The new APSIM-Wheat Model - performance and future improvements

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Abstract

APSIM-Wheat combines modelling approaches from two previous Nwheat and I_wheat models and some new approaches. It has a modular structure with externalised model constants/parameters. It performed well in three locations in Queensland for simulation of biomass (RMSD=162g/m^2) and yield (RMSD=74g/m^2) with R^2>0.80 and nitrogen uptake (R^2>0.75,RMSD=2.0g/m^2), and also explained 66% of the variation in both biomass and yield at four locations in WA.

Key Words

APSIM-Wheat, generic crop template, wheat growth, nitrogen uptake, modelling

Introduction

APSIM is able to simulate growth and development of more than 20 crops. Two wheat modules existed in APSIM: Nwheat, a derivative of CERES-Wheat (6), and I_wheat (3). Increasing need for scientific transparency of crop models had led to the development of a generic crop template in APSIM (7). Based on this generic approach, we extracted the modelling approaches from Nwheat and I_wheat, and combined them with some new approaches to create a new APSIM-Wheat module and to share the common code with other cereal crop modules in APSIM for easy maintenance. Here we present the performance of APSIM-Wheat and discuss future improvements.

Methods

APSIM-Wheat has the same generic structure as other cereal crop modules in APSIM and uses a parameter file (WHEAT.INI) for wheat crop, in which all the species-specific constants and cultivar parameters are stored for easy modification. Sharing common process approaches (eg, water/N uptake etc) with other crops enables APSIM-Wheat to inherit improvements made elsewhere in APSIM crop template. The modular structure allows easy improvement at process level.

Detailed description of crop template, Nwheat and I_wheat can be found in references (7), (2) and (3) respectively. The default configuration uses water/N uptake subroutines from the crop process library and some newly modified approaches. These new approaches include: (a) Response of RUE and leaf critical nitrogen concentration to CO_2 level (4). (b) Stage dependent root/shoot ratio. (c) New biomass partitioning rules - leaf fraction 65% (new biomass) till terminal spikelet then linearly decrease to 0.0 at flag leaf. (d) Grain number is determined by stem biomass accumulation from flag leaf to start of grain filling. (e) Tillering is simulated as one tiller per phyllochron after 2.5 main stem leaves and is reduced by stress. (f) Potential leaf area growth is simulated using a modified I_wheat approach - leaf area on each stem is a function of thermal time since its emergence.

APSIM-Wheat was validated against experimental data from Queensland and Western Australia. The Queensland datasets cover three locations, four experiments with 4 N treatments, some with water treatments or residue treatments, and one soil fertility experiment covering 8 years from 1987-1995 (2). The WA datasets cover 4 locations, 4 soil types, 5 cultivars and several years (1).

Results

The model explained >80% of the variation in maximum LAI, total biomass (RMSD=161.8g/m^2), grain yield (RMSD=161.8g/m^2) and grain number, 79% of the variation in total N uptake (RMSD=2.0g/m^2) and 75% of the variation in grain nitrogen content (RMSD=1.8g/m^2) compared with the experimental data in Queensland (Fig.1). Grain protein level is also reasonably predicted with a R^2=0.58 and RMSD=1.9%. The performance of the model with the WA datasets is not as good as with the Queensland data. However, it explained more than 65% of the variation in biomass and grain yield and more than 83% of the variation in total N uptake (although only a few data points available).

Grain number was well simulated for the Qld data, but poorly simulated for the WA data (data not shown). In general, grain size and N content were poorly simulated in WA (not shown).

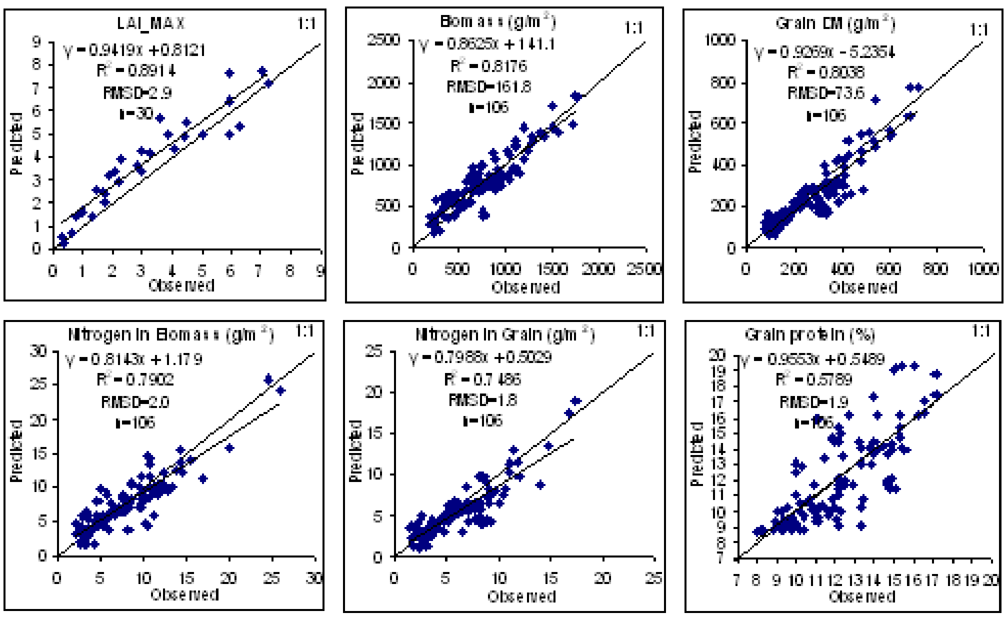

Figure 1. Simulated versus observed maximum LAI, biomass, yield and N in biomass and grain in Queensland

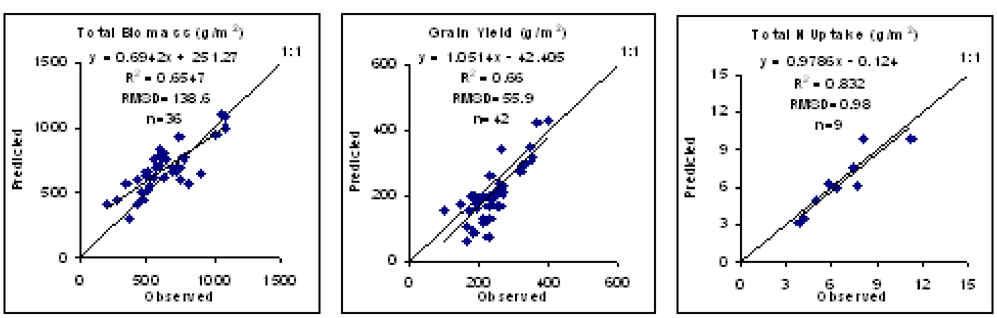

Figure 2. Simulated versus observed biomass, grain yield and nitrogen uptake in Western Australia

Conclusion

The new APSIM-Wheat has a process-oriented modular structure and externalised model parameters. Compared with the two previous wheat modules, it has a similar performance in terms of biomass, yield and nitrogen uptake simulation, is easy to modify and able to inherit improvements in the crop template development. It is able to explain >80% and >65%of the biomass/yield variation in Queensland and WA respectively and >75% of variation in total N uptake. Simulation of grain size needs to be improved because its effect on grain protein content. The model's performance for the southern regions of the Australian wheat belt is demonstrated elsewhere in these proceedings (5).

References

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