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Automatic regulator for channel flow control on flooded rice

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Abstract

The low efficiency water control provided by sluice gates and weirs used in the flooded rice tillage system in Rio Grande do Sul, Brazil, have caused significant water losses. Such devices are utilized to control the water flow from the main to the secondary channels. The water flow through the gates is highly influenced by the water depth fluctuation in the main channel. The purpose of this work was to construct and evaluate a flow regulator to reduce flow variations in the secondary channels, resulting from water level fluctuation in the main channels. The prototype operates with a float that prevents the water head variation over the water passage orifices. The regulator flow control was compared to the sluice gate flow control. Both structures were installed at a lateral inlet, and the depth of water in the main channel ranged from 70 to 90 cm. The flows from the regulator and sluice gate were measured with ''H'' flumes. To relate the flow provided by the regulator to the water head over the water passage orifices, the regulator was submitted to six different water heads, ranging from 5 to 30 cm. The comparison between the structures showed that both presented variation in the controlled flow. However, the flow control provided by the automatic flow regulator was more effective than that provided by the sluice gate. The controlled flow variation was 5.5% for the automatic flow regulator, and 23.7% for the sluice gate. Regulator

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flow analysis for the different water heads showed that it can operate with flows ranging from 24 to 49 L s^{-1}. Comparing the sluice gate to the automatic flow regulator, the latter is a more efficient flow control device, reducing the waste of water.

Keywords: Water division; Sluice gate; Water control; Channel automation

1. Introduction

Approximately 15% of all cultivated lands in the world are irrigated. However, food production from irrigated areas contributes with almost half the total crop production in terms of value. By 1995, the irrigated area worldwide was 254 million ha, with the expectation of increasing to 330 million ha by 2025. Nevertheless, the proportion of water used for agriculture will decrease in the future mainly due to growing water demand for industrial and public purposes (Shiklomanov, 1998).

Rice is the most widely grown irrigated crop, occupying one-third of the world's total cereal planted area. About 75% of the global rice volume is produced in irrigated lowlands. Decreasing water availability for agriculture threatens the productivity of the irrigated rice ecosystem and alternatives must be created to save water and increase water productivity in rice fields (Guerra et al., 1998; Maclean et al., 2002).

Rio Grande do Sul is the state in Brazil with the largest area of irrigated lands. This is mainly due to the fact that rice is grown under flooded conditions (Righes, 2000). For the major crop management systems, the recommended amount of water needed to meet crop demand ranges from 1.5 to 2.0 L s^{-1} ha^{-1}, for an irrigation period ranging from 80 to 100 days (Instituto Riograndense do Arroz, 2001). Thus, for a water consumption of 1.75 L s^{-1} ha^{-1} for a period of 80 days, about 12,000 m^3 ha^{-1} of water is needed, i.e., a 1200 mm depth.

Southern Rio Grande do Sul is one of the major rice producing regions. Water is delivered in unlined channels. Several factors limit water delivery and decrease water use efficiency. One of these factors is the low efficiency control provided by the water control devices currently used: most manually regulated sluice gates and weirs. These devices do not maintain constant flow when the upstream water level changes, resulting in alternating periods of deficit and excess water delivery to the field.

About 71% of the farmers in the region pump water using electric engines (Instituto Riograndense do Arroz, 2002). Farmers do not operate the pumps between 18:00 h and 21:00 h, when the cost of electricity is greater than at other times. This stoppage reduces the water depth in the main channels. When the pumps are turned on again, an additional flow is required to rapidly elevate the water level. However, there is a delay before the water level in the channels stabilizes, because they are very long, reaching several kilometers in length. Nevertheless, at the head end, the water level exceeds the desired depth, resulting in greater water flow through the gates, and potential waste of water.

The utilization of electromechanical gates to control flow in the channels would prevent water waste and facilitate water management. According to García (1999), the