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Natural Resources Research Update

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Title: Using Computer Models to Explore Alternative Scenarios for Managing Limited Irrigation Water

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Summary: The Root Zone Water Quality Model was used to simulate corn yields under varying irrigation water applications. The simulations included dividing the available water (4 to 40 inches) between vegetative (V) and reproductive(R) stages of corn growth in different proportions. The simulation of a 20:80 split irrigation between V and R stages performed better other split treatments. Simulations of the higher irrigation amounts resulted in yield decline because of N-stress as a result of N being leached out of the root zone.

Crop water stress due to low precipitation and high temperatures are the main limiting factors for agricultural production in the Great Plains. Corn is grown under either rainfed or irrigated regimes. Irrigation can improve corn profitability in this region, but over-irrigation accelerates depletion of ground water, which may result in limits to agricultural water use. Agronomic practices which increase water use efficiency (WUE) need to be developed to maximize returns from a combination of limited irrigation and optimum utilization of the precipitation received. Such water management strategies should be based on knowledge and planning that considers the underlying natural climate variability. This can only be achieved through long-term field studies with cropping systems under limited irrigation conditions for specific climates and soil regimes. These studies can be very expensive and do not account for the future changes in management practices or climate. Agricultural system simulation models of the soil-water-crop-atmosphere-management system provide an alternative approach.

Agricultural systems models are potential state-of-the-art tools, that help us integrate and synthesize knowledge gained in field studies. These models can be set up to evaluate the changes in crop growth and development in response to soil, water, and nutrient management alternatives. Scientists with the Agricultural Systems Research Unit of the USDA-ARS used the CERES-maize model for developing water production functions for corn. The scientists used field studies conducted at the Central Great Plains Research Station, USDA-ARS, in Akron, Colorado. The model accurately simulated the irrigated corn grown at this location. The ARS scientists further used the model to simulate irrigation scenarios using 94 years (1912-2005) of weather data recorded at Akron. Fixed amounts of irrigation (4 to 40 inches), were split between the vegetative (V) and reproductive (R) stages in the following manner: 20:80; 40:60; and 50:50 (V:R) 18 weeks after planting. Within the V or R stage, irrigation amount was equally split between weeks and applied at weekly intervals. Simulations showed declining grain yield with irrigation amounts greater than 16 inches. Figure 1 can be used as a decision tool for assessing in advance the expected grain yield return when irrigation water is limited.

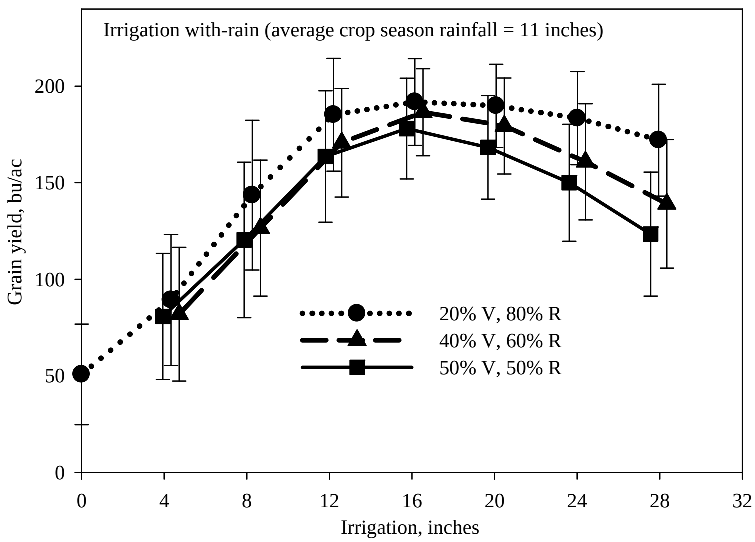

Figure 1: Simulated grain yield response with 4 to 28 inches of applied irrigation (gross irrigation), split between vegetative and reproductive stages at 20:80, 40:60, and 50:50 with 22 June as the date differentiating vegetative and reproductive growth stages for corn grown at Akron, Colorado. The figure shows the average for the 94 years of climate information and the standard deviation (vertical error bar). The curves serve as guides to estimate the corn yield to expect at different irrigation levels under natural conditions of normal (average), below normal (average minus one standard deviation), and above rainfall (average plus one standard deviation).

With increasing irrigation amounts, there is increasing threat of N leaching as well, which affected productivity. The 20:80 split irrigation between V and R stages is preferred over other split treatments.

In Figure 2 given below, simulated average N leached, residual soil N at crop harvest, and plant N uptake for corn grown in response to 4 to 28 inches irrigations split between vegetative and reproductive stages at 20: 80 are shown. The figure can be used as a decision tool for assessing N needs with different amounts of water available for irrigation.

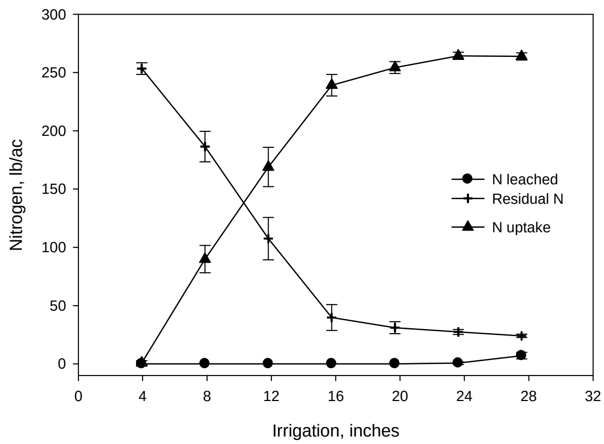

Figure 2: Simulated average N leached, residual soil N at crop harvest, and plant N uptake for corn grown at Akron, Colorado in response to 4 to 28 inches irrigations split between vegetative and reproductive stages at 20: 80. The N uptake curve can be used to estimate how much N fertilizer to apply at different levels of irrigation.