Impacts of Perforated Sheet Pipe Installation on Some Soil Properties

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（シートパイプ敷設が土壌特性に及ぼす影響）

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論　文　内　容　の　要　旨

One of the possible solutions to increase agricultural production under climate change is improving water use efficiency (WUE). It can be achieved by saving water and increasing soil water storage. Modern irrigation and drainage technologies intend to promote WUE. Moreover, these practices provide some benefits of controlling water quality, reducing soil salinity, and conserving soil erosion. Recently, it is highlighted that the improvement of drainage is still required, and this can solve the future food demand strategically.

Agricultural drainage is to remove excess water from farmland, and to creates a better environment for crops. In agriculture, surface, subsurface drainage and combination of both ones are common field practices. Recently, it is expected that subsurface-shallow drainage can accelerate the ability of drainage. Besides, it enables us to prevent water logging in root zone, higher groundwater table, and soil salinity. Subsurface-shallow drain such as perforated sheet-pipe has been widely installed at rice paddy fields in Japan for about forty years.

Subsurface drainage enables to change physical, chemical and biological properties of soils due to water table fluctuation and above human induced practices including by different cropping, land use, soil, and water management. Under installation of sheet-pipe, it has not been clarified yet where drainage water passed through and why & how the sheet pipe function. And when do these impacts appear after installation? Hence, the assessment of effective management and performance on such a shallow drainage system in paddy fields is new and becomes essential.

The main objective of this study is to investigate the impacts of the sheet-pipe installation on changes in soil properties. Thus, we conducted three field experiments separately in different regions of Japan. To confirm the performance of the sheet-pipe, we set up the preliminary trials in Kagoshima, Japan. Then, the research was conducted in Oita to investigate the impacts of some soil characteristics changes and differences by the sheet-pipe for one rice cropping. Then, we continued to investigate the effects of the installed sheet-pipe on paddy soils for long-term in Fukuoka and Oita, Japan.

Some soil properties are expected to change and to be different under the sheet-pipe installation. To investigate these changes and some differences, we studied at Kunisaki, Oita. Two sets of soil samples were collected just after installation of sheet-pipe and after a rice cropping of the same field. Regarding the drainage stream sites along the sheet-pipe (upstream, midstream, downstream) at the field, distances from the sheet-pipe (0 m, 1 m, 2 m), and soil depths (10 cm, 25 cm, 45 cm), we studied changes and differences of some soil properties such as soil bulk density, organic matter content, saturated hydraulic conductivity (-log Ks), macro-pores, meso-pores, and plant-available water. During a rice cropping, we could not find significant impacts on some soil properties by the sheet-pipe except larger pores. We observed larger meso-pore portion at 0 m and 1 m distance from the sheet-pipe at deeper soil layers (both 25 cm and 45 cm depth). Although difference in macro-pores in this study was not so significant, the meso-pores supposed to lead to develop macro-pores and cracks.

To understand the long-term impacts of the sheet pipe on some paddy soils, we made a research at two places with different paddy soils and converted paddy soil. Using (3 × 3 × 2) factorial design with three replications, we collected soil samples on farmland at Hisayama, Fukuoka, and Usa, Oita, Japan. In this study, the ages of installed sheet-pipe in Hisayama and Usa were seven years and fifteen years, respectively. This design based on three-stream sites (upstream, midstream, and downstream of the fields), three distances from the sheet pipe (0 m =above, 1 m and 2 m), and two soil depths of 10 cm and 25 cm, respectively. We measured thirteen items of soil properties. As a result, there was some improvement in air-filled capacity and infiltration above the installed sheet pipe. Also, the soil bulk density near the sheet-pipe became smaller with a significant increase in soil organic matter, and soil aggregation. All these characters promoted formation of soil macro-pores in deeper soil layer. The increase in porosity, especially in these macro-pores of soils allowed more water and air to pass through. These macro-pores assumed as cracks generated by the installed sheet-pipe under long-terms.

In sum, a change in meso-pores near the sheet-pipe at the downstream site was observed as a prominent impact due to the installed pipe in short-term study. In long-term study, variations of soil hydraulic, physical properties, and chemical properties were noticeable. Improvements of soil bulk density, aggregation, organic matter, saturated hydraulic conductivity, and air-filled capacity are significant near the sheet-pipe (at 0 m distance and 25 cm soil depth). An increase in total soil pores especially with macro-pores contributed to an improvement of air-filled capacity and much water passing through.

Our study enlightens that an increase in meso-pores by short-term study and macro-pores by long-term study seem to be small cracks generated by the installed sheet-pipe. The development of such soil characteristics enhances to change in some hydrological, physical, and chemical properties of paddy soils.