CropSyst VB – Simpotato, a crop simulation model for potato-based cropping systems: II. Evaluation of nitrogen dynamics

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Abstract

Application of the CROPSYST-SIMPOTATO model was evaluated for potato production systems in the Pacific Northwest of the United States. Model predictions showed that unaccounted N at the end of the crop growth varied from 102 to 170 kg/ha in the year 2001, and were much greater in the year 2002. Further studies are needed to validate the fate of this unaccounted N. Results also demonstrated the use of model predictions to assess N transport and losses under different water and N management practices. Therefore, the model simulation can be used to predict the fate and transport of N under different N and water management options. This information is useful to optimize the rate and timing of N and water applications to support the maximum production, while minimizing the negative effects of N losses.

Media summary

Crop simulation models can be used as decision tools to improve the efficiency of input management for cropping systems and minimize negative environmental impacts.

Key Words

CropSyst; Simpotato; N Uptake; N Leaching; N Balance; Potato Yield.

Introduction

Crop models are useful tools to simulate the plant growth, production, as well as to estimate the fate of nitrogen (N) in a variety of production systems. Therefore, these models can assist in crop production decisions to maintain high production, while minimizing N losses that may have negative environmental impacts. The Pacific Northwest (PNW) supports a wide range of agriculture production systems with an annual farm gate value of about 13 billon dollars. The value added returns of these commodities and the economic opportunities of the related industries are of significant importance to this region. The farm gate value of Potato production in the PNW is about $1.5 billion. Potato production occurs under irrigation systems, predominantly center pivot and most of it on coarse, low organic matter, sandy soils subject to nitrogen leaching if water and nitrogen are applied in excess. Groundwater nitrate levels in the region have increased, thus the need to develop improved nitrogen and irrigation management practices as well as the need to assess their impacts on the environment. Increased scrutiny of impact of agricultural production practices on the environment can influence the economic sustainability. The overall objective of this study is to develop tools that will be useful to growers to optimize their production systems while minimizing the negative effects on the environment.

Objectives

The specific objective of this research study was to use the CROPSYST-SIMPOTATO model to predict the fate and transport of water and nitrogen below the root zone of potato under different levels of nitrogen management practices.

Methods and Materials

The model

The growth and phenology components of the SIMPOTATO potato model (Hodges et al., 1992) were integrated into the CROPSYST (Stockle et al., 1994) crop simulation model. CROPSYST is a multi-year and multi-crop simulation model. Its structure allows the simulation of diverse crops in a rotation and therefore the assessment of the water, carbon and nitrogen dynamics in the whole production system. The updated CROPSYST-SIMPOTATO model was used to simulate the growth and production of potatoes using the input parameter for two years of field study as explained below. The predicted yields under different N management practices were compared with the measured yields from the field experiment. The water and N leaching below the rootzone were predicted using the above model.

Field experiment

Ranger Russet cultivar was grown for two years (2001 and 2002) in a sandy soil in the Columbia basin region with different rates of pre plant N. Pre-plant N application rates were: 0, 56, and 112 kg/ha in 2001 (soil residual N at planting of 56 kg/ha) or 56, 112, and 168 kg/ha in 2002 (with negligible soil residual N at planting). The total N for the entire growing period across all treatments was 336 kg/ha, including the soil residual N. An additional treatment of 448 kg/ha total N with 112 kg/ha pre-plant N was also evaluated. The in-season N was applied at 5 and 10 frequencies in 2001 and 2002, respectively. Center pivot irrigation was used to supply water to replenish the crop ET on a daily basis. Tuber yields were measured for all treatments. Plant N uptake was estimated based on the plant sampling to measure the dry matter and N concentration.

Results

Table 1. Model prediction of tuber yield for Ranger Russet cultivar on a Quincy fine sand, and soil N balance.

	2001- Pre Plant N applied (Kg/ha)					2002- Pre Plant N applied (Kg/ha)			
	0	56	112	56		56	112	168	112
Total N (kg/ha)	336	336	336	448		336	336	336	448
Measured Yield (Mg/ha)	64.5	78.6	64.1	78.9		65.8	67.2	68.4	61.6
Measured N Uptake (Kg/ha)	186	242	210	274		189	207	225	214
Model predictions:									
Predicted Yield (Mg/ha)	63.3	70.1	76.8	69.8		73.7	79.2	78.0	81.2
Drainage (mm)(below 0.6m soil)	136	136	136	136		297	297	297	297
Nitrogen balance (kg/ha):									
N in the root depth at planting	54	110	166	110		61	117	173	117
N in the profile at harvest	102	82	73	159		38	30	25	56
N uptake	221	235	240	270		212	224	214	263
Unaccounted N in top 0.6m soil	113	103	102	170		143	134	112	143
Unaccounted N in top 1.2m soil	32	36	41	39		110	108	112	143

Residual soil N at planting was 56 kg/ha in 2001, and negligible in 2002.

