学位論文要旨
Abstract of Thesis

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題目 Title	Modeling of the optimized subsurface irrigation system (OPSIS) with APSIM-Sugar and assessing the applicability of OPSIS to Sri Lankan conditions 地下灌漑システム OPSIS の APSIM-Sugar を用いたモデルかと OPSIS のスリランカへの適用性の検討

Climate change threatens the sustainability of most rainfed sugarcane farming systems. Hence, rainfed sugarcane farming systems are gradually being replaced by irrigated farming systems wherever such transition is possible. Also, low-efficiency irrigation systems are being replaced by high-efficiency systems to make sugarcane farming more economically sustainable. However, irrigation is one of the most expensive practices of sugarcane farming systems; the dimensions of sugarcane irrigation systems need to be adjusted for water conservation while simultaneously reducing operational costs.

The optimized subsurface irrigation system (OPSIS) is a subsurface irrigation system for irrigating the root zone of upland crops by capillarity. In design, OPSIS can significantly reduce percolation losses, which are common problems in other subsurface irrigation systems. Because a small solar-powered pump is used to lift water and create a pressure head and because minimum operational activities are required, OPSIS offers the potential to lower the operational costs of irrigation for sugarcane farmers drastically.

Agricultural Production Systems sIMulator (APSIM) is widely using crop model with numerous uses, including the evaluation of different irrigation management practices. However, developing simulation capabilities of crop models aligned to modern technologies is vital to get the maximum benefit for the development of crops and new management strategies. In such, proper parameterization, calibration, and validation are essential in achieving the success of simulations using crop models.

This study aimed to develop OPSIS as a user-friendly, economically viable, and environmental sound irrigation method for upland farmers worldwide. Specifically, this study aimed to, 1) to introduce and scientifically validate the optimized subsurface irrigation system (OPSIS); 2) to enhance modeling capability of Agricultural Production Systems sIMulator (APSIM) to use with OPSIS; 3) to study the applicability of OPSIS for tropical environments.

We conducted field experiments representing all planting conditions (spring and summer planting, main and ratoon crops) to compare the performances of OPSIS over

sprinkler irrigation. This study showed that OPSIS offers advantages over sprinkler irrigation for sugarcane cultivation in Okinawa in respect of both sugarcane yield and WUE. Compared with sprinkler irrigation, OPSIS produced significantly taller plants, and thus significantly longer millable stalks, and significantly more millable stalks. Therefore, OPSIS achieved significantly higher fresh cane weight using less irrigation water than did sprinkler irrigation. OPSIS is a water-conserving irrigation technique that can irrigate sugarcane crops with minimal operational cost, energy consumption, and human intervention. Therefore, it may be a sustainable alternative for sugarcane crop irrigation in Okinawa and similar subtropical environments.

We parameterized and calibrated the APSIM-Sugar model to simulate growth and yield of sugarcane cultivar Ni21 under Okinawan conditions, then, validated the APSIM to use with OPSIS. We developed APSIM-OPSIS module to couple OPSIS with APSIM engine. Simulated plant height and fresh cane yield showed good agreement with the observations. However, APSIM showed overestimation for soil water content in upper soil layers and irrigation water use of OPSIS. Hence, it is concluded that the newly developed APSIM-OPSIS module can successfully be used to simulate the crop growth and yield of sugarcane with optimized subsurface irrigation system.

We parameterized and calibrated the APSIM-Sugar model to simulate growth and yield of Sri Lankan local sugarcane cultivar SL96128. Then we simulated the growth and yield of sugarcane under rainfed, surface irrigated, and OPSIS irrigated conditions for two locations in Sri Lanka with distinct soils. Results revealed that in both soils, OPSIS performed better than the rainfed and surface irrigation. However, the performance of OPSIS is remarkable with clay loam soil. Hence, it is concluded that the OPSIS can significantly increase the crop growth and sugarcane under Sri Lankan conditions, especially in the places with clayey soils. Even in future climates, APSIM may perform better than the surface irrigation and rainfed conditions. The design modification may require achieving expected performances of OPSIS under sandy soil conditions.