OPTIMIZING WATER ALLOCATIONS AND CROP SELECTIONS FOR LIMITED IRRIGATION

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ABSTRACT Irrigators are facing challenges with declining well yields or reduced allocations from water districts. To make reductions in water use, irrigators are considering shifts in cropping patterns that earn better net economic returns. A cropping season planning tool, the Crop Water Allocator (CWA), available at www.oznet.ksu.edu/mil , has been developed to find optimum net returns from combinations of crops, irrigation amounts, and land allocations (crop rotations) that program users choose to examine. Because personal computers can bring solutions to complex questions, this program can be used by individual irrigators at their workplace. The model uses yield-irrigation relationships for 280-530 mm of rainfall in western Kansas. The user can customize the program with crop localized crop production costs or rely on default values from typical western Kansas farming operations. Irrigators are able to plan for the optimum economic use of their limited water supply by testing their options with CWA.

Groundwater declines and dwindling surface water deliveries are normal rather than infrequent. Record energy costs are driving irrigators to fewer applications or crops that require less water. Irrigators have adjusted by turning to more efficient irrigation application techniques and water-conserving cropping practices. All of these measures have given incremental improvement to the use and effectiveness of water at the farm level.

Irrigators choose crops on the basis of production capabilities, economic returns, crop adaptability to the area, government programs, crop water use, and their preferences. When full crop evapotranspiration demand cannot be met, yield-irrigation relationships and production costs become even more important inputs for management decisions. Under full irrigation, crop selection is driven by the prevailing economics and production patterns of the region. Crops that respond well to water, return profitably in the marketplace and/or receive favorable government subsidies are usually selected. These crops can still under perform in limited irrigation systems, but management decisions arise as water is limited: should fully watered cops continue to be used; should other crops be considered; what proportions of land should be devoted to each crop; and finally, how much water should be apportioned to each crop? The final outcome of these questions is returning the optimal net gain for the available inputs.

Determining the relative importance of the factors that influence the outcome of limited-irrigation management decisions can become complex. Commodity prices and government programs can fluctuate and change advantages for one crop relative to another. Water availability, determined by governmental policy or by irrigation system capacity, may also change with time. Precipitation probabilities influence the level of risk the producer is willing to assume. Production costs give competitive advantage or disadvantage to the crops under consideration.

With computationally powerful personal computers becoming common on the desks of irrigators during the last 5 years, mathematical models for decision tools can be given to managers at their work place. The objective of this project has been to create a decision tool with user interaction to examine crop mixes and limited water allocations within land allocation constraints to find optimum net economic returns from these combinations. This decision aid is for intended producers with limited water supplies to allocate their seasonal water resource among a mix of crops. But, it may be used by others interested in decisions concerning allocating limited water to crops. Decisions are intended as a planning tool for crop selection and season allocations of land and water to crop rotations.

BACKGROUND

Net economic return occurs is calculated for all combinations of crops selected and the water allocated. Subsequent model executions of land-split (crop rotation) scenarios can lead to more comparisons. The land split options are: 50-50; 25-75; 33-33-33; 25-25-50; 25-25-25-25. Irrigation system parameters, production costs, commodity prices, yield maximums, annual rainfall, and water allocation were also held constant for each model execution, but can be changed by the user in subsequent executions. The number of crops eligible for consideration in the crop rotation could be equal to, or greater than, the number of land splits under consideration. Optimum outcomes may recommend fewer crops than selected land splits. Fallow is considered as a crop (cropping system selection) because a valid option is to idle part of a field or farm.

The model examines each possible combination of crops selected for every possible combination of water allocation by 10% increments of the gross allocation. The model has an option for larger water iteration increments to save computing time. For all iterations, net return to land, management, and irrigation equipment is calculated:

Net return = (commodity price) X (yield) – (irrigation cost + production cost)
(1)
where:

commodity prices determined from user inputs,
crop yields calculated from yield-irrigation relationships derived from a simulation model based on field research,
irrigation costs calculated from lift, water flow, water pressure, fuel cost, pumping hours, repair, maintenance, and labor for irrigation, and
production costs calculated from user inputs or default values derived from Kansas State University projected crop budgets.

All of the resulting calculations of net return are sorted from maximum to minimum and several of the top scenarios are summarized and presented to the user.