The model predicted the yield and N uptake reasonably well (Table 1, Fig. 1). However, it tended to overestimate yields during 2002, particularly for the highest N rate. The model simulated less N stress and greater leaf area index and transpiration during the 2002 than the 2001 season. This might explain the simulated high yields in 2002. Model simulations showed no significant yield increase with the highest N rate. Simulations also showed that, for the highest N rate , N unaccounted in the rooting zone at the end of crop growth increased significantly, particularly during the year 2002. Irrigation applied in 2002 was about 215 mm greater than that in 2001. This excess of water increased drainage and, therefore, may have contributed to N loss from the soil. N uptake increased rapidly during the 60 to 100 days after planting (Fig. 2), which coincided with the period of rapid dry matter increase (Fig. 3). N uptake increased marginally at 448 than at 336 kg/ha total N treatment (Fig. 4).

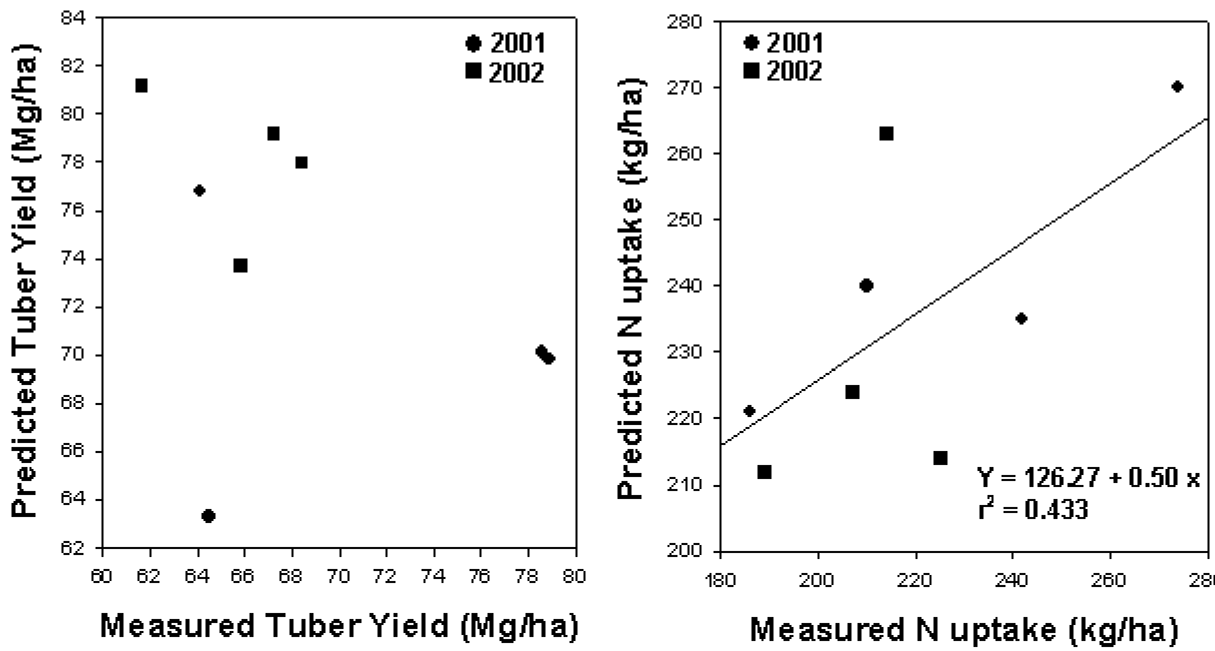

Fig. 1. Comparison of predicted vs. measured tuber yields and N uptake.

