CROPSYSTVB-CSPOTATO: A CROP SIMULATION MODEL FOR POTATO-BASED CROPPING SYSTEMS

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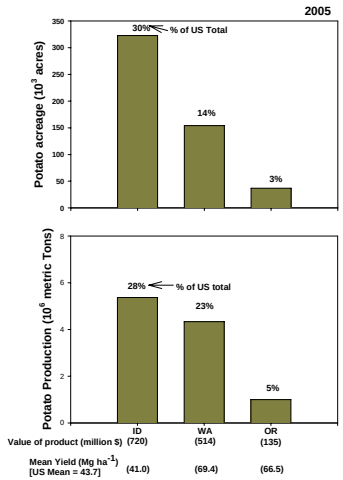
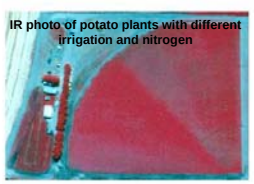
INTRODUCTION

- The irrigated Pacific Northwest (PNW) is an important potato production area in the US. The farm gate value of potatoes in the PNW is about $1.5 billion, and accounts for 56% of the total U.S. potato production.
- Potato production in the PNW occurs under irrigation, predominantly center pivot, and most of it is on coarse, low organic matter, sandy soils. These soils are vulnerable for nitrogen (N) leaching if water and N are applied in excess and or poorly managed.
- Groundwater nitrate (NO_3-N) levels in parts of the PNW potato production region have increased, thus the need to develop improved N and irrigation best management practices (BMP) as well as validate the long term affects on these BMP's to mitigate the negative environmental impacts.
- Simulation models which incorporate nitrogen transformation, transport and uptake along with prediction of crop growth and production are valuable support tools to guide crop management decisions.
- Most potato simulation models simulate potential biomass accumulation based on radiation-use efficiency
- Transpiration-use efficiency based models are better predictors of potential biomass accumulation under conditions of higher VPD and water stress, as they exist in the PNW.
- CropSyst model, developed specifically for the conditions prevalent in the PNW, predicts potential biomass accumulation as the minimum of radiation-use efficiency and transpiration-use efficiency.



Soil water monitoring probes



IR photo of potato plants with different irrigation and nitrogen

OBJECTIVE

1. To improve a potato simulation model (CSPotato).
2. Integration of CSPotato model with CropSystVB (A multi-year, multi-crop simulation model).
3. Validation of CropSystVB-CSPotato model simulations with field measured data for potatoes grown under different N rates and water regimes in a sandy soil.

MATERIALS and METHODS

- The model CropSystVB-CSPotato is the integration of a component (CSPotato) that simulates growth and development of potato with the multi-year, multi-crop, crop simulation model (CropSystVB).
- Simulations of phenology and plant growth in CSPotato are based primarily on a potato model of the CERES family with some modifications.
- The daily growth of potato (g/plant) in CropSystVB-CSPotato is simulated as the minimum of daily demand of C and daily available C. Daily demand of C is the sum of the demands of C for growth of leaves, stems, tuber and roots.
- If soil N plus that remobilized from the soil is not adequate to supply the plant N demand at critical N concentrations, growth is reduced subject to available soil N. Attainable soil N uptake is estimated by CropSystVB and supplied to CSPotato.
- A field experiment was conducted using 'Ranger Russet' potato cultivar, in Benton County, WA on a Quincy fine sand (mixed, mesic, Xeric Torripsamments).
- Treatments consisted of a combination of three levels of total applied nitrogen (N):
  - ✓168 (L); 336 (M); 504 (H) kg/ha
- and two levels of Irrigation:
  - ✓(i) Replenish full ET (980 mm total irrigation) and
  - ✓(ii) Replenish 80% of ET (790 mm)
- Potatoes were planted at 5 plants per m^2 in 0.86 m spaced rows (45,600 pl/ha).
- Total dry biomass (TDB), leaf dry biomass (LDB), stem dry biomass (SDB), tuber dry and fresh biomass (TuDB and TuFB) and leaf area index (LAI) were measured during the growing season at about 15 days interval.
- Soil water content was measured at 0.1, 0.3, 0.6, 0.9, and 1.2 m depths every hour using multi-sensor capacitance probes (Sentek Sensor Technologies. Stepney, Australia).

