CROP SELECTIONS AND WATER ALLOCATIONS FOR LIMITED IRRIGATION

N. L. Klocke, L. R. Stone, T. J. Dumler, S. Briggeman

Norman L. Klocke, Kansas State University, Professor, Water Resources Engineering, 4500 East Mary Street, Garden City, KS 67846, phone: 620-276-8286; fax: 620-276-6028; e-mail nklocke@ksu.edu. Loyd R. Stone, Kansas State University, Professor, Soil Physics, Throckmorton Hall, Manhattan, KS, Troy J. Dumler, Kansas State University, Extension Economist, SWREC, Garden City, KS, and Steven Briggeman, Software Developer, Sprout Software, Manhattan, KS.

INTRODUCTION

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 decision 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. The model uses yield-irrigation relationships for 11-21 in. of rainfall in western Kansas as a basis to estimate yields for particular rainfall zones. 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.

Irrigators choose crops on the basis of production capabilities, economic returns, and 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 often 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 still can 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 outcome of these questions is finding optimal economic return 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.

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 crop rotations and water allocation choices.

BACKGROUND

CWA calculates net economic return for all combinations of crops selected for a rotation and water allocated to each crop. Subsequent model executions of land-split (crop rotation) scenarios can lead to more comparisons. Individual fields or groups of fields can be divided into in the following ways: 50-50; 25-75; 33-33-33; 25-25-50; 25-25-25-25. The number of crops eligible for consideration in the crop rotation could be more than the number of land splits under consideration. Optimum outcomes may recommend fewer crops than selected land splits. Fallowing part of the field is a valid option. Irrigation system parameters, production costs, commodity prices, yield maximums, annual rainfall, and water supplied to the field were held constant for each model execution, but can be changed by the user in subsequent executions.

The model examines each possible combination of crops selected for every possible combination of water allocation by 10% increments of the water supply. 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)

where:

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

Field research results have been used to find relationships between crop yields and amounts of irrigation (figure 1). Yields from given irrigation amounts multiplied by commodity prices are used to calculate gross income. Grain yields for corn, grain sorghum, sunflower, and winter wheat were estimated by using the “Kansas Water Budget” 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 irrigation amount for annual rainfall and silt loam soils. The resulting yield-irrigation relationship for corn (fig. 1) shows a convergence to a maximum yield of 220 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.

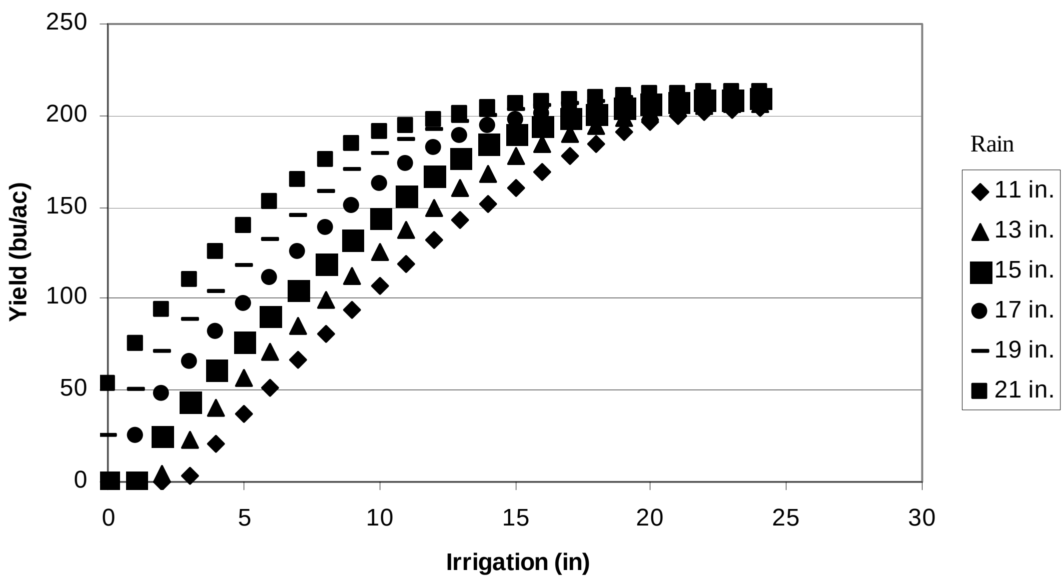

Figure 1. Yield-irrigation relationship for corn with annual rainfall from 11-21 in.

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 (www.agmanager.info/crops/) provided the basis for default production-cost values for CWA. Results can be sensitive to production costs, which require realistic production inputs.

TREND ANALYSIS

Reducing income risk is often an irrigator's motivation for switching crops as water availability declines. The Crop Water Allocator (CWA), in its present form, ranks alternative planting patterns based on mean income alone, without considering outcomes associated with changes in input variables. This risk arises from a variety of factors that are uncertain at the time of planting; the most important of these is weather conditions during the growing season. For example, although corn often generates the highest mean income, it is also likely to have a highly uncertain yield because its growth is sensitive to water stress during critical stages of the growing season. Adding trend analysis to CWA can project net returns over a range of input variables. Years with above normal, below normal and average rainfall can be simultaneously examined to find trends in net returns. The same methods can be used to project income trends for ranges of commodity prices, maximum yields, production costs, irrigation costs, and irrigation efficiency. Ranges of user input variables can be entered with ranges of net economic returns as the output. These results indicate the income risks when rainfall, irrigation costs, crop production costs, irrigation efficiencies, commodity prices, or crop maximum yields vary.

Trend analysis allows the user to find net returns over a range of possible inputs: rainfall, irrigation efficiency, commodity prices, maximum crop yields, irrigation costs, and crop production costs. For example, the program user may be interested in the response of net returns if annual precipitation varies from 13 to 21 inches and corn price ranges from $2 to $4/bu (tables 1 & 2). CWA executes a series of calculations over the range of irrigation costs, producing the corresponding range of net returns.

Two input ranges can be simultaneously processed in fixed trend analysis to find the influence of both inputs on net return.

Table 1. Net returns for $2 to $4/bu corn and 13-15 inches of annual precipitation.

	Annual Rainfall (inches)				
Crop Price - Corn ($/ bu.)	13	15	17	19	21
2	$-197 /ac	$-190 /ac	$-183 /ac	$-176/ac	$-172 /ac
3	$-76 /ac	$-50 /ac	$-25 /ac	$-4 /ac	$10 /ac
4	$46 /ac	$89 /ac	$132/ac	$168 /ac	$192 /ac
5	$168 /ac	$229 /ac	$289 /ac	$341 /ac	$375 /ac
6	$289 /ac	$369 /ac	$447 /ac	$513 /ac	$557 /ac

Table 2. Inputs for example in table 1.

Crop:	Corn
Acres:	130 acres
Gross Irrigation	12.0 inches
Total Production Costs:	$389/ac
Maximum Yield:	200 bu./ac
Irrigation Costs:	$94 /ac
Irrigation System Efficiency:	85%

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