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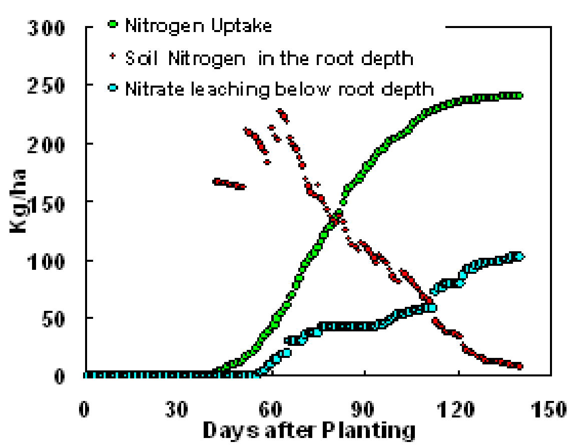

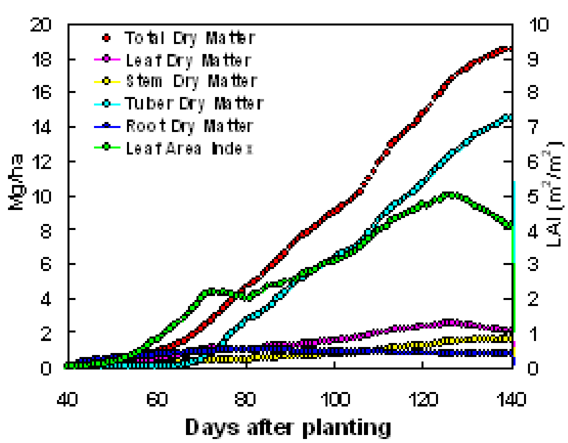

Figure 2. Predicted Nitrogen Uptake, Soil Nitrogen in the root depth and Nitrate leaching below the root depth. (Example: 2001 data for 112 Kg/ha pre-plant N treatment (left) and Predicted Dry Mater and Leaf Area Index

(Example: 2001 data for 112 Kg/ha pre plant N treatment) (right).

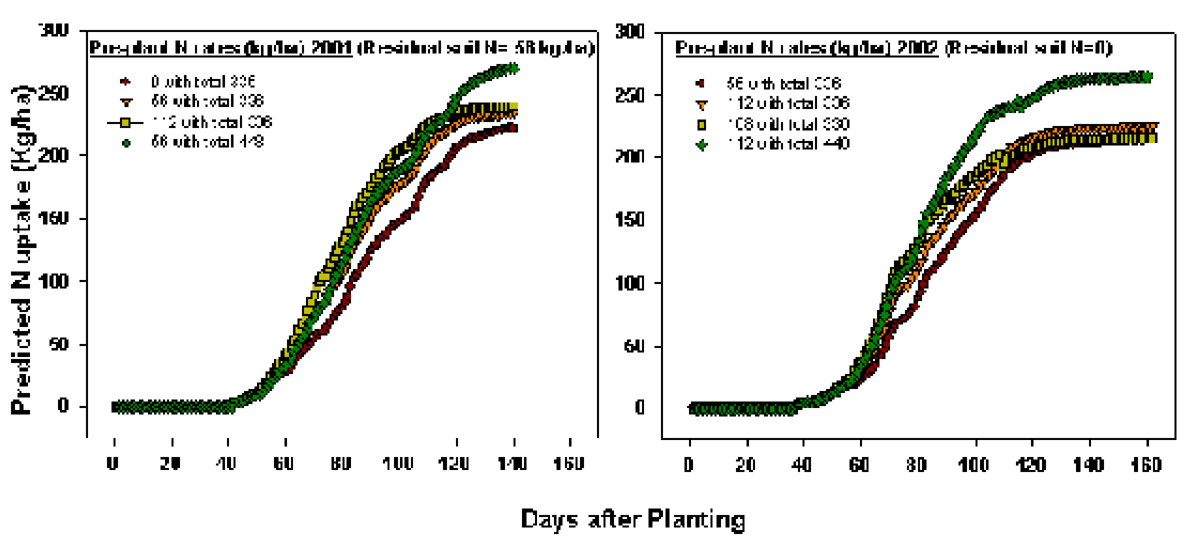

Figure 3. N uptake by potato plants, under four N management practices, simulated by the model.

Conclusions

SIMPOTATO model is a crop growth simulation model for potato. The utility of this model was enhanced by linking SIMPOTATO with CROPSYST, which enables prediction of fate and transport of N under potato production system. The model predictions of crop yield and N uptake compared reasonably well with the respective measured parameters for Ranger Russet potato variety in the Pacific Northwest production conditions.

References

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