One of the features of CWA is that the user can choose among five land splits or fixed configurations of dividing the land resource (50-50; 25-75; 33-33-33; 25-25-50; 25-25-25-25). These splits reflect the most probable crop-rotation patterns in western Kansas. The user can examine the results of each one of the land splits in sequential executions of the model, but the algorithm treats land split as a constant during an individual scenario. Producers divide their fields into discrete parcels, and rotate their crops in this same pattern, which led to this simplifying assumption and to the possibility of an iterative solution of the model.

The grain yield-irrigation relationship forms the basis for calculating the gross income from the crop Irrigation translates into grain yield, which combines with price to determine income. Grain yields for corn, grain sorghum, sunflower, and winter wheat were estimated by using the "KS Water Budget v. T1" software. Software development and use are described in Stone et al. (1995), Khan (1996), and Khan et al. (1996). Yield for each crop was estimated from relationships with irrigation amount for annual rainfall and silt loam soils with loess origins derived from research in the High Plains of western Kansas and eastern Colorado. The resulting yield-irrigation relationship for grain sorghum (fig. 1) shows a convergence to a maximum yield of 10.7 Mg/ ha (159 bu/ac) from the various combinations of rainfall and irrigation. A diminishing-return relationship of yield with irrigation applied was typical for all crops. Each broken line represents normal annual rainfall for an area.

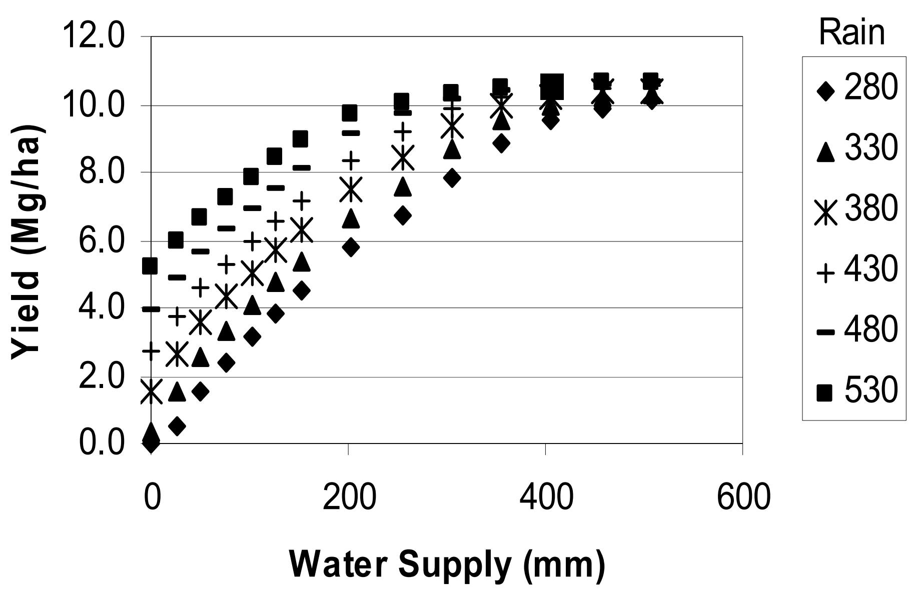

Figure 1. Yield-irrigation relationship for grain sorghum with annual rainfall from 280-530 mm (11-21 in).

The crop production budgets are the foundation for default production costs used in CWA. Program users can input their own costs or bring up default costs to make comparisons. For western Kansas, cost-return budgets for center-pivot irrigation of crops (Dumler and Thompson,

2004) provided the basis for default production-cost values for CWA. Results can be sensitive to production costs, which require realistic production inputs.

The program was designed with user-friendly, customized interface screens with discrete input information cells or keyed actions. The input cells have drop-down choices, where appropriate, and direct links to help information. A help library is also available that serves a technical guide for the program. Information inputs are categorized into general, irrigation, and crop production, according to the input screens receiving the data. Each crop has a separate production-cost screen. User inputs including water supply, irrigation costs, crop production costs, commodity prices, and maximum crop yields can be tailored to user circumstances. These inputs directly influence the selection of the optimum crop rotation, water allocation among those crops, and ultimate net return of the cropping system. The Crop Water Allocator can be found at: www.oznet.ksu.edu\mil

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