The use of coal ash to improve the properties of agricultural soils

Abstract

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2005-2006

This study explored possible applications of coal ash to improve the physical and chemical properties of agricultural soils. The soils chosen for the study were loess (from the Ministry of Agriculture's research station in Arad) and dune sand (from the sands of Rishon Letzion near the Shafdan Water Reclamation Plant).

Loessial soils are characterized by the formation of a surface crust that reduces the water infiltration rate, making it difficult to use such soils for agricultural purposes. Rain causes the unstable aggregates in the loess soil to break up resulting in the dispersion of the soil's clay fraction. Part of this fraction is leached down the soil and part remains suspended on the soil surface, forming a dense crust there when it dries.

Different loads of coal ash were added to the loessial soil in order to determine the effect of the coal ash on the formation of the crust. Two techniques were used to assess the extent of crust formation at the soil's surface: measurement of the water infiltration rate into the soil using a rain simulator, and spectral measurement of the reflected radiation from the soil surface. Both dry and pre-saturated soil samples were tested in the rain simulator. Both procedures demonstrated that the addition of coal ash to the soil improved the water infiltration rate and delayed the formation of a crust on the soil surface. This positive effect of the ash was maintained for the duration of three rain–dry-period cycles.

The spectral measurements were used to assess the extent of the formation of crust in soil samples with different fly ash loads. The better formed the crust, the higher the level of reflected radiation from the crust layer in the frequency ranges of nonspecific absorption. The addition of coal ash to the soil decreased the reflected radiation. The addition of coal ash decreased the extent of aggregates breakup due to the impact of raindrops, weakened the crust-formation process and reduced the vertical movement of suspended clay particles.

In order to assess the effect of coal ash on the water retention of sandy soils, dune-sand with varying loads of coal ash was examined, using a rain simulator. Sands have a low water-holding capacity and a high water-infiltration rate.

The effect of fly ash on the water-infiltration rate and water retention of the soil was also examined using columns. The effect of fly ash on the water retention of the soil was tested by weighing the amounts of water held against gravity along the soil columns from which the water was drained over a period of one week. In addition, the aggregation capacity of the dune sand particles in the presence of the coal ash was examined using a penetrometer.

The results showed that addition of coal ash to the sandy soil led to a reduction of 90% in the rate of water-infiltration compared to the same soil without coal ash, while the water holding capacity increased. These findings are related to the fact that the fly ash contains a large fraction of particles much smaller than the quartz particles of the sand, and these small particles lodge themselves in bottle-necks inthe pores between the sand particles. Similarly, the addition of the pozzolanic coal ash increased the strength of the aggregates formed in the ash-loaded soil.

The repeated addition of low portions (2.-2.5 percent) of fly ash to sandy soil resulted in a lower water-infiltration rate than that obtained following the addition of the first portion of ash. This finding points to the cumulative effect of the gradual application of fly ash.

High concentrations of boron were found in the water drained from the dune-sand soil enriched with a second portion of ash. These concentrations represent an agricultural impediment that should be taken into account.

This study also examined the possibility that the addition of fly ash to sodic soil could decrease the levels of sodium because of the high concentrations of calcium in the ash and that consequently, the formation of cracks typical of high-sodium soil would be reduced. The ash's pozzolanic nature can also contribute to the reduction in crack formation. A plot near Kibbutz Revadim with a clay soil (41% clay, 42% sand and 17% silt) and a high sodium content (9 percent exchangeable sodium = ESP 9) was selected. Coal ash was added to plots at proportions equivalent to 20 and 80 tons per 1000 square meters, and this was compared to identical plots without coal ash. The corn planted in the soil was sent for elemental analysis. The results showed that chrome was the only element whose absorption in the corn ears was affected significantly by the addition of coal ash to the soil, but even at the higher load of ash chrome concentrations did not reach health-threatening concentrations. The ash did not affect the absorption of chrome in the vegetative part of the plants.

Because no rise in the concentration of chrome in the ash-treated soils was observed and because the concentration of chrome in the particular coal ash that was examined was not significantly different from the concentration of chrome in the soil, it appears that the increase in the absorption of chrome by the plants was due to the fact that a considerable fraction of the added chrome was in chemical species relatively available to the plant. The ash had no effect at all on the cadmium and lead concentrations in either the corn ears or the vegetative part of the corn plants.