Cooperative Research Centre for Sustainable Rice Production

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Program 1: Sustainability of Natural Resources in Rice-Based Cropping Systems

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SIMULATION OF YIELD AND ENVIRONMENTAL IMPACTS OF WHEAT AFTER RICE IN BANGLADESH AND AUSTRALIA

J. Timsina [1], E. Humphreys [2], D. J. Smith[2], D. Godwin[2], M. A. Quayyum[3], and D. J. Connor[1]
[1]Institute of Land and Food Resources, University of Melbourne, Parkville-3052, Victoria
[2]CSIRO Land and Water, PMB 3, Griffith, NSW-2680
[3]Bangladesh Agriculture Research Institute, Joydebpur, Bangladesh

ABSTRACT

CERES-wheat and SWAGMAN® Destiny models, respectively, were used to estimate the optimum time of sowing, and trade-off between yield and net recharge of the watertable, for wheat grown after rice in northern Bangladesh and southern NSW, Australia. Simulated wheat yields in Bangladesh, for sowings from Sept to Jan, with two supplemental irrigations, ranged from 0.4 to 4.6 t/ha. November-sown crops yielded more than the earlier- or later-sown crops due to reduced water and heat stress during grain filling. In Australia, simulated yields of non-irrigated wheat were always greater for April than June sowings due to less water deficit at the end of the season. With an initial shallow (0.5 m), fresh (1 dS/m) watertable, simulated yields usually exceeded 3 t/ha, and declined as watertable salinity increased. Non-irrigated wheat almost always lowered the watertable. Frequent irrigation increased simulated yields to 5-6 t/ha, regardless of initial conditions and sowing date, but this was at the cost of decreased discharge or increased recharge leading to rising watertables.

KEY WORDS:

Irrigation, CERES wheat, SWAGMAN® Destiny, Watertable, Salinity, Bangladesh

INTRODUCTION

In Bangladesh, wheat is sown after wet-season rice, using stored soil water plus supplemental irrigation on relatively permeable soils, on about 0.8 Mha, or 80% of the total wheat area, in regions where winter temperatures are relatively low. Grain yields are often small, especially when sowing is delayed, due to water deficit and heat stress during the reproductive stage. In southern NSW, Australia, about 20% of farmers regularly sow wheat immediately after rice. The number of irrigations ranges from zero (about 20% of farmers) to three (very few). The objective of this paper is to demonstrate the application of simulation models to estimate the optimum sowing date of wheat for northern Bangladesh and the trade-off between yield and watertables for southern NSW, Australia

MATERIALS AND METHODS

The CERES-wheat model (1) was used to estimate the optimum time of sowing of wheat after rice at Nashipur in northern Bangladesh, and the SWAGMAN® Destiny model (2) was used to examine the trade-off between yield and net recharge of the watertable for wheat after rice at Griffith, NSW, Australia. The models were calibrated and validated against independent data sets prior to running the simulations. At Nashipur, the effect of sowing date, ranging from 1 Sept to 1 Jan, on the yield of cv. Kanchan was investigated, on a sandy loam soil, with low initial soil mineral N and a full profile of extractable water. The crops were supplied with 50 kg N/ha at panicle initiation and a total of 200 mm in 2 irrigations during grain filling. At Griffith, wheat cv. Janz was sown early (24 Apr) and late (29 June) on a Mundiwa clay loam soil with deep drainage of 0.1 mm/d. The model was run for initial watertable depths (WTD) of 0.5, 1 and 1.5 m, watertable salinities of 1 and 20 dS/m, and with wet or intermediate starting soil water contents (SWCs) (wet = drained upper limit (DUL) throughout profile; intermediate = average of DUL and lower limit to 1.5 m depth, then DUL below 1.5 m). Early and late sowings were compared for crops grown with or without irrigation. Irrigation was applied when cumulative ET reached 60 mm, using 100% irrigation efficiency, with irrigation water salinity of 0.2 dS/m. Ten years of local daily weather data were used for all simulations.

