OPTIMIZING WATER USE EFFICIENCY IN FLOOD IRRIGATION SYSTEMS IN UGANDA: A CASE OF DOHO RICE IRRIGATION SCHEME (DRIS) #9423

Patrick Onen, Emmanuel Opolot, Gorreti Aguttu and Giregon Olupot
Department of Agricultural Production, College of Agricultural and Environmental Sciences, Makerere University, Kampala-Uganda
e-mail: emmanuel.opolot@mak.ac.ug; tel: 256779624011

ABSTRACT

There is growing demand for water across different sectors of production. Yet the extent of water wastage to furnish inefficient irrigation systems especially in flood irrigated rice systems, is not known. In developing countries and in Uganda in particular, most irrigation scheduling in the irrigation schemes is based on rotational system of water access rather than crop water needs. In Doho Rice Irrigation Scheme (DRIS) in eastern Uganda for example, farmers' plots receive up to 50mm ponding of irrigation water for three days in a week for four months which translates to about 2,400mm of water applied way above average rice water requirements of 700 mm in a season. Too much water not only compromises nutrient use efficiency but has also been associated with a wide spread of water snail, a pest that eats up the young rice seedlings and transmits bilharzia. Though System of Rice Intensification (SRI) has been found to not only reduce greenhouse gas emissions, water and nutrient wastage but also increase rice yields, its benefits in flooded rice systems in Uganda have not fully been explored. The overall objective of this study was to optimize water and nutrient use efficiencies under the system of rice intensification (SRI) in flood irrigated systems in Uganda. The specific objectives were (i) establish the minimum flooding depth for optimal water use efficiencies and grain yields (ii) determine the effect of spacing and plant population on rice growth parameters, grain yield and water use efficiency and water use efficiency. Field experiments were established for two seasons (December 2021– March 2022 and May - September 2022) in DRIS in eastern Uganda. The main treatments included four flooding depths (0mm / Field Capacity, 10 mm, 20mm and 40mm) and within each flooding depths were split plots that included (i) the number of seedlings per hill (1 or 3) and (ii) two plant spacings (20 cm x 20cm or 25 cm x 25 cm). Crop parameters measured included plant height, number of leaves, number of tillers, number of panicles, above ground biomass, root biomass and grain yield. Our preliminary analysis of results indicates no significant differences in biomass and grain yields among the four flooding depths. Planting one seedling per hill at a spacing of 25 cm x 25 cm led to a higher number of tillers, panicles and consequently biomass and grain yields. We conclude that ponding of up to 10 mm of water every three days and planting of 1 seedling per hole at a spacing 25 cm x 25 cm leads to optimum water use efficiency and increased rice grain yields this was selected as the plant looks vigorous without undergoing water stress as observed in the field.

INTRODUCTION

Water resources are continuously under immense pressure from all sectors of production and in the phase of climate change, optimizing the use of this important resource cannot be over emphasized. Water use efficiencies in flooded irrigation systems, especially in developing countries remain very low (<50%) and the question of how much water is needed to produce rice in a season remains unanswered. In Doho Rice Irrigation Scheme (DRIS) for example, farmers flood their fields to a depth of 50 mm of water, every three days in a week translating into 2,400mm of water used in a rice season. This amount of water is way above the estimated rice crop water requirement of 700mm in a season (Koffi Djaman et al, 2016).

Direct implications of excessive water use include reduced crop yields, reduced nutrient use efficiencies, conflicts, waterborne diseases, degradation, and reduced ecosystem services. Thus, there should be deliberate efforts to promote practices that help to reduce water use, nutrient losses and pollution of aquatic life yet enhance yields.

There is sufficient literature that System of Rice Intensification (SRI) leads to optimal water and nutrient use, reduced greenhouse gas emissions and increased yields (Sato and Uphoff, 2007; Sinha and Talati, 2007). The System of Rice Intensification (SRI), developed in Madagascar in the 1980s, has proved to be one of the most important recent agricultural innovations which is being adopted across farmers' fields around the globe (Sinha and Talati 2007). It modifies conventional practices of paddy cultivation by managing plant, water, soil, and nutrients in more effective ways, which increase the productivity of available land, labor, water, and energy and improve food security for vulnerable farming communities. Studies in some countries have shown a significant increase in rice yield, with substantial savings of seed (80-90%), water (25-50%), and cost (10-20%) compared to conventional methods (Lhendup, 2008).

One way to reduce N loss through leaching and washing away from rice fields might be to practice alternate wetting and drying (AWD) forms of irrigation, maintaining a shallow water depth with intermittent drying rather than continuous flooding (Thakur et al., 2013). Reliance on organic sources of nutrients as opposed to inorganic sources is one of the principles under SRI, seeking to enhance soil structure and functioning as well as soil microbial abundance and activity. However, this practice is not known and not yet adopted to rice farmers in Uganda. The overall objective of this study was therefore to optimize water and Nitrogen Use Efficiencies under SRI in paddy rice systems in Uganda. Specifically, the study sought to (i) establish the minimum flooding depth for optimal grain yields and water use efficiency and (ii) assess the effect of spacing and seedling rate on water use efficiency.

