DRYING PROPERTIES OF CRACKING SOILS IN THE MUDA IRRIGATION SCHEME

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Introduction

Puddling of soils during land preparation for irrigated rice destroys aggregates and accentuates soil cracking upon drying. Soil cracking turns a clay soil into a varying heterogeneous two-phase medium: soil matrix and cracks. The extent and severity of cracking depends upon some soil physical parameters like type and amounts of clay, organic matter content and rapidity of moisture depletion from the soil. A mathematical relationship of these parameters with the shrinkage parameters (volumetric shrinkage, shrinkage geometry) would help predict soil cracking and deciding water management options. Bypass flows through the soil cracks greatly affect moisture conditions and availability during the growing season and post-season land preparation. The objective of the study was to understand the dynamics of drying, cracking and rewetting of three rice soils in the Muda Irrigation Scheme and to develop a simple model for estimating bypass flow.

Materials and Methods

Undisturbed soil samples were collected in 144.13 cm^3 ring with 5.1 cm height and 5.32 cm inner diameter from the puddled, hardpan and subsoil layers of the Chengai, Tebengau and Tualang soil series after the harvest of the main season rice crop to study soil drying, shrinkage and rewetting behaviours of these soils. The American Society for Testing and Materials D427 and D4943 methods for volumetric shrinkage were modified using sand, a non-toxic natural material, instead of mercury and wax, respectively. Shrinkage geometry was determined as proposed by Bronswijk (1990). The crack volume was studied in three 1x1 m^2 randomly selected plots for each soil series. X-Y grid lines spaced 20 cm apart were laid out in each plot to measure crack width and depth (Tuong et al. 1996). These field measurements were made at two weeks after the draining out of water (DOW) and repeated on alternate days until the 8^{th} day and finally at 8 weeks after DOW. Based on the shapes, rectangular, triangular and square root models were used to calculate the crack volume density (in cubic meter per hectare) for each soil series. A model was developed to calculate crack volume and quantify bypass flow during land soaking.

Results and Discussion

In the measurement of shrinkage volume, there was no significant difference between the mercury, wax and sand methods. Therefore, the sand method provides a useful alternative because it is environmentally friendly, less hazardous and more economical to use. The partitioning of total volume change into subsidence and cracking is characterised by the geometric factor, rs. Results showed that *rs* values of 3 for all layers except the subsoil of the Tualang series indicating isotropic soil shrinkage in the three soil series. The highest subsidence was observed in the subsoil and lowest in the topsoil layer for all three soil series. The differences were attributed to the amount of clay and organic matter content in the different layers. The highest calculated and measured crack volume was found in the Chengai and Tebengau soils and they were significantly different than those of the Tualang soils. This was again attributed to differences in mineralogy, amount of clay and organic matter content. Chengai and Tebengau are predominantly montmorillonitic clays while Tualang is dominated by kaolinitic clay. Isotropic soil shrinkage of these soils caused soil cracking whereby cracking dominates subsidence for all layers except for the subsoil of the Tualang series. Thus, all the three soils would show large crack volumes and this would have great implications on water management during land soaking. Relative to each other, Chengai and Tebengau soils would require more water to saturate than Tualang soils. Crack volumes were also computed using a simple model based on the shrinkage and other physical properties. These values were highly correlated with the measured values (R=0.97). The amount of water that bypassed the topsoil accounted for 59-67% of the total input water (260 mm) as calculated by the model for the three soils studied. Reducing water losses during land soaking may greatly increase the water use efficiency of irrigated rice production systems.

Conclusions

The extent and severity of cracking in the soils studied are related to mineralogical differences and organic matter content Proper management of crop residues need to be considered so as to inhibit severe soil drying and hence its cracking in order to minimise water requirement for subsequent land preparation.

References

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