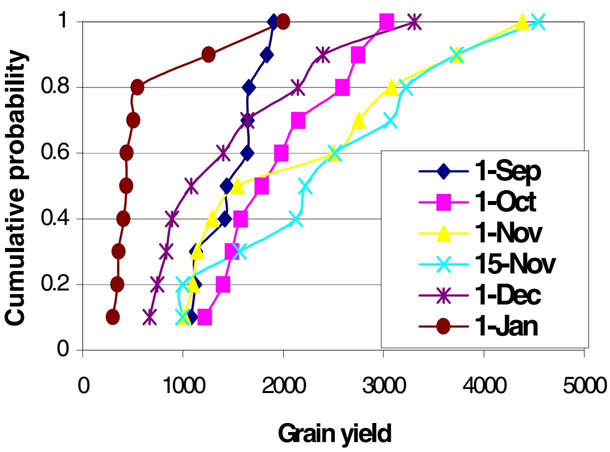
RESULTS AND DISCUSSION

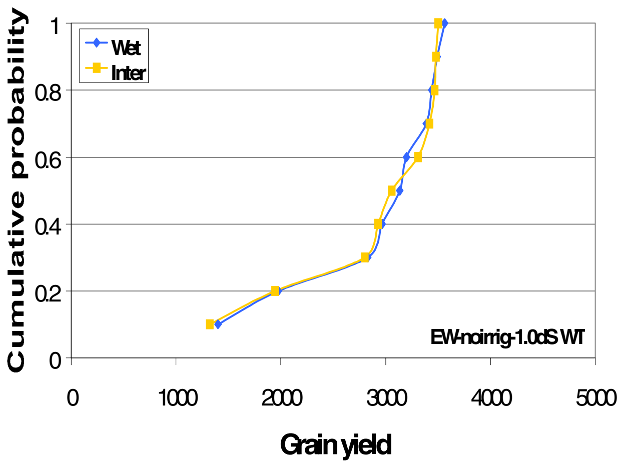
Bangladesh

The simulated dates of anthesis and physiological maturity revealed that late-sown (Dec and Jan) crops flowered and filled grain during periods of high temperature (not shown), resulting in small yields. Grain yields ranged from 0.4 to 4.6 t/ha, and were greatest for 15 Nov and smallest for 1 Jan sowings (Fig. 1). Yields for 1 Nov sowings varied from 1.0 to 4.6 t/ha, and were less than 2.5 t/ha in 50% of years, and greater than 3.0 t/ha in 20% of years. November-sown crops had the best chance of low temperature during flowering and low water stress during grain filling, contributing to greater yields than the later-sown crops. With September sowings, rainfall during the vegetative growth period varied from 200 to 550 mm. With sowings later than September, rainfall seldom exceeded 100 mm and in 50% of years was less than 40 mm.

Australia

With an initial WTD of 0.5 m and salinity of 1 dS/m, yields of early-sown wheat without irrigation ranged from 1-3.5 t/ha and exceeded 2.9 t/ha in 70% of years, with little difference between the wet and intermediate initial SWCs (Fig. 2). With WTD 0.5 m yield declined when the salinity of the watertable was increased to 20 dS/m (range 0.8-2.4 t/ha). However, for starting WTD of 1m or deeper, yield was not greatly affected by watertable salinity. Yields of late-sown non-irrigated wheat were smaller than of early-sown wheat for all starting conditions. For example, with a 0.5 m, 1 dS/m watertable at sowing, yields of late-sown wheat were always less than 2 t/ha. With frequent irrigation, yields ranged from 5-6 t/ha, regardless of sowing dates and initial SWCs, WTD and salinity. For non-irrigated wheat, WTD at harvest was almost always lower than at sowing – i.e. there was net discharge of groundwater, regardless of starting conditions and sowing date. With frequent irrigation, watertables were always higher at the





end of the season compared with the non-irrigated situation, and they often rose over the season (net recharge), more so for deeper starting WTD (not shown).

Fig. 1. Cumulative probability distributions for Fig. 2: Cumulative probability distributions for simulated yields (kg/ha) of wheat for various simulated yields (kg/ha), with initial watertable sowing dates at Nashipur, Bangladesh.depth 0.5 m and salinity 1 dS/m and no irrigation, at Griffith, Australia.

CONCLUSION

This work demonstrates how models can be used to estimate the optimum sowing date to increase yield and to predict agronomic strategies to determine yield versus environmental trade-off for wheat sown after rice in Bangladesh and Australia.

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About the Rice CRC

The Rice CRC is strengthening the rice industry's research and development (R&D) effort through its focus on sustainability.

Its mission is to increase the environmental, economic and social sustainability of the Australian Rice Industry and enhance its international competitiveness through both strategic and tactical research and the implementation of practical, cost-effective programs.

The Centre uses the intellectual resources of some of Australia's peak R&D organisations to target five main program areas:

1. Sustainability of Natural Resources in Rice-Based Cropping Systems
2. Sustainable Production Systems
3. Genetic Improvement for Sustainable Production
4. Product and Process Development
5. Education, Skills Development and Techology Transfer

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Cooperative Research Centre for Sustainable Rice Production
C/- Yanco Agricultural Institute
Private Mail Bag
Yanco, NSW 2703
Telephone: (02) 6951 2713
Facsimile: (02) 6951 2533
Email: crc.rice@agric.nsw.gov.au
Website: www.ricecrc.org