MATERIALS AND METHODS

In order to achieve these objectives, we implemented the following key activities; Matching supply with requirements in increasing WUE under the System of Rice Intensification (SRI): Transplanting seedlings at 14Days After Emergencies (DAE) vs >30days (farmers' practice); use of organic fertilizer, alternate wetting and drying and wider spacing (25 cm x 25 cm one seedling) vs farmers' 20cm x 20 (>3) (Laulani´e, 1993; Katambara *et al*., 2013). Field experiments were established for two seasons (December 2021– March 2022 and May - September 2022) in DRIS in eastern Uganda. The experimental design was a randomized complete block design with split plot (RCBD-split plots), where ponding depth was a main treatment while spacing and seedling rate were split plots. Four levels of ponding depth included: FC (0 mm), 10 mm, 20 mm and 40 mm while plant spacing and seedling rate were both at two levels of 20 X 20 and 25 X 25, 1 seedling per hole and 3 seedlings per hole respectively.

Key practices implemented include: (i) use of soil moisture sensors (tensiometers) only in field capacity plots, (ii) transplanting seedling 14 DAE vs 30 DAE (iii) Incorporating rice straws + Municipal Solid Waste Compost (MSWC) in the soil, (iv) planting 1 seedling per hole vs >3 and (v) water management trials.

RESULTS AND DISCUSSION

Water use efficiency was defined as grain yield divided by water used. As per results, there was a general decrease in the water use efficiency with the increase in the amount of water use under different treatment and also as the season changes there is a general improvement in the water use efficiency as a results of soil ammendment that is use of organic fertilisers from the municipal solid waste (Fig. 1).

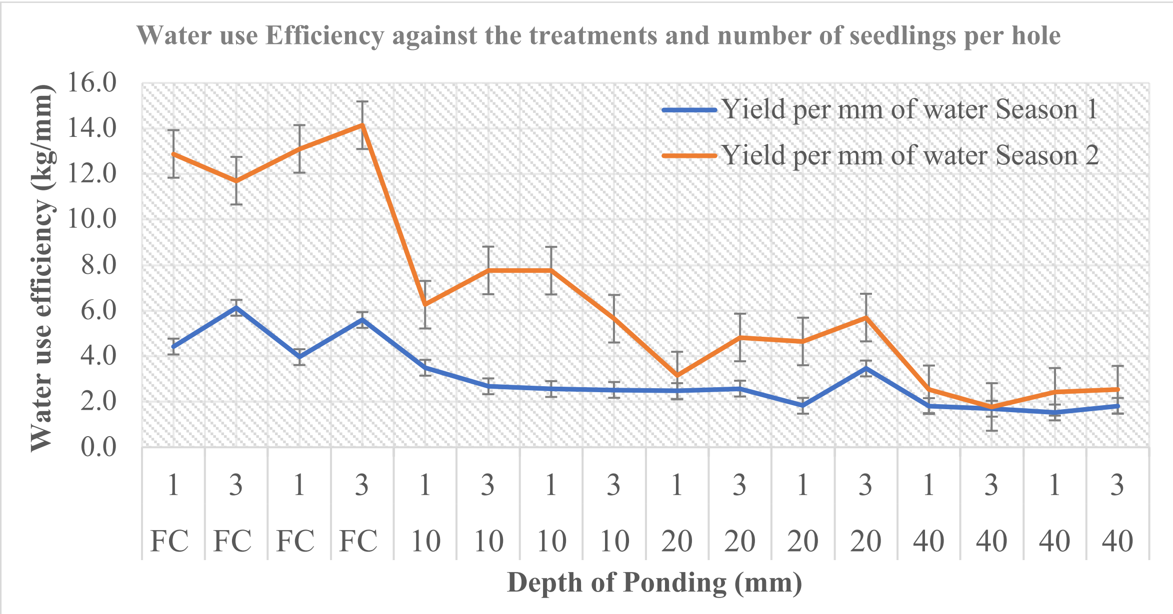

Fig. 2. Water use efficiency across contrasting flooding depths and number of seedlings per hole in Doho Rice Irrigation Scheme as of December 2021 – September 2022.

As observed in the water use efficiency graph, there is better water use efficiency as we reduce the quantity of water use hence the best water use efficiency for both the two season were recorded under field capacity treatment 6.1 and 14.1 kg/mm of water used for season one and two respectively. This is in-line with the study conducted by Limei *et al* in 2011 under minimum watering regimes with the best results. However, we recommend 10mm depth of ponding which does not allow the paddy rice to show signs of water stress.

There was no significant difference in term of biomass yield and grain yield between one seedling per hole and three as this was attributed to compensation through increased tillering, number panicles and grain yield. This could also translate into savings in terms of seeds, better yield under one seedling per hole and best use efficiencies (Fig. 1).