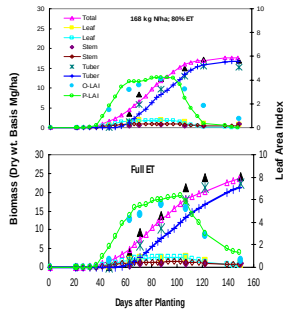
RESULTS

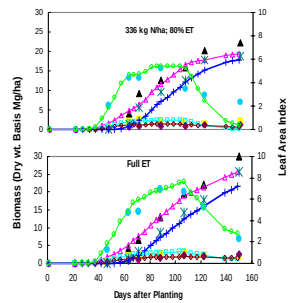
Crop parameters used for parameterization of CropSystVB-CSPotato model

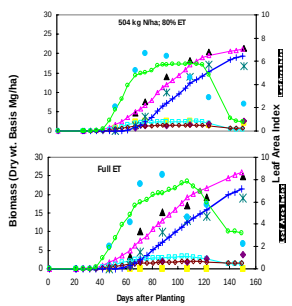
Parameter	Value
PHENOLOGY:	
Tc (Coefficient for critical temp.)	17°C
Pc (Genetic Coefficient)	0.6
ATTAINABLE C ASSIMILATON:	
K	12 Pa
Radiation Use effi.	3 g/MJ
K_G	0.55
LEAF EXPANSION AND SENESCENCE:	
Le_{max} (Max Leaf Expansion)	475 cm^2/ plant/ day
SLW (SP. Leaf wt.)	0.0043 g/ cm^2
ψU (Water pot. - Upper limit)	-400 J/ kg
ψL (Water pot. - Lower limit)	-600 J/ kg
Leaf Duration	55 days
TUBER GROWTH:	
P (Tuber priority for biomass)	1
TG_{max} (Max. tuber growth rate)	7 g/ plant/ day
WATER UPTAKE AND TRANSPIRATION:	
Crop Coefficient	1
Max Root Depth	0.6 m
Max Water Uptake	12 mm/ day
ψLC (leaf water pot. at onset of stomatal closure)	-700 J/ kg
ψLW (leaf water pot. at permanent wilting point)	-1000 J/ kg

Model predicted (P) and measured (M) leaf and tuber parameters and harvest index as influenced by the Low(L), Medium(M) and High (H) N rates and deficit irrigation (DI) and Irrigation to replenish full ET (FI)

	Leaf Expansion cm²/plant/day		Tuber Growth g/plant/day		Tuber Dry Biomass Mg/ha		Tuber Fresh Biomass Mg/ha		Peak LAI		Harvest Index	
Treat-ments	P	M	P	M	P	M	P	M	P	M	P	M
L-DI	116	126	5.0	4.4	17	15	72	63	4.2	4.1	0.94	0.90
M-DI	171	150	4.9	4.9	18	19	77	79	5.4	5.2	0.94	0.85
H-DI	186	211	4.9	5.3	19	17	84	75	5.8	6.7	0.90	0.79
L-FI	297	338	5.4	6.5	21	22	92	92	6.4	5.5	0.87	0.92
M-FI	237	271	5.2	5.6	22	26	94	104	7.7	6.9	0.84	0.85
H-FI	239	310	5.2	4.4	22	19	93	85	7.9	8.4	0.84	0.76







CONCLUSION

- A potato simulation model (CSPotato) was developed and integrated into the multi-year, multi-crop simulation model CropSyst (CropSystVB-CSPotato) to improve overall model capabilities for the assessment of N fate under different nitrogen and irrigation regimes in potato production systems
- In the above integrated model, when the crop in rotation is potato, the CSPotato model simulates potato growth and development and plant carbon and N balances. CropSystVB-CSPotato uses the dual approach of predicting potential biomass accumulation as the minimum of radiation-use efficiency and transpiration-use efficiency.
- Model simulations compared favorably to seasonally measured data of dry matter, leaf area index, plant N and yield of potatoes grown with 3 rates of applied N (168, 336, and 504 kg/ha) and 2 irrigation regimes.
- The model simulated total biomass and leaf area index adequately. Improved accuracy in the simulation of potato N and carbon balances by the integrated model demonstrates that this model can be used to predict soil and plant N dynamics and production of potato based cropping systems.