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SUMMARY OF DOCTORAL THESIS

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Title: Water saving in irrigation by sand mulch on drip lines
（点滴灌漑施設の砂マルチによる灌漑水の節減）

Agriculture consumes about 70 % of the developed fresh water in the world. It is possible to reduce the amount of additional fresh water withdrawals by 40 % if water saving techniques are improved. As the water crisis continues to manifest itself, planners and policy makers will continue to be faced by gaps between supply and demand for water and ultimately food. There is, therefore the need to improve water saving techniques to ensure adequate food for future generations with same or less amount of water than the amount of water that is presently available for agriculture. Surface drip irrigation is the most effective way to supply water and nutrients to the plant and does not only save water but also increases yield of crops. However, irrigation water loss by soil evaporation is inevitable under surface drip irrigation. This study, therefore, attempted to reduce soil evaporation thus improving irrigation water saving through a combination of surface drip irrigation and sand mulch on drip lines. Sand soil was used since it is a readily available material, especially in the sand dune soil areas.

The following aspects were made clear in this study: 1) the quick development of a dry layer on a wet layer of the Tottori sand dune soil and the effect of the dry layer on soil evaporation reduction, 2) the effect of sand mulch on drip lines on the water content of soil, 3) the effect of sand mulch on drip lines on water recharge in the root zone, and 4) estimation of soil evaporation by soil hydraulic factor under sand mulch on drip lines.

The quick development of a dry layer of the Tottori sand dune soil was studied to identify its suitability as a self-mulching material to reduce soil evaporation. Enough water was applied to the sand soil and that was naturally dried. The sand soil quickly dried and formed a dry layer near the surface that covered the lower wet layer. The effect of a dry surface layer on soil evaporation was also studied. Sand soil columns were covered with a 2 cm and 5 cm thickness of dry sand soil. The 5 cm thickness was more effective than the 2 cm with soil evaporation reduction of more than 72 %, compared to a sand soil column with no cover.

To evaluate the effect of sand mulch on drip lines on water content of soil, 0 cm thickness and 5 cm thickness sand soil on drip lines, and three plant densities of 0 plants/m^2, 12 plants/m^2 and 21 plants/m^2 were used. Almost the same amount of irrigation water was applied to the treatments. The 5 cm sand mulch on drip lines maintained higher water content of soil than the 0 cm sand mulch. The higher water content of soil under 5 cm sand mulch on drip lines resulted in higher plant height and higher dry matter yield.

To evaluate the effect of Tottori sand dune soil on water recharge in root zone, two irrigation levels of 60 % and 100 % of evapotranspiration, and three sand mulches of 0 cm thickness, 2 cm thickness and 5 cm thickness were used. Water recharge in the root zone under 5 cm sand mulch was the highest of the three sand mulches. The 2 cm sand mulch was not practical because of the protrusion of the drip lines from the sand mulch.

To increase water recharge in the root zone, the minimum thickness of sand mulch on the drip lines was 5 cm.

Estimation or measurement of soil evaporation is important for quantifying water saving in irrigation. To derive a soil hydraulic factor, potential soil evaporation was estimated from small evaporation pans and actual soil evaporation was measured from sand soil columns under 0 cm sand mulch, 2 cm sand mulch and 5 cm sand mulch. Actual soil evaporation from field condition was measured by weighing lysimeters, and actual soil evaporation was compared with soil evaporation estimated by the soil hydraulic factor. The soil hydraulic factor gave better estimates of cumulative soil evaporation under 0 cm and 2 cm sand mulch than that of 5 cm sand mulch.

The quick development of a dry layer on the sand soil surface makes it a suitable self-mulching material. Sand mulch reduces soil evaporation, thus sand mulch can be used to increase water saving in irrigation. The sand mulch on drip lines can maintain a high water content of soil, and increase water recharge in the root zone. Maintaining a high water content of soil and increasing water recharge in the root zone results in saving water in irrigation. Estimation of soil evaporation using the soil hydraulic factor becomes more difficult as the sand mulch thickness increases. Covering drip lines using 5 cm sand mulch is practical in a normal farming operation. No special machine is necessary to cover the drip lines by 5 cm of the sand soil. It is easy to remove the drip lines after the growing season or harvesting. The combination of surface drip irrigation and sand mulch is effective in saving more water in irrigation than only surface drip irrigation.