DETERMINING CROP MIXES FOR LIMITED IRRIGATION

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INTRODUCTION

Full irrigation is the amount needed to achieve maximum yield. However, when water supplies for irrigation are insufficient to meet the full evapotranspiration (ET) demand of a crop, limited irrigation management strategies will need to be implemented. The goal of these strategies is to manage the limited water to achieve the highest possible economic return. Restrictions on water supply are the primary reasons for using limited irrigation management. These restrictions may come in the form of mandated water allocations, from both ground water and surface water supplies, low yielding wells, and/or drought conditions which decrease available surface water supplies.

KEY MANAGEMENT STRATEGIES FOR DEALING WITH LIMITED IRRIGATION

The key management choices for dealing with insufficient irrigation supplies are as follows:

Cropping Management/Choices

- Reduce irrigated acreage and maintain the irrigation water applied
- Reduce amount of irrigation water applied to the whole field
- Rotate high water-requirement crops with those needing less water

Irrigation Management

- Delay irrigation until critical water requirement stages of the crop
- Manage the soil water reservoir to capture precipitation

Reducing irrigated acreage is one response to limited water supplies. When the irrigated area is reduced the amount of irrigation per acre more closely matches full irrigation requirements and it's corresponding per acre yield. Ideally, the land that reverts to dryland production should still produce some level of profitable returns. Another strategy may be to reduce the amount of irrigation per acre that is applied to the entire field. This would create the possibility for near normal crop yields if above normal precipitation occurred. In normal to below normal rainfall years, grain yields per acre would be less than those achieved with full irrigation. Rotating high water-requirement crops, such as corn, with crops needing less water would also be a possibility. Soybean, edible bean, winter wheat, and sunflower are the major crops with lower water requirements. Splitting fields between corn and one of these crops would reduce total water requirements for the field and distribute the water requirements across a longer portion of the growing season. For example, peak water demands for wheat are during May and June, while corn uses the most water during July and soybean water needs peak in August. Splitting the field into multiple crops allows producers with low-capacity wells to more completely meet the peak requirements of all crops.

Delaying irrigation until critical times is also a possible alternative if the volume of water is limited but well capacity is normal. Water availability during reproductive and grain filling growth stages is the most important for grain production. During vegetative growth some water stress can be tolerated without affecting grain yield and root development can be encouraged so that the crop can utilize deeper soil water. This period also typically coincides with the highest monthly rainfall amounts in the central plains. Field research from the West Central Research and Extension Center (WCREC) near North Platte has shown that corn can utilize water from deep in the soil profile when necessary. However, the irrigation system must be capable of keeping up with water demands during the reproductive growth stage of the crop if irrigation is delayed. Delayed irrigation is more feasible with center pivots than with furrow irrigation. In furrow irrigation, dry and cracked furrows do not convey water very well, especially during the first irrigation. A combination of furrow packing during the ridging operation, surge irrigation, and increased stream size may overcome some of the effects of late initiation of furrow irrigation.

An important management strategy under all limited irrigation situations is to capture and retain as much precipitation as possible. Crop residues on the soil surface intercept rainfall and snow, enhance infiltration, and reduce soil evaporation. Again, residue management is much easier with center pivot irrigation than furrow irrigation. Advancing water down a furrow may be more difficult with high residue levels. Ridge-till management along with furrow packing and surge irrigation may overcome some of these problems. Leaving room in the soil to store precipitation during the non-growing season enhances the possibility for capturing rainfall for the next growing season. Leaving room in the soil to store rainfall during the growing season may ensure more water availability during grain filling under limited water conditions.

It is very important to know the soil water status during the entire season. Limited irrigation management causes the irrigator to operate with more risk of crop water stress and grain yield reductions. Knowledge of soil water can help anticipate how severe the stress might be and help avoid disaster.

HOW CROPS RESPOND TO WATER

Yield vs Evapotranspiration

Crops respond to evapotranspiration (ET) in a linear relationship (Figure 1). For each inch of water that crop consumptively uses, a specific number of bushels is the resulting output. This relationship holds true unless excessive crop water stress occurs during the early reproductive growth stages. Where the response function intercepts the X-axis is the development and maintenance amount for each crop. The more drought tolerant crops (winter wheat) typically have lower development requirements than do high response crops (corn). Not all of the water that is applied to a crop through rainfall or irrigation is used by the crop. Losses such as runoff or leaching occur and are not useable for ET.

