CROPSYST-SIMPOTATO model to Predict the Fate of Nitrogen under Potato Production System

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Introduction

The Pacific Northwest (PNW) supports a wide range of agriculture production systems with an annual farm gate value of about 13 billion 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

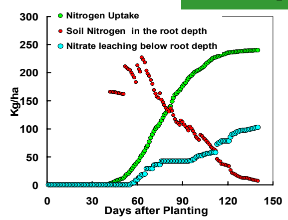
The model

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.

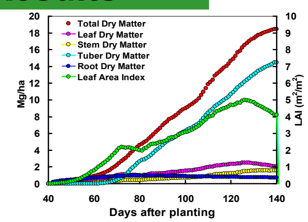
Field experiment

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



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)



Predicted Dry Mater and Leaf Area Index (Example: 2001 data for 112 Kg/ha pre plant N treatment

2001 (Total ET= 1333 mm; irrigation= 745 mm)

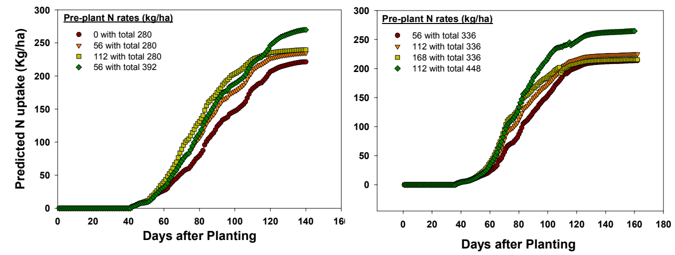
Pre Plant N applied (Kg/ha)	0	56	112	56
Total N (kg/ha)[1]	336	336	336	448
Measured Yield (Mg/ha)	64.5	78.6	64.1	78.9
Measured N Uptake (Kg/ha)	186	242	210	274
Total Fertilizer (Kg/ha)	280	280	280	392
Model predictions:				
Predicted Yield (Mg/ha)	63.3	70.1	76.8	69.8
Drainage * (mm)	136	136	136	136
Nitrogen balance (kg/ha):				
N in the root depth at planting	54	110	166	110
N in the profile at harvest	102	82	73	159
N uptake	221	235	240	270
Nitrate leaching below the root depth	113	103	102	170
Nitrate leaching below 1.2 m	32	36	41	39

* Drainage of water below the root depth, of 0.6 m
[1] Including soil residual N at planting, which was 56 kg/ha

2002 (Total ET= 1308 mm; irrigation= 960 mm)

Pre Plant N applied (Kg/ha)	56	112	168	112
Total N (kg/ha)[1]	336	336	336	448
Measured Yield (Mg/ha)	65.8	67.2	68.4	61.6
Measured N Uptake (Kg/ha)	189	207	225	214
Total Fertilizer (Kg/ha)	336	336	336	448
Model predictions:				
Predicted Yield (Mg/ha)	73.7	79.2	78.0	81.2
Drainage * (mm)	297	297	298	297
Nitrogen balance (kg/ha):				
N in the root depth at planting	61	117	173	117
N in the profile at harvest	38	30	25	56
N uptake	212	224	214	263
Nitrate leaching below the root depth	143	134	112	143
Nitrate leaching below 1.2 m	110	108	112	143

* Drainage of water below the root depth, of 0.6 m
[1] Including soil residual N at planting, which was close to zero



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

The model predicted the yield and nitrogen uptake reasonably well. However, it tended to overestimate yields during 2002, particularly for the highest rate of applied nitrogen. The model simulated less nitrogen 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 rate of applied nitrogen. Simulations also show that, for the highest rate of nitrogen, N leaching 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, the leaching of N.

Conclusions

The CROPSYST-SIMPOTATO model predictions showed leaching losses of N in the range of 102 to 170 kg/ha in the year 2001, and much greater losses of N in the year 2002. Further studies are needed to validate the model predictions of N leaching losses. The nitrate leaching is dependant on the applied water and the timing of nitrogen applications. Results also demonstrated the use of model predictions to assess nitrogen transport and looses under different water and nitrogen management practices. Therefore, the model simulation can be used to predict the potential for N leaching 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 negative effects of N leaching below the rootzone.

References

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Stockle, C. O., Martin, S. A. and G. S. Campbell. 1994. CropSyst, a cropping simulation model: water/nitrogen budgets and crop yield. Agricultural Systems, 46:335-359.