ABSTRACT

Coal ash and municipal sewage sludge are rich sources of bio-essential nutrients and their application in agriculture is being advocated as one of the avenues for their utilization. However, presence of considerable amount of heavy metals has raised concern for their use in agriculture because accumulation of metals in soil is an irreversible process and metals can be harmful at elevated concentrations. For sustainable agriculture, it is also necessary to prevent metal accumulation beyond threshold levels in soils. Therefore, evaluation of the effect of these solid wastes at low application rates and understanding their interactions with soil-crop-water system become imperative.

With this major goal, a comprehensive field investigation comprising two experiments was done on a coarse textured lateritic soil over a period of two years during February-June 2000 and February-May 2001, to assess the effects of short-term low application rates of coal fly ash and sewage sludge on soil water and heavy metal distribution and balances in the rootzone along with crop responses under variable moisture regimes. Coal fly ash (26 & 52 Mg ha^{-1}), sewage sludge (6.5 & 13 Mg ha^{-1}) alone, and a mixture of ash-sludge in 2:1 proportions (26:13 & 13:6.5 Mg ha^{-1}) were incorporated in the top 15 cm soil during first and second experiments. In addition, plots with chemical fertilizer and control (untreated) were also considered for comparison. Experiments included plots under both uncropped and cropped conditions with similar treatments. The experimental crop was peanut (*Arachis hypogaea L.*), cultivar AK-12-24. Irrigations were scheduled at 15% and 50% maximum allowable depletion (MAD) of available soil water in the rootzone. All the treatments were replicated thrice. The water extractable concentrations of Cd, Cu, Ni, Pb, and Zn were determined in the profile soil samples along with their total concentrations in soil, fly ash, sludge and plant parts. VS2DI model was used to simulate the depth and time distribution of water and heavy metals under different treatments and schedules of irrigation while CROPGRO model was used for simulating soil water balance and peanut crop growth. The relative performance of the models for predicting soil water balance was also evaluated.

The results of the investigation revealed that application rates of fly ash and sewage sludge used in the present investigation could not significantly influence evapotranspiration and

deep percolation in lateritic soil. Irrigation scheduled at low volume high frequency resulted in higher deep percolation losses than high volume low frequency irrigation. Ground cover and irrigation schedule did not have significant effect on vertical distribution of total concentrations of heavy metals in the soil profile. Among the metals studied, Zn was the one that moved significantly below the top 15 cm soil layer, especially in the plots where sludge was added while movement of Cu and Pb was marginal. Mass balances showed low recoveries for all the metals in soil profile, indicating occurrence of some unexplained metal losses due to micropore leaching.

Plant water extraction by peanut was mostly limited to 0-45 cm of soil profile and hence, only top 45 cm soil profile should be targeted for scheduling of irrigation for peanut in sandy loam soils. The soil moisture depletion of 50% of available soil water in the rootzone of peanut during flowering and pod development stages caused considerable reduction in peanut yields. Therefore, in case of water scarcity, water stress may be maintained selectively during the non-critical stages of peanut growth so as to have water saving without affecting the yields. Application of coal ash at higher rates (52 Mg ha^{-1}) significantly increased peanut yield while sludge applications at 26 Mg ha^{-1} showed considerable yield reductions over the control. Elevated levels of Cd, Cu, Ni, Pb, and Zn were found in peanut grown on sludge treated plots. VS2DI and CROPGRO models reasonably predicted soil water distribution in the rootzone and total seasonal evapotranspiration, although both models underpredicted deep percolation. Performance of CROPGRO was in general, superior to that of VS2DI in predicting daily crop evapotranspiration. However, CROPGRO could not simulate effect of higher rates of sewage sludge application on peanut crop when sludge was considered input to the model through residue incorporation.

Keywords: coal fly ash; sewage sludge; heavy metal; peanut; irrigation scheduling; water balance; heavy metal mass balance; yield; plant uptake; VS2DI; CROPGRO