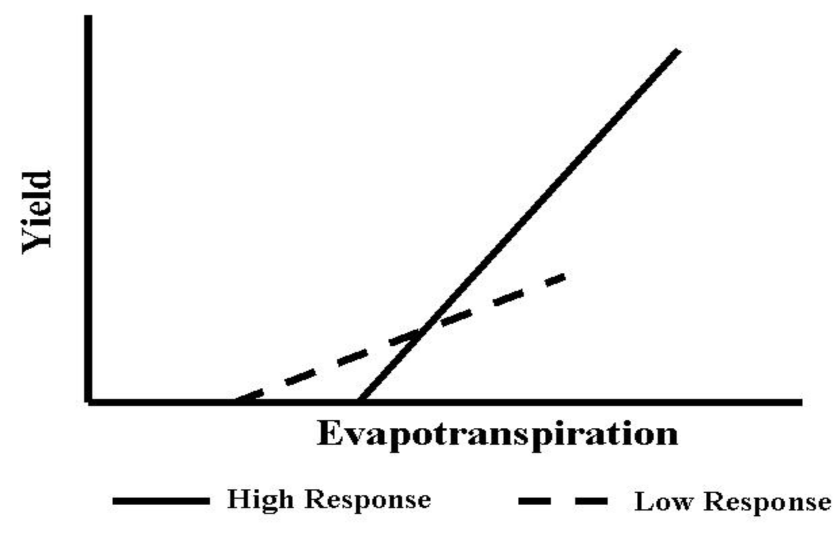

Figure 1. Generalized Yield vs Evapotranspiration response for high response crop and low response crop.

Yield vs Irrigation

Irrigation is applied to supplement rainfall when periods of ET are greater than available moisture. However, not all of the water applied by irrigation can be used for ET. Inefficiencies in applications by the system result in losses. As ET is maximized, more losses occur since the soil is nearer to field capacity and more prone to losses such as deep percolation (Figure 2). When producers are limited on the amount of water that they can apply by either allocations or low capacity wells, wise use of water is important for maximizing the return from water.

The yield increase of crops to water decreases as input levels approach maximum yield levels. In simple terms, as the amount of input and yield increases, the return from each unit is less than the previous unit. The yield increase from adding water from amount A to amount B is more than when increasing from amount B to C (figure 2). A producer must use this type of input to make informed decisions. The decision that must be made is irrigating at amount C with fewer acres or at amount B with more acres. The same question must be asked when comparing irrigation amount B to A. Developing a realistic yield vs irrigation production function is critical to managing limited water supplies. Producers must know what the yield increase from adding additional units of irrigation water to that crop is to determine the optimal amount of water to apply to that crop. The trade off that must be evaluated is the potential return per acre with each scenario.

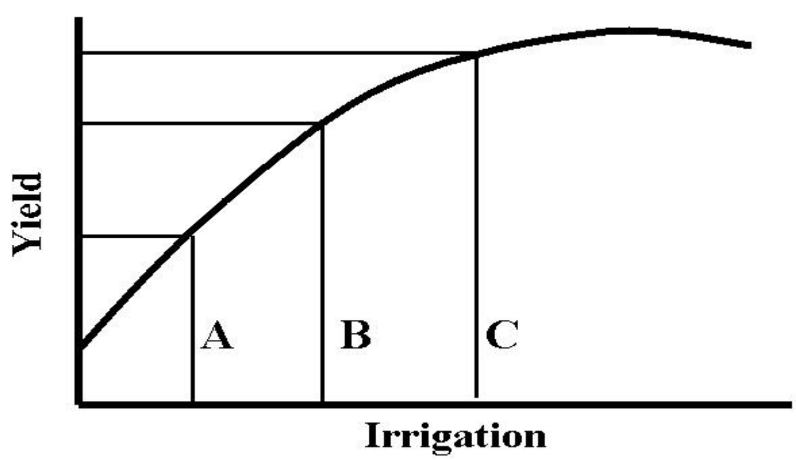

Figure 2. General Yield vs Irrigation Response.

ALLOCATING LIMITED WATER SUPPLIES

When water is unlimited, the management strategy is to add inputs such as water until the return from that input is equal in value to the added crop production. However, when water is limited, the management strategy should look at maximum return from each unit of input of water. When producers are limited in the amount of water they can either pump or are allocated and that amount of water is less than what is needed for maximum economic production, producers must look at management options that will provide the greatest possible returns to the operation.

A Single Irrigated Crop and a Dryland Crop

The easiest production option would be to look at a single irrigated crop with the remainder of production in either a dryland crop or fallow. When the amount of water is less than adequate for maximum production, producers must ask themselves whether the yield increase from increasing the amount of irrigation to each acre will offset the reduction in irrigated acres and increased dryland production. Increasing the amount of irrigation to a crop reduces the total number of irrigated acres. An example of this would be if you have 10 inches per acre available for irrigation. One option is to irrigate all acres at 10 inches. A second option would be to irrigate 2/3 of the acres at 15 inches and have the remainder at dryland production. The question to answer is "Does the yield increase offset the reduction in irrigated acres and having 1/3 of the potential irrigated acres in dryland production?" With a 130 acre irrigation system, a change in strategy such as this would reduce the irrigated acres from 130 to 87 acres and increase the dryland acres from 0 to 43 acres. If corn is the primary irrigated crop, several crops could be used as dryland crops in this scenario including winter wheat, soybeans or sunflowers.

Two or More Irrigated Crops

The use of two or more irrigated crops in a rotation may increase the number of irrigated acres as compared to a single irrigated crop and a dryland crop. The philosophy of this strategy is to use a high water use and response crop such as corn and a low water use and response crop such as winter wheat, soybean, dry edible beans or sunflowers. This strategy uses the yield vs irrigation to its maximum advantage. The first amounts of irrigation that are applied are used efficiently resulting in a yield response similar to that of the yield vs ET response shown in Figure 2.

