

## Risk in Income Return from Limited Irrigation using the Crop Water Allocator

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### Abstract

The Crop Water Allocator (CWA) has been developed for irrigators to allocate limited water among selected crops. Irrigators are under pressure to develop cropping strategies as pumping capacities dwindle and water allocations become more restrictive. Pumping costs, crop production costs, and fluctuating commodity prices are also forcing producers to examine crop selections and water allocations. CWA calculates net economic returns from all possible combinations of crops, irrigation patterns, and land allocations, proposed by a user's inputs and ranks the net returns from maximum to minimum values. Income risk analysis was added to the existing CWA software. Users can account for net income shifts in response to a range for input variables--rainfall, production costs, commodity prices, irrigation costs, irrigation efficiency, and maximum yields. Output shows net returns for each range of selected inputs. CWA is available to download to an individual's computer at: [www.oznet.ksu.edu/mil](http://www.oznet.ksu.edu/mil)

### CWA Features

Water supplies for irrigation are declining in many irrigated regions due to lower pumping capacities, smaller surface water supplies, and regulated restrictions of water applications. To reduce irrigation, irrigators can consider shifts in crop rotations. Irrigators with shrinking water supplies who are considering different crops and rotations need to know the potential net economic returns from each combination of crops and water applications to each crop that suit their management system

The Crop water Allocator (CWA) has been developed to assist irrigators in evaluating an array crop rotations and water allocations to each crop (Kansas State University, 2006 and Klocke et al., 2006). It is an agronomic/economic model that predicts the net economic returns from all possible crop and irrigation combination. Net return to land, management, and irrigation equipment is:

$$(\text{Crop price} \times \text{Crop Yield}) - (\text{Production Costs}) - (\text{Irrigation Costs})$$

Gross return is calculated from the multiplication of crop yield and crop price. Net return is gross return minus crop production costs and irrigation costs. Crop production costs can come from the CWA user's information that is entered in production cost screens for each crop or from default production costs, internal to the program, as entered by extension agricultural economists (Dumler and Thompson, 2006).

The CWA determines crop yields from irrigation and precipitation available to the crop. Tables of yield versus irrigation over the range of annual precipitation, from 11 to 21 inches, for alfalfa, corn, soybeans, grain sorghum, wheat, and sunflowers are in the CWA (Khan et al., 1996; Stone et al., 2006). Figure 1 is the graphical representation of the table for corn. The data for the yield versus irrigation and precipitation were developed from field research plots, using conventionally tilled management in

western Kansas on silt loam soils. CWA users also can add crop and yield versus irrigation and precipitation data through the “custom crop” screen, accessed by the “tools” menu on the main input screen. The “custom crop” option allows users add grain or forage crops with their own irrigation versus irrigation and precipitation data or add custom data to the default crops by adding a crop name like corn2 or forage sorghum.

