Geophysical Research Abstracts
Vol. 12, EGU2010-6537, 2010
EGU General Assembly 2010

Do rock fragments participate to plant water and mineral nutrition?

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Rock fragments modify soil properties, and can be a potential reservoir of water. Besides, recent studies showed that this coarse soil fraction is chemically active, release nutrients, and could therefore be involved in biogeochemical nutrient cycles. However, these studies carried out on rock fragments, crushed pebbles or mineral particles do not answer the question whether the coarse soil fraction has significant nutritive functions. Only a couple of studies were conducted on plants, one on grass and the other on coniferous seedlings. This present work attempted to assess if pebbles may act as water and nutrient sources for poplar saplings, a deciduous species.

Remoulded soils were set up in 5 L-pots with three percentages of pebbles: 0, 20, and 40% in volume. We used, as substrate either fine earth or sand (quartz), and as rock fragments either calcareous or inert pebbles (quartz). Additional modalities were settled with sand mixed with 20 and 40% pebbles enriched with nutrients. Both fine earth and calcareous pebbles were collected from the Ap horizon of a calcareous lacustrine limestone silty soil located in the central region of France. After cleaning, all pebbles were mixed to reach a bulk density in pots of 1.1 g/cm3 for the fine earth and 1.5 g/cm3 for the sand. Ten replicates were settled per modality, and one cutting of Populus robusta was planted in each. The experiment was conducted under controlled conditions. All pots were saturated at the beginning of the experiment, then irrigated by capillarity and controlled to maintain a moderate water stress. Growth and evapotranspiration were followed regularly, while water stress status was measured by stomatal conductivity every day during two drying periods of 10 days. After three months, plants were collected, separated in below- and above-ground parts for biomass and cation analysis (Ca, Mg, K).

Results showed that pebbles can participate to plant nutrition, but no reduction of water stress was observed. Indeed, plants' water stress increased along the drying periods but no significant difference of stomatal conductivity was measured between modalities. This indicates that water stored in the porosity of calcareous pebbles had no influence on the plant water status, suggesting that this reserve is either too low or not accessible for poplar saplings.

Besides, the presence of pebbles reduced the growth (plant height and biomass), and even more the proportion of pebbles was high. This dilution effect was the main effect on plant development observed in this experiment. However at moderate pebbles proportion, mineralomass of plants grown with or without 20% calcareous pebbles were similar, and higher than that of modalities with quartz pebbles. In addition, plants had a biomass 16% higher when grown with calcareous pebbles than with quartz pebbles. These results indicate that plants access nutrients from pebbles and that growth conditions were significantly better in pots with calcareous compared to quartz pebbles at moderate proportion (20%). For modalities with 40% pebbles, no difference was found between calcareous and quartz pebbles when mixed with fine earth. However, plant biomass grown in sand were 2.5 to 3 times higher when mixed with 20 and 40% enriched pebbles respectively, than biomass of plants grown on sand only. These results suggest that plants access nutrients from pebbles, especially those adsorbed, but at higher proportion (40%) the detrimental effects of rock fragments (such as limitation of root development can mask their nutritional value.

This study strengthen the hypothesis that coarse soil fraction may act as a nutrients source. The concept of an inert stone matrix that, from the plant point of view, only dilutes ecological functions of the soil, must be revised.