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

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A thesis by prior publications submitted to The University of Adelaide, South Australia
In the fulfilment of the degree of DOCTOR OF PHILOSOPHY

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THE UNIVERSITY of ADELAIDE
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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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Sudhir Yadav......................................   Date..................................................
PUBLICATIONS ARISING FROM THIS THESIS


ACKNOWLEDGEMENT

At the very outset, with folded hands, I bow my head to the ‘Almighty’ Lord, whose grace glory and blessing gave me the courage in odd critical times for the successful completion of this degree.

First of all I put on record my deepest gratitude to my esteemed principal supervisor Dr Gurjeet Gill for his competent guidance, meticulous suggestions, constructive criticism which had enabled me to complete my research and degree successfully. No appropriate words could be traced in the present lexicon to convey my sublime obeisance to my supervisor Dr Elizabeth Humphreys whose unfold support, persistent inspiration and emotional attachment always catalysed my efforts. Her vast and deep knowledge of the subject, sense of dedication and above all, her parental nature throughout the tenure of this research, will be a part of memory forever. Words are too less to express by heartiest feelings to my supervisor Dr. S.S.Kukal whose support and encouragement helped me to develop interest in the research field. I couldn’t imagine completing my field experiments without his professional and personal support.

I feel privileged to express my gratitude to U.S.Walia for his support during field experimentation. Many thanks to Dr R. Rangarajan and his team to providing instruments and enriched my experiment methodology with ‘Tritium tagging’ technique. I acknowledge the support of Dr K.K.Vashist and Dr S.K.Jaltoa for landing instruments for my field experimentation. Invaluable help rendered by Sandeep Singh, Sarbjeet and Hardeep Kumar during field experimentation is duly acknowledged.

I am also thankful to my friends Vicky, Kishan and Naveen Gupta for their invaluable help during my field experimentation. I duly acknowledge Dhamija and Pandher family for their personal support throughout my stay in India during field experimentation.
I wish to express my profound thanks to International Rice Research Institute (IRRI), Philippines for a very productive collaboration during my research tenure. Especial thanks to Dr. B.A.M Bouman for making arrangement to access ORYZA model and for his constant support and guidance during my research. Many thanks to Dr. A. Boling for her assistance in basic training of ORYZA. I couldn’t imagine to complete crop modelling part of my research without the support provided by Dr Tao Li. He not only helps me to run the model but also enabling me to understand the complexity of the model. His prompt action to modify the model as per my need would always be appreciated.

I would like to acknowledge the financial support from Australian Centre for International Agriculture Research (ACIAR) in the form of John Allwright Fellowship. I would like to thank Niranjala Seimon and Sharon Harvey for academic help. I also would like to acknowledge the financial, academic and technical support of University of Adelaide and its staff.

I would also like to acknowledge all my friends in Adelaide (Raj Setia, M.S.Mavi, Prem-Suman, Shankar, Paras, Hasim) for their personal and professional support during my PhD tenure.

Finally and most sincerely, I wish to deeply thanks to my family who through their blessing, support and love gave me strength to continue my work. I fumble for words to thank my better half Seema for her love, emotional support and persistent inspiration for my work.

All may not be mentioned but none is forgotten.
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ANOVA</td>
<td>Analysis of variance</td>
</tr>
<tr>
<td>AWD</td>
<td>Alternate wetting and drying</td>
</tr>
<tr>
<td>CF</td>
<td>Continuous flooding</td>
</tr>
<tr>
<td>DAS</td>
<td>Days after sowing</td>
</tr>
<tr>
<td>DAT</td>
<td>Days after transplanting</td>
</tr>
<tr>
<td>DOY</td>
<td>Days of year</td>
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<tr>
<td>DSR</td>
<td>Dry seeded rice</td>
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<tr>
<td>EM</td>
<td>Establishment method</td>
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<tr>
<td>ET</td>
<td>Evapotranspiration</td>
</tr>
<tr>
<td>FL</td>
<td>Flowering</td>
</tr>
<tr>
<td>FSE</td>
<td>FORTRAN simulation environment</td>
</tr>
<tr>
<td>GHG</td>
<td>Greenhouse gases</td>
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<tr>
<td>GY</td>
<td>Grain yield</td>
</tr>
<tr>
<td>I</td>
<td>irrigation</td>
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<tr>
<td>IGP</td>
<td>Indo-Gangetic Plains</td>
</tr>
<tr>
<td>IS</td>
<td>Irrigation schedule</td>
</tr>
<tr>
<td>LAI</td>
<td>Leaf area index</td>
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<tr>
<td>LSD</td>
<td>least significant difference</td>
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<tr>
<td>P</td>
<td>Percolation</td>
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<td>PAU</td>
<td>Punjab Agricultural University</td>
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<tr>
<td>PI</td>
<td>Panicle initiation</td>
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<tr>
<td>PTR</td>
<td>Puddled transplanted rice</td>
</tr>
<tr>
<td>R</td>
<td>Rainfall</td>
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<tr>
<td>S</td>
<td>Seepage</td>
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<td>SAHEL</td>
<td>Soils in semi-Arid Habitats that Easily Leach</td>
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<td>SARP</td>
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<tr>
<td>SAWAH</td>
<td>Simulation Algorithm for Water flow in Aquic Habitats</td>
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</tbody>
</table>
SRI  System of rice intensification
STTIME  Start time
SWC  Soil water content
SWT  Soil water tension
$W_{P_{ET}}$  Evapotranspiration based water productivity
$W_{P_{I}}$  Irrigation water productivity
$W_{P_{I+R}}$  Input water productivity