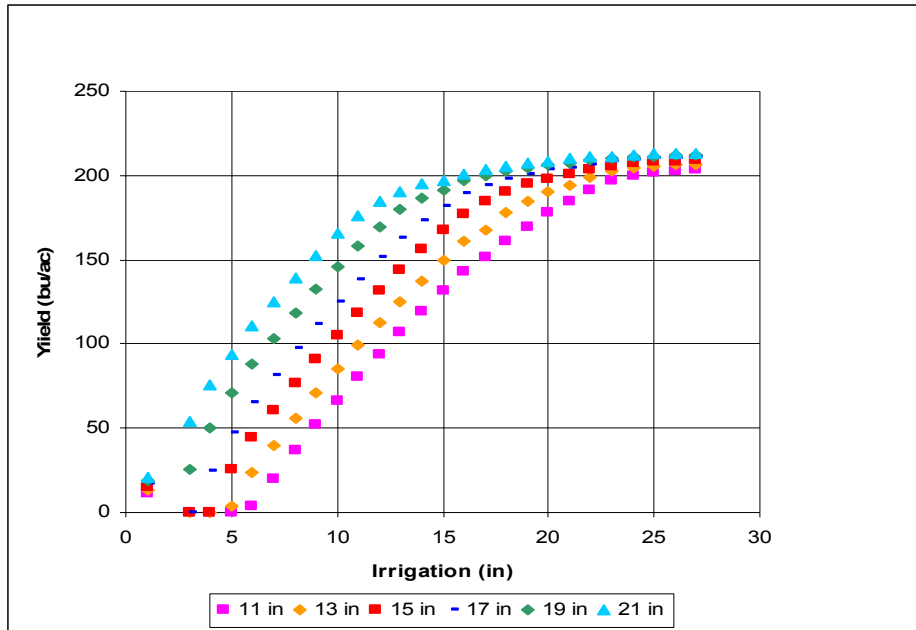


Figure 1. Grain yield for corn versus irrigation over a range in precipitation, derived from research data in western Kansas for silt loam soils.

CWA assumes that farming practices are carried out with good crop management in dryland, limited irrigation, and full irrigation situations. The yield relationships with irrigation that are the foundation for the model are based on research and management practices in “best management” crop production. Crop management that does not meet “best management practices” will not achieve the predicted results of CWA.

The user of CWA can choose a rotation scheme five possible “land splits”: 50%-50%; 75%-25%; 33%-33%-33%; 50%-25%-25%; or 25%-25%-25%-25%. These land splits were chosen as predominate divisions fields or farms for crop rotations. The user can choose one land split for each execution of CWA or hold “land split” constant as other inputs are changed. The program will assign every combination of every selected crop to each part of the land split. More crops than land splits can be selected for CWA analysis. One crop may be in more than one part to all parts of the rotation.

Irrigation is then allocated to each crop in each combination of selected crops for the rotation. The irrigation allocation is an iterative process. The “irrigation iteration factor”, accessed by edit/options menu on the main input screen, sets the number of irrigation allocation calculations executed by CWA. The default “irrigation allocation iteration factor” is 10. If the user decreases the “irrigation allocation iteration factor”, CWA calculates more net returns and results are “coarser” iterations of water allocations to each crop. For example, an “irrigation allocation iteration factor” with a value of 10, tells CWA to calculate net returns for each of 10% increment of the input water allocation (e.g. 12 inches of water is divided into equal units of 1.2 inches). An “irrigation allocation iteration factor” with a value of 5 tells CWA to calculate net returns for each increment 20% of input water allocation (e.g. 12 inches of water is

divided into equal units of 2.4 inches). If more crops are selected for more land splits and irrigation iterations, CWA execution time will increase dramatically.

Net return results from all combinations of crops in each part of the rotation and irrigation iterations are “stacked” from maximum to minimum. The user can scroll through approximately 20 of the largest net return results displayed on the output screen. Some of the crop combinations in the rotation may not be feasible for the user even though they have more net return than others. For example, soybeans in all parts of the rotation would not be feasible because continuous soybeans are not recommended.

If a CWA user chooses to evaluate the net returns from a range of an input variable (commodity prices, production costs, irrigation costs, maximum crop yields, precipitation, or irrigation system efficiency), multiple executions of CWA will produce the range of net returns over the range of that input variable. The output of multiple executions will indicate the income risk when an input varies. The “trend processing” feature of CWA, accessed through the “tools” menu on the main input screen, automates multiple executions to obtain ranges of net returns from user chosen ranges of these input variables. For example, the program user may be interested in the net returns if irrigation costs are from \$5 to \$15 per acre-inch. CWA executes a series of calculation over the range of irrigation costs, producing the corresponding range of net returns. Another example, annual precipitation may have 80%, 50%, and 20% probability for occurrence which corresponds to 15, 18, and 21 inches.

