Effect of Crop Establishment Method and Irrigation Schedule on Productivity and Water Use of Rice

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SUB CRUCE LUMEN

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ABSTRACT

Management strategies that reduce ground water depletion and labour requirement, while maintaining yield are urgently needed in north-west India where ground water table is declining at an alarming rate. Dry seeded rice (DSR) has been proposed as one means of achieving these objectives, but optimal water management for DSR is not well understood. Therefore field experiments were conducted to investigate the effects of irrigation scheduling on water balance and land and water productivity of DSR relative to the current practice of puddle transplanted rice (PTR). The irrigation scheduling was based on soil water tension (SWT) ranging from continuous flooding (CF)/daily irrigation to alternate wetting and drying (AWD) at SWT thresholds of 20, 40 and 70 kPa. Data from the field experiments were used to parameterise and evaluate the ORYZA2000 rice crop model which was then used to evaluate establishment method x water management practices.

Grain yield of DSR and PTR was similar (6.6-7.4 t ha^{-1}) when irrigation was scheduled daily or at 20 kPa. Yield of both PTR and DSR declined under higher water deficit stress (40 and 70 kPa irrigation thresholds), but to a greater extent in DSR, and more so in the drier year possibly due to severe iron deficiency. There was a large reduction (47-82%) in irrigation water input with irrigation at 20 kPa compared to daily irrigation in both crop establishment methods. Irrigation water use in DSR-AWD treatments was significantly lower than in respective PTR treatments (e.g. by 33–53% when irrigation was scheduled at 20 kPa). Maximum irrigation water productivity (WP_I) was obtained with 20 kPa SWT threshold, and was much higher for DSR (1.46 g kg^{-1}) than PTR (0.85 g kg^{-1}). Water productivity with respect to ET (WP_{ET}) was also highest with the 20 kPa threshold, with similar values (1.18 g kg^{-1}) for DSR and PTR. In both establishment methods, regardless of irrigation threshold, water saving was mainly due to reduced deep drainage, seepage and runoff.

ORYZA2000 predicted crop growth and yield well for CF and the 20 kPa irrigation threshold for both crop establishment methods, but predictions were sub-optimal for some parameters for PTR at higher irrigation thresholds. Model performance was unsatisfactory for DSR at thresholds >20 kPa, at least partly because of iron deficiency, which is not simulated by ORYZA2000. Based on the weather data for 40 rice seasons, the predicted yields for DSR were slightly higher than under PTR, and yield declined gradually but similarly for both establishment systems as irrigation threshold increased. As in the field experiments, there was a large reduction in irrigation input through changing from CF to AWD, primarily due to less deep drainage, and a small reduction in ET. Additional irrigation at panicle initiation and flowering reduced the yield penalty under AWD but did not eliminate it completely.

Both the field and modelling studies suggest that DSR can be grown with comparable yield to PTR, and with lower irrigation input, provided that AWD water management with a low irrigation threshold (10-20 kPa) is used.

DECLARATION

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Sudhir Yadav and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

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ACRONYMS

ANOVA	Analysis of variance
AWD	Alternate wetting and drying
CF	Continuous flooding
DAS	Days after sowing
DAT	Days after transplanting
DOY	Days of year
DSR	Dry seeded rice
EM	Establishment method
ET	Evapotranspiration
FL	Flowering
FSE	FORTRAN simulation environment
GHG	Greenhouse gases
GY	Grain yield
I	irrigation
IGP	Indo-Gangetic Plains
IS	Irrigation schedule
LAI	Leaf area index
LSD	least significant difference
P	Percolation
PAU	Punjab Agricultural University
PI	Panicle initiation
PTR	Puddled transplanted rice
R	Rainfall
S	Seepage
SAHEL	Soils in semi-Arid Habitats that Easily Leach
SARP	Simulation and Systems Analysis for Rice Production
SAWAH	Simulation Algorithm for Water flow in Aquic Habitats

SRI	System of rice intensification
STTIME	Start time
SWC	Soil water content
SWT	Soil water tension
WP_{ET}	Evapotranspiration based water productivity
WP_{I}	Irrigation water productivity
WP_{I+R}	Input water productivity