VALIDATION OF MODELED SOIL SOLUTE PROFILES IN IRRIGATED COTTON

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Abstract

In cotton (Gossypium spp.) crop production systems in the irrigated desert southwest there are two major inputs that serve to stimulate crop growth, water and nitrogen (N). The two are also interrelated in the way they are managed. Management of irrigation water and fertilizer N is done in order to obtain the highest level of efficiencies possible and to reduce the amount of loss due to leaching, denitrification, volatilization, etc. The are several crop simulation programs available that, given certain inputs will attempt to simulate the fate of fertilizer N. As with any computer model, validation is an extremely important part of development. GOSSYM-COMAX is a cotton crop growth and management model that is very aggressive in that it attempts to take into account many of the aspects and factors that govern a cotton crops growth, development, and maturation. A project was initiated in 1994 with the objective of validating the crop simulation model, GOSSYM, in Arizona by comparing specific plant growth parameters (i.e. plant height, nodes, height to node ratios) and yield obtained from actual field data to that simulated by GOSSYM. This study found that plant height was simulated well over the entire season. There were large discrepancies however, in the number of mainstem nodes generated by GOSSYM and what was actually measured in the field. Review of the GOSSYM output found that the termination in mainstem node production was related to a simulated in-season N stress that did not occur in the field. This led to GOSSYM simulating as many as nine fewer nodes than what was measured in the field. Nitrate maps of the soil profile provided by GOSSYM demonstrated large fluctuations and movement of NO_3^--N concentrations with irrigation water. This prompted a further investigation into the soil solute transport portion of the model. In an effort to validate this portion of the model we compared actual NO_3^--N profiles to those generated by GOSSYM. The actual profiles were obtained by collecting soil samples out of an existing N-management experiment at the University of Arizona Maricopa Agricultural Center. The experiment was a split-plot within a randomized complete block design with varieties DPL 5415 and Pima S-7 as mainplots and four different N regimes as subplots (treatments). Soil samples were taken out of each variety by treatment combination in two of the three replications on each of five sample dates. Samples were taken to a depth of 120cm by 30cm increments. Soil:water (1:1) extracts were prepared and then analyzed for NO_3^- by ion chromatography. Resulting data was subjected to analysis of variance. The data showed no significant differences among mainplots, and treatment effects were only significant on three of the five sample dates. There was, however, significant ($P<0.05$) differences due to date, depth, and a significant treatment by depth interaction. The actual data was then summarized by date, treatment, and depth. Each value was then compared to its corresponding date*treatment*depth simulated value from GOSSYM. The actual and simulated profiles did not vary greatly from each other, but due to the high degree of spatial variability in the actual data, the resulting standard deviations in most cases were quite broad. GOSSYM simulated values occurred quite frequently within the standard deviation of the mean of the actual value for a particular date*treatment*depth. There were, however, extreme fluctuations in the simulated profiles that did not occur in the actual profiles. The fluctuations appeared to coincide with fertilizer applications and irrigations. Sharp increases were seen in the simulated profiles immediately following a N fertilization event, and then would decrease quickly with a subsequent irrigation. Treatment number three in this experiment, which has proven to be the optimum N-fertilization regime in Arizona, received 3, 45 lbs. N/acre applications for a total of 135 lbs. of N/acre. These applications occurred just prior to first bloom, just after first bloom, and at peak bloom. Simulated soil NO_3^--N levels increased in the top portion of the profile for each fertilizer application. Once fertilizer applications ceased and irrigations continued, the majority of the simulated NO_3^--N was transported down and out of the profile resulting in a simulated N-stress and cessation of node production in late July for that treatment. The difference in mainstem node number between GOSSYM and actual measured data was nine. GOSSYM simulated 21 mainstem nodes while the actual value measured in the field was 30. The irrigations in this experiment occurred at a rate of 4-6 acre-inches of water per irrigation. It appears that the method used by GOSSYM to calculate NO_3^--N movement through the soil is a type of piston displacement equation. The large quantities of water being applied in a single irrigation event might explain why the simulated solute profiles showed such extreme fluctuations. There is an apparent need for some improvement in the manner that GOSSYM simulates the movement of NO_3^--N through the soil. It also appears that GOSSYM inadequately simulates the ability of the plant to take up available NO_3^--N at low concentrations. This is evidenced by the fact that simulated concentrations of NO_3^--N were very often higher than actual concentrations yet a simulated N-stress still occurred.

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