Fixed and variable trend processing are the two options of trend processing. Fixed trend processing is executed after a user has chosen one of the options of crop rotation and water allocation for each of the crops in the rotation from the output screen of CWA. Fixed trend processing allows the user to evaluate income risks of this particular scenario if any two of the input variables change. The “generate output” key on the main input screen will initiate calculations of net returns for the chosen scenario, as normally executed by CWA. An example set of inputs are in table 1. Activating the “Run Fixed Trend on selected option” button on the output screen will take the user to a screen to designate ranges for one or two variables. For example, clicking on “annual rainfall” allows the user to enter a range of rainfall expected for the location. The “add a trend variable” button switches for entry of a second variable such as irrigation cost. CWA executes multiple calculations of net return for all combinations of annual rainfall and irrigation costs over their designated ranges. The results can be exported to EXCEL in the form of a two way table. See table 2 for the example’s output.

Table 1. Input values for determining net return with Crop Water Allocator (CWA).

Item	Value	Units	Comment
Irrigation efficiency	100	%	Net irrigation values were used.
Annual precipitation	15, 18, 21	inches	80%, 50%, 20% precipitation probability--semi-arid climate
Annual Irrigation allocation*	8	inches	
Maximum expected grain yield	210, 150	bu ac <sup>-1</sup>	For corn, grain sorghum
Commodity prices	4.00, 3.50	\$ bu <sup>-1</sup>	For corn, grain sorghum
Irrigation operating cost	7-15	\$ ac <sup>-1</sup> in <sup>-1</sup>	

Table 2. Net return (\$/ac) from fixed trend processing for 15, 18, 21 inches of annual precipitation and irrigation operating cost of \$7-15 ac<sup>-1</sup> in<sup>-1</sup>.

Irrigation Costs (\$/ ac-in)	Annual Rainfall (inches)		
	15	18	21
7	173	238	285
9	158	222	269
11	142	206	253
13	125	190	237
15	110	174	221

Variable trend processing is the second option for trend processing in CWA. In variable trend processing net returns are calculated for optimum combinations of crops, water allocations to each crop, and land allocations for each selected crop are free to change to find optimum solutions over the range of one input variable. Variable trend analysis is activated through the “tools” menu selection on the main input page. All inputs, including crop selections, land area, irrigation costs, land split, irrigation efficiency, seasonal irrigation, rainfall, production costs, commodity prices, and maximum yields, must be entered before executing variable processing. After initiating variable trend processing through the “tools” menu, CWA will go to a screen to designate the range of one variable. Only one input variable can be used with variable trend processing. CWA then executes multiple runs to find net returns over the range of the designated variable. The results from CWA’s of variable trend processing can be exported to an EXCEL file (see table 3). Corn and grain sorghum were chosen by the user. Annual water allocation was 800 ac-inches for the 100 ac field. Net returns were calculated for a range of annual precipitation, 15, 18 and 21 inches. For 15 inches of annual precipitation, corn and sorghum would be rotated with 3.2 inches of irrigation applied to the sorghum and 12.8 inches to the corn. As rainfall increased to 18 and 21 inches, continuous corn would grown with the uniform application of the 8 inch irrigation allocation.

Table 3. Variable trend output for inputs in table 1.

Annual Rainfall (in)	Crop	Acres	Net Irr (in)	Price (\$/bu)	Max Yield (bu/ac)	Irr Cost (\$/ac)	Total Prod Costs (\$/ac)	Net Return (\$/ac)
15	Sorghum	50	3.2	3.5	150	40	181	146
	Corn	50	12.8	4	210	144	456	
18	Corn	100	8	4	210	92	372	218
21	Corn	100	8	4	210	92	393	200

### Summary

The CWA model allows irrigators, Extension personnel, consultants, or water planners to calculate net economic returns for combinations of selected crops for a rotation, land allocations to each crop, and water allocations to each crop. The CWA is user friendly and can be executed with inputs crop selection, land area, irrigation and production costs, commodity prices, irrigation system efficiency, and irrigation amount. As water resources become more limited, programs such as the CWA can be used to assist in planning for future farming operations or to assess potential impacts of changes in water policy.

The trend analysis feature of CWA gives producers the ability to find income risks from net returns when input values vary over a specified range. Producers and policy makers can project micro and macro economic effects of volatile commodity prices, escalating production and irrigation costs, uncertain rainfall, and possible water allocations.

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