and contribute to the formation of WRL. The hydrophobic properties of humic substances are unfavorable for the nutrient cycling at this area. Wetting angles of fulvic acids and humic acids are pH-dependent. Increasing solution pH reduces hydrophobic strength for fulvic acids and/or humic acids. Isolated fungi TCHC-15 and TCHC-16 exude strongly acidic metabolites (pH2.7-3.0), which will increase the hydrophobic strength of soil layers. Humic substances with aliphatic chain are the main components that form WRL in soils. Soil pH could be an indicator of hydrophobic potential for organic matter.

Introduction

Casuarina plants are the main plantation on the seashore and are usually used as windbreaks in Taiwan. Due to monsoon in the drought season, Casuarina stands usually accumulate more litter and result in highly hydrophobic and flammable litter layers because of mat formation and stimulated growth of some fungi. The purpose of this study was to search for a feasible method for the reclamation of WRL by investigating the mechanisms of fungi on the formation of water repellency and the nutrients cycling in the Casuarina stands.

Materials and Methods

Litters and soils were sampled randomly from three quadrates each with a width of about 2m x 2m at the Casuarina plantation suffering from water repellency with serious retardation growth. The samples cultivated under the controlled temperature of 26°C for 2 to 5 days with the Potato-Dextrose Agar (PDA), Penicillin G, and Rose Bengal added (see table 1). Their hyphae and/or spores were planted onto the chosen nutrient medium, until the individual colonies are subculture in pure culture for identification. Small pieces of the isolated colonies were planted onto a Yeast extract-Malt extract Agar (YMA). A slide was embedded on each plate for hyphae development, and incubated at the temperature of 26°C for 1 to 2 weeks, until each cultured colony's need had been fulfilled. The slides were picked out respectively for the observation of hydrophobic strength of each isolated fungus. Isolated fungi were punched 10 discs (ID=8mm) in the previous YMA cultured, and planted onto a Yeast extract-Malt extract Broth (YMB) subculture in an incubator (26°C, 100 rpm) for 2 weeks. Hyphae and culture solution of each fungus were collected for slide smear (wetting-angle measurement) and chemical analysis.

Soil property analysis are based on the recommendation of American Society of Agronomy (Klute, 1986; Page, 1982). The hydrophobic strengths of the samples were directly estimated from the wetting-angle measured by contact-angle meter (Mallik and Rahman, 1985). Macro elements of the litter were determined by the procedures of digestion with sulfuric acid and hydrogen peroxide. Trace elements of the litter were determined by the procedures of digestion with nitric acid and perchloric acid. The procedures of extraction of humic substances, in a sequence of extraction by the 0.1M HCl and 0.1M NaOH solution, are based on the recommended method of the International Humic Substance Society (Aiken, 1985). 10 ppm P of KH_2PO_4 was used as a tracer in columns containing

Table 1. Components of nutrient medium (g/l).

Components	PDA	YMA	YMB
Diced potato	200	—	—
Dextrose	20	10	10
Yeast extract	—	3	3
Malt extract	—	3	3
Peptone	—	5	5
Agar	15	20	—
Penicillin G	0.3		
Rose Bengal	0.5		

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topsoil (0-5 cm; hydrophobic) and subsoil (10-15cm; nonhydrophobic) respectively, which were sampled from Casuarina windbreak site and packed in the glass column. The soil columns were saturated by deionized water before displacement experiments.

Results and Discussions

Several fungi were isolated from the Casuarina stands in Taichung harbor. These included *Mucor, Rhizopus, Collybia, Aspergillus, Fusarium, Penicillium, Trichoderma,* and *Verticillium.* The wetting angle of cultured colony of each isolated fungus was difficult to measure accurately due to the fluffy texture; however, all of the isolated fungi were showing hydrophobic when using the water droplets on them. Wetting-angle measured from slide smear (hyphae + CS) revealed that the isolated fungi TCHC-2, TCHC-5, TCHC-12, TCHC-20 and TCHC-21 were significantly different in water repellency. Having filtered the culture solution to remove hyphae, fungi TCHC-5 and TCHC-20 were still hydrophobic (measured from slide smeared CS only). This showed that the metabolites of some fungi were hydrophobic. Fungi TCHC-15 and TCHC-16 exuded strongly acidic metabolites (pH2.7 - 3.0), which could affect the behavior of water repellency of hydrophobic substances in soil layers.

Humic acids and fulvic acids extracted from repellent soils of Casuarina windbreak were hydrophobic. Figure 1 and figure 2 show that wetting angles of fulvic acids and humic acids varied with solution pH. There was a trend of declining hydrophobic strength in accordance with increasing solution pH. Generally speaking, soil pH ranges from 4 to 8 at the natural soil environment. Under such soil pH condition, the difference of hydrophobic strength between fulvic acids and humic acids was not significant. Usually measured in a solum base, soil pH was an average value of the sampling solum. In fact, the real soil pH in local soil layers, due to the metabolites of microorganism, may be less than 4. Fungi TCHC-15 and TCHC-16 can exude strongly acidic metabolites. Such phenomenon will cause polymerization and/or precipitation of the fulvic acids and humic acids. It also suggests that it is easy to increase the hydrophobic strength of soil layers.

