

2DSPUD, A TWO-DIMENSIONAL MODEL OF POTATO GROWTH AND DEVELOPMENT

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Potato is an intensively managed crop that requires large amounts of nutrients and water. Potato is also planted on hills or ridges which imposes a strong two-dimensional structure to infiltration and runoff. Our goal is to develop a mechanistic simulator of potato growth and development that is coupled with comprehensive two dimensional models of soil and atmospheric processes. The model calculates two-dimensional fluxes of water and movement of chemicals between rows and within the soil profile to simulate row position effects. The purpose of the model is to provide information on crop development stage, irrigation timing and amount, nitrogen fertilizer requirements and timing, and expected time to harvest.

There are a number of useful computer programs for the simulation of soil and atmospheric processes, and potato growth and development. Much of the modeling code that is currently available has also seen extensive use and testing. The ability to re-use code is a critical requirement to make full use of our investments. The use of a modular structure can facilitate the ability to choose the best tested and most appropriate code from an existing model and incorporate it into a new model. This will also allow us to match the level of detail between the plant and soil components. We have developed 2DSOIL, a modular two dimensional simulation model of soil and atmospheric processes, to be used for soil processes simulation in crop models. 2DSOIL is modular in the sense that components of the model can be added or removed with only minor modifications to the existing computer code. This model uses a finite element description of solute and water flow. Much of the code was adapted from SWMS_2D (water, solute and heat movement), SOIL-N (nitrogen dynamics), and GLYCIM (atmospheric and root processes). For potato growth and development we chose the model SIMPOTATO (Hodges, 1992). The model SIMPOTATO uses a daily time step and models photosynthesis on a canopy level using a parameter to model daily carbon assimilation as a function of the daily solar radiation integral. Temperature, nitrogen and water stresses are modeled using stress indices.

The 2DSOIL model was incorporated into the potato simulation model, SIMPOTATO, (Hodges, 1992) to build the new model, 2DSPUD.

In order to simulate photosynthesis on a more mechanistic level, we added a coupled, leaf level model of photosynthesis, stomatal conductance, and transpiration (Kim, 2001). This allows a coupling of the supply function of diffusion of CO₂ through the stomata (as controlled by stomatal resistance) to the demand function of the CO₂ fixation reaction. Recent advances in gas-exchange systems greatly simplify the parameterization of the model. The model was parameterized using data from leaf level photosynthesis measurements. Canopy level photosynthesis measurements from the Alternate Crops and Systems Laboratory's SPAR (Soil Plant Atmosphere Research) chambers were used to evaluate the performance of the photosynthesis model. Simulated photosynthesis values did follow the measured data at the extremes of the temperature ranges. However, uncertainties in leaf age and canopy light interception were sources of error.

The use of a more detailed model of photosynthesis will allow us to model the effects of environmental stresses with less dependence on stress factors and provide a more realistic method to model the effects of climate change. The results suggest that a good canopy radiative transfer model is important to be able to scale leaf level photosynthesis to the canopy level. Future work will be directed toward this area. The addition of a more mechanistic model of photosynthesis will help us better understand the photosynthetic process in potatoes and the effects of environmental variables.

References

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