25th International Congress on Modelling and Simulation, Darwin, NT, Australia, 9 to 14 July 2023
mssanz.org.au/modsim2023

# Use of SCRUM-APSIM to predict soil water and soil nitrogen dynamics in arable crop rotations

**E.N. Khaembah, S. Thomas, R. Cichota, J. Sharp and H. Brown**

*The New Zealand Institute for Plant and Food Research Limited, Christchurch, New Zealand*
*Email: Hamish.Brown@plantandfood.co.nz*

**Abstract:** Nitrogen (N) lost from agricultural fields to surface and groundwater systems is an important environmental problem. There is growing research interest in N management strategies to improve the sustainability of farming systems. Monitoring N balance in agricultural field is technically difficult and is complicated by differences in soil types, crops, and variability between and within seasons. Simulation modelling is an alternative approach that provides a way to evaluate mitigation options across a range of management and growing conditions. To serve as a reliable basis for nutrient management, prediction accuracy of simulations models needs to be demonstrated.

This study evaluated the Simple Crop Resource Uptake Model operating within the Agricultural Production Systems sIMulator framework (SCRUM-APSIM) against field data for yield, N balance components (N uptake, soil mineral N and leaching) and soil water. Evaluation data were from a wheat-broccoli-onion crop rotation subjected to two irrigation rates (recommended and excessive) and four fertiliser N rates (N0, N1, N2, N3). No fertiliser was applied in N0, while N2 represented the recommended rate for each crop. N1 and N3 represented half and twice the rate of N2, respectively. Broccoli and onion crops were evaluated across all four fertiliser rates while a flat rate of 150 kg N/ha was applied to wheat irrespective of fertiliser N treatment.

SCRUM-APSIM satisfactorily simulated crop rotations and managements as indicated by performance indices: Coefficient of determination ($R^2$), root mean square error (RMSE), relative RMSE (rRMSE; expression of RMSE as a percentage of the observed mean), and the Nash-Sutcliffe model efficiency coefficient (NSE). Total biomass (n = 152) was accurately reproduced by SCRUM-APSIM ($R^2$ = 0.84, RMSE = 2.65 t DM/ha, rRMSE = 43%, NSE = 0.81). The agreement between measured and predicted total N uptake (n = 144) was even better ($R^2$ = 0.93, RMSE = 21.5 kg N/ha, rRMSE = 26%, NSE = 0.93), indicating that the model accurately captured the pattern of N uptake by crops in rotation. Prediction of soil mineral N (0–90 cm depth) was good ($R^2$ = 0.83, RMSE = 49.3 kg N/ha, rRMSE = 59%, NSE = 0.65). Nitrogen leaching was estimated for the wheat crop from leachate concentrations and SCRUM-APSIM-derived drainage. Graphical data comparison (Figure 1) and performance indices ($R^2$ = 0.83, RMSE = 4.39 kg N/ha, rRMSE = 43%, NSE = 0.83) show that the model accurately estimated N leaching. The prediction accuracy for yield and N balance components shown here indicates that SCRUM-APSIM is suitable a tool to assist in evaluating productivity and environmental effects of cropping systems. This may result in the development of strategies to mitigate N leaching and improve water quality. We observed that the model could be improved further, and the areas of improvement will be discussed.

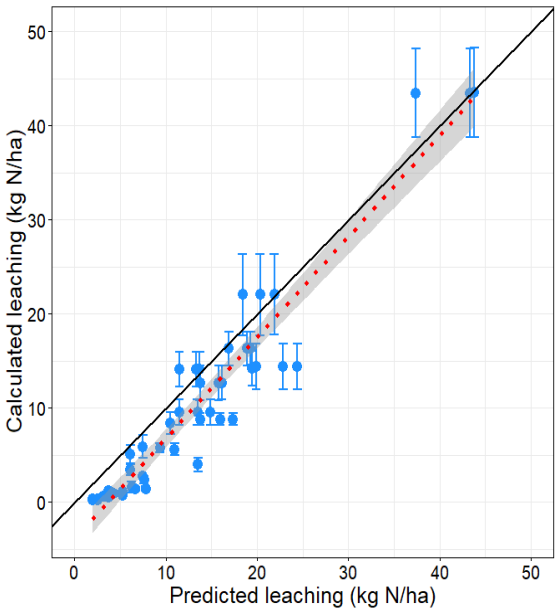


**Figure 1.** Calculated (mean ± SD) versus predicted values of nitrate leached under wheat in a wheat-broccoli-onion rotation. The solid line is a 1:1 relationship and the dotted is the linear relationship between calculated and predicted with a 95% confidence interval

***Keywords:*** *Crop rotation, nitrogen leaching, resource management, simulation modelling*