The strategy to find the most economical split of water and acres is similar to that of the one irrigated crop strategy. Producers must look at the yield increase of adding water to one crop and the effect upon the irrigated acres and yield of the other irrigated crop. The potential options become more numerous because now producers need to look at increasing the irrigation amount for one crop versus reducing the irrigation amount to the other crop or increasing the number of irrigated acres for the other crop to compensate for the additional water to that crop. An example of this would be if you again had a water supply of 10 inches per acre available and are irrigating two crops such as corn and winter wheat. If a producer were irrigating corn at 15 inches per acre and wheat at 5 inches per acre, the irrigated acres would be even at 65 acres per crop to match your water supply. If this producer decides to irrigate wheat at 6 inches per acre, a first option would be irrigating corn at 14 inches per acre to keep the irrigated acres of each crop similar. A second option to keep corn at the 15 inch per acre of applied water would be to reduce the irrigated acres of corn and increase the irrigated acres of wheat. Using the second option, the final acres would be irrigating 58 acres of corn and 72 acres of wheat. When using three potentially irrigated crops, the options become even more numerous.

Rotation Considerations

It is important to look at the short-term rotation aspects with multiple crops being grown. One of the more important aspects is can a crop be grown after itself. There are several crops that do not perform well when planted after the same crop. The typical problem associated with this is the build up of diseases and weeds in the system. Crops such as winter wheat, soybeans or sunflowers should not be grown immediately after itself so this must be a consideration in how many acres of each crop can be grown or whether to grow more than two irrigated crops to increase the options in the rotation.

Low Capacity Systems

When working with low capacity systems, irrigation management strategies are limited due to the systems ability to meet the ET of the crop during the critical and high ET time periods. Irrigators must start their systems before the soil moisture reaches typical management criteria with best management practices. This must be done since the system can not replace the used soil moisture and crop ET so the soil must be managed so that it is closer to field capacity in anticipation of the greater crop ET demand later in the season. The use of more than one irrigated crop decreases the amount of irrigated acres at any one point in time so the system can apply water closer to or in excess of the demand by the crop.

Another important consideration with more than one irrigated crop is to choose crops that do not have critical water timing needs. Crops such as winter wheat and corn fit together well in a system such as this since wheat uses water in May and early June while corn requires water during July and early August. Planting two crops that have similar water timing needs together is not advantageous since both crops would be irrigated at the same time.

CALCULATING CROP ENTERPRISE COST OF PRODUCTION

Calculating cost of production and enterprise net returns is accomplished with enterprise budgeting techniques. In basic terms, an enterprise budget is a listing of income generated and expenses incurred to produce that income. In this setting, the enterprise is the production of corn, winter wheat, soybean, dry edible bean or sunflower, whichever crop is used in the rotation.

Enterprise Income

The income section of the budget lists all the income generated per acre from production of the crop. This would also include any secondary income such as aftermath grazing or roughage sales. For planning purposes, it would be more efficient not to include government programs in this analysis, but recognize net income will be lower as a result. The price received for each commodity can be based on national crop loan rates as a minimum. A realistic expectation of price received will produce realistic results in the analysis.

Enterprise Expenses

The expense section of the enterprise budget lists all the expenses associated with production of the commodity. The expenses can be broken down by variable and fixed costs. Variable costs of production are those costs that change with the level of production. For instance, fertilizer cost increase as more fertilizer is applied to increase crop yield. Other variable costs include seed, chemical inputs, fuel and labor among others. In the absence of accurate machinery operating costs, custom rate estimates can be substituted in the enterprise budget. A breakdown of all expenses included in the custom rate will be required to avoid double counting of fixed or variable expenses.

Fixed costs of production are those costs that need to be covered regardless of whether production occurs or not. These include machinery replacement, land and machinery debt payments, lease payments and other overhead costs such as insurance, taxes and interest payments.

Enterprise Net Income

The net income section of the budget calculates the difference between estimated cost and returns. A positive difference (income – expenses = net income) indicates there is a positive return to the factors of production whereas a negative return would indicate the income generated is not sufficient to cover the factors of production.

Once net return per acre is calculated for each enterprise, then net return for the chosen mix of crops to be produced under a limited irrigation situation can be determined. Working through this process on paper will identify the best option for producing the greatest net returns given resource limitations.

SPREADSHEET

A spreadsheet is under development to help producers determine the optimum crop mix is under development. This tool will allow producers to input cost of production, yield vs irrigation production functions and water allotments. The spreadsheet will then give producers a starting point in helping them determine the optimum crop mix and water allocation for several management options. This spreadsheet should be available in March or April.

CONCLUSION

It is important for producers to consider management and cropping practice changes when faced with limited water availability. Management strategies for limited water generally favor introduction of low water use crops to supplement high response crops. Full irrigation management strategies favor high water use-high response crops. An economic analysis will help producers with decisions on what irrigated crops are to be grown and how much water will be applied to each crop. It is important to for producers to have accurate information relating to yield response of crops to irrigation in making these decisions.