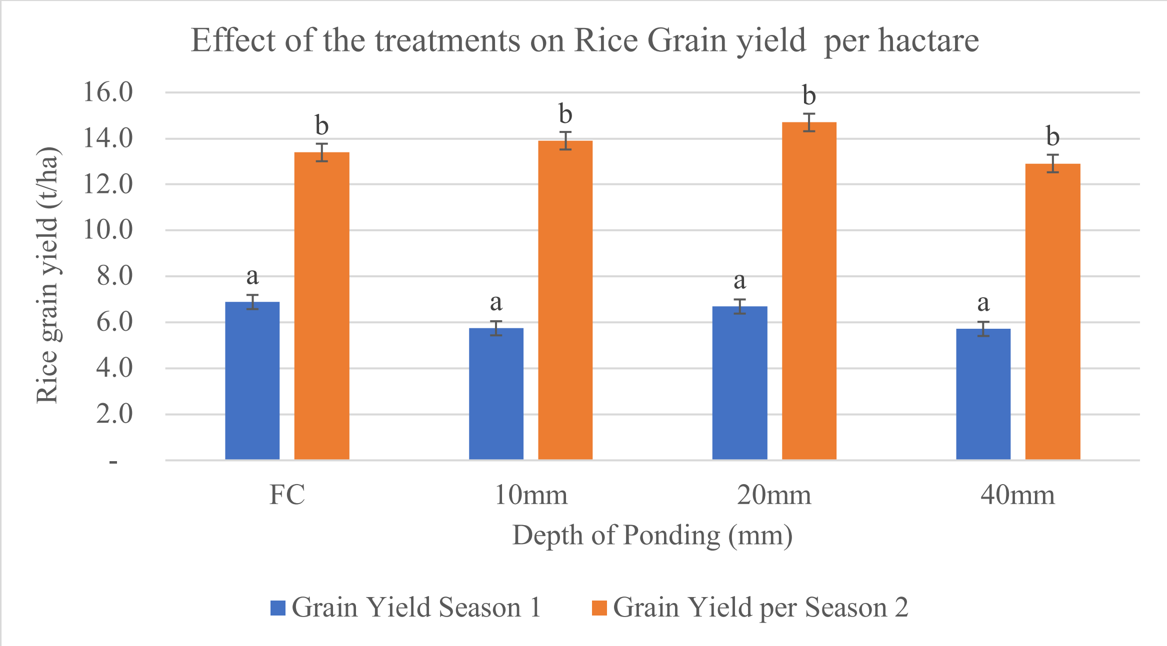

Fig. 3. Grain yields across the water regimes / treatments in Doho Rice Irrigation Scheme as of December 2021 – September 2022.

The general trend of yield increase in season two is attributed to continued good practices of Systems of Rice Intensification (SRI); planting young seedlings of 14 days, wider spacing, in cooperating the rice straws as organic fertilizers, user of organic fertilizer from municipal solid waste which act as soil amendment hence and slowly releases its nutrients hence the cumulated effect being observed in second season's yield. This agrees with the findings from Anitha and Chellappan (2011) giving the optimal yield under the SRI recommendations.

Better yield recorded under FC (field capacity) treatment in season one, this could be attributed to increased decomposition of the organic fertilizer as the soil is well drained hence improving the work of soil microbes.

The good performance under the field capacity has greatly indicated that we can save a lot of water that can bring more land under production, use for ecological services, and also prevent leaching, and washing away of the nutrients in the tail water from the irrigation field.

REFERENCES

De Laulanié, H. 1993. Le système de riziculture intensive malgache. Tropicultura 11(3), 110-114.

Sinha, S.K., Talati, J. 2007. Productivity impacts of the system of rice intensification (SRI): A case study in West Bengal, India. Agricultural Water Management 87(1), 55-60.

Stoop, W.A., Uphoff, N., Kassam, A. 2002. A review of agricultural research issues raised by the system of rice intensification (SRI) from Madagascar: opportunities for improving farming systems for resource-poor farmers. Agricultural Systems 71(3), 249-274.

Thakur, A.K., Rath, S., Mandal, K.G. 2013. Differential responses of system of rice intensification (SRI) and conventional flooded-rice management methods to applications of nitrogen fertilizer. Plant and Soil 370(1), 59-71.

Mishra, A., Salokhe, V.M. 2008. Seedling characteristics and the early growth of transplanted rice under different water regimes. Experimental Agriculture 44(3), 365-383.

Djaman, K., Mel, V.C., Bado, B.V., Manneh, B., Diop, L., Mutiibwa, D., ... Futakuchi, K. 2017. Evapotranspiration, irrigation water requirement, and water productivity of rice

(Oryza sativa L.) in the Sahelian environment. Paddy and Water Environment 15(3), 469-482

Evans, R.G., Sadler, E.J. 2008. Methods and technologies to improve efficiency of water use. Water Resources Research 44(7).

Ge, T., Sui, F., Bai, L., Tong, C., Sun, N. 2012. Effects of water stress on growth, biomass partitioning, and water-use efficiency in summer maize (Zea mays L.) throughout the growth cycle. Acta Physiologiae Plantarum 34(3), 1043-1053.