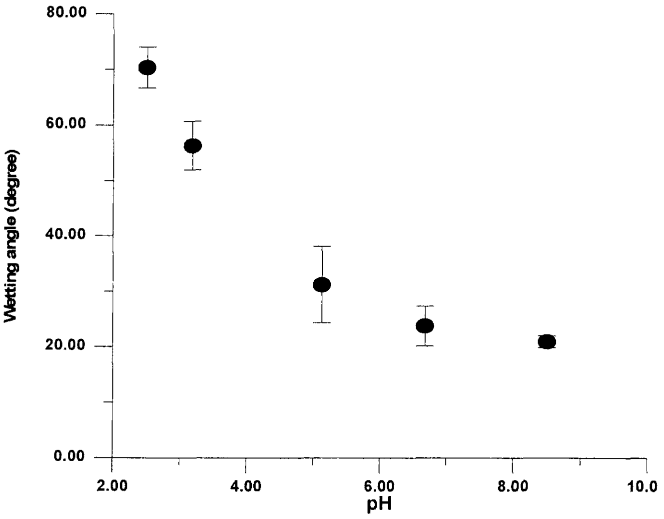

Figure 1. Changes of wetting angle of fulvic acids in different solution pH.

The breakthrough curve (P-sorption curve) and P-desorption curve is shown in figure 3. Hydrophobic soils had higher phosphorus concentration of effluent under the process of KH_2PO_4 solution displacement, and lower phosphorus concentration in the next process of H_2O displace-

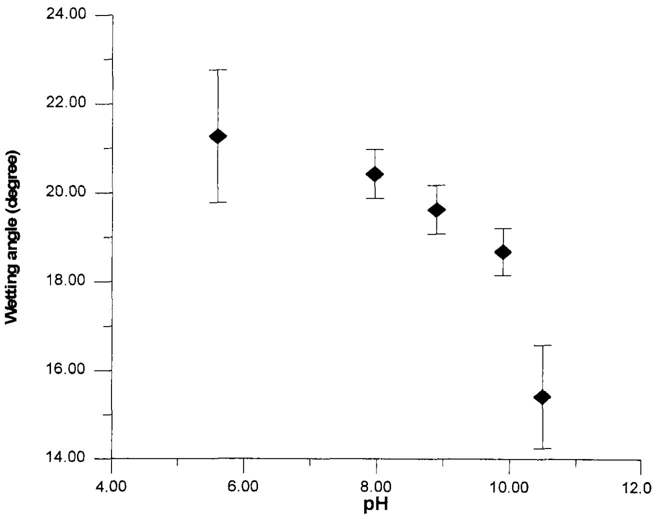

Figure 2. Changes of wetting angle of humic acids in different solution pH.

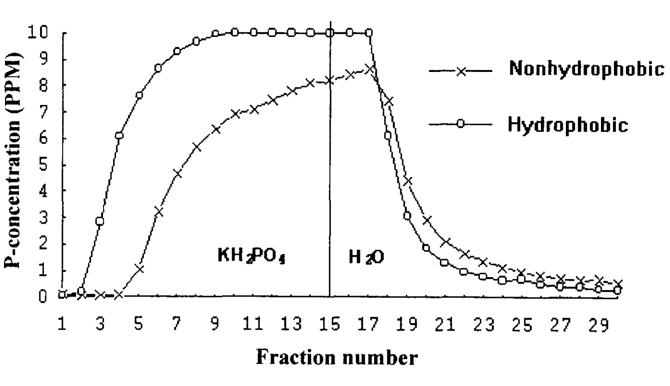

Figure 3. P-sorption and desorption curves of tested samples in the processes of miscible displacement.

ment. This shows that hydrophobic soils have lower P-sorption than non-hydrophobic soils. Besides, from the breakthrough curve of non-hydrophobic soils (C/Co =0.5, V/Vo =3.7), one can see there exists a significant P-sorption reaction in figure 4. Hydrophobic soils shows a slight P-sorption reaction in figure 5 (C/Co =1/2, V/Vo =1.0). Humic substances have the ability to reduce oxidized forms of certain metal ions, a typical case being the reduction of Fe III.

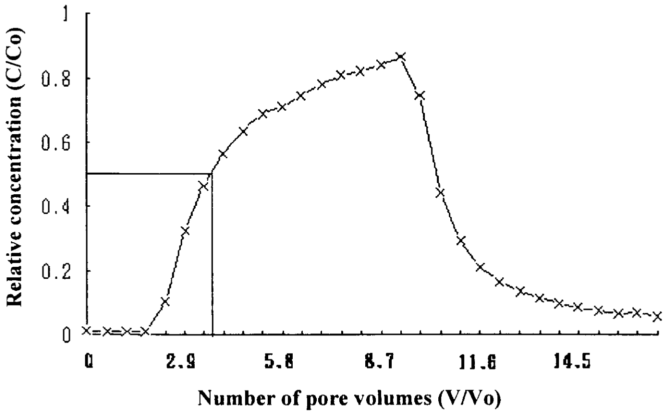

Figure 4. P-sorption and desorption curve of non-hydrophobic soils.

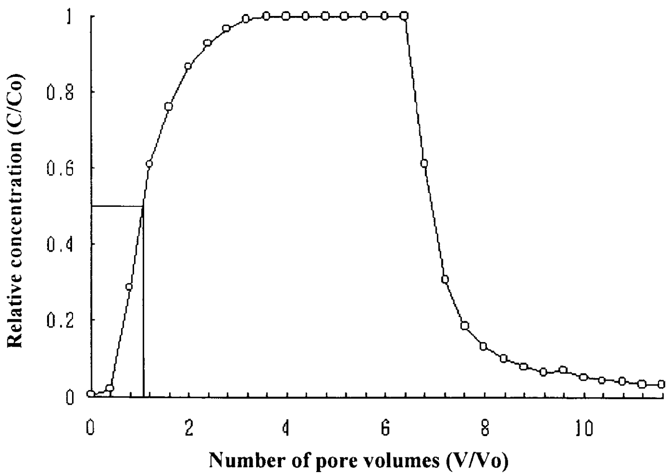

Figure 5. P-sorption and desorption curve of hydrophobic soils.

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