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Drought Response - Agriculture Water Management Alternatives

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This summer's drought conditions have stimulated producer interest in strategies to reduce risk. It is too late to apply some risk-reduction strategies, such as buying crop insurance. However, one strategy producers can still consider this summer is management of irrigation water. How can a limited amount of water be managed to the best advantage?

Assuming not enough water is available to irrigate all crops, should a little be applied to the entire acreage? Or, should the full amount be applied to fewer acres? **No matter which strategy is chosen, water should go first to the crop or crops that offer the highest economic payoff from irrigation.**

This discussion is designed to help producers decide what to do with available water resources. For simplicity, this discussion will focus on alfalfa production with case studies. The results of this case study example may not be applicable to grain crops where timing of irrigation can be more important than the seasonal quantity of water. Another exception is that of fruit trees and grape vines, which need occasional watering for plant survival.

Case Study Assumptions

- The crop is alfalfa hay in Millard County.
- Sprinkler irrigation, water is pumped from a canal.
- There will be no rains to supplement irrigation.
- The water-holding capacity of the soil is 2 inches per foot of root zone, with a 5-foot root zone, for total capacity of 10 inches.
- Irrigation efficiency is 70 percent; i.e. irrigation water stored in the soil = 0.7 × applied water. (This is due to non uniform application, evaporation, and other water losses.)
- The timing of irrigation makes no difference in crop response to water.
- All harvest machinery is owned so fixed costs are ignored.
- Alfalfa too short to harvest is worth $9 an acre as pasture.

FIELD RESEARCH

Research at Utah State University (Hill, 1983) indicated that alfalfa yields in Millard County had the response to water as shown in Figure 1. The relationship of alfalfa yield to water use can be estimated as,

$$Y = 0.243 \times Et - 0.765 \qquad \text{(Equation 1)}$$

where Y is alfalfa yield in tons per acre at 12 percent moisture, and Et is crop water use (evapotranspiration) in inches. For example, with 5 inches of soil moisture and no additional water applied, the expected yield would be 0.45 tons per acre of alfalfa (0.45 = 0.243 × 5.0 - 0.765). Because the yield equation is linear, the marginal value of water is the same, regardless of the amount of application, as long as the water-holding capacity of the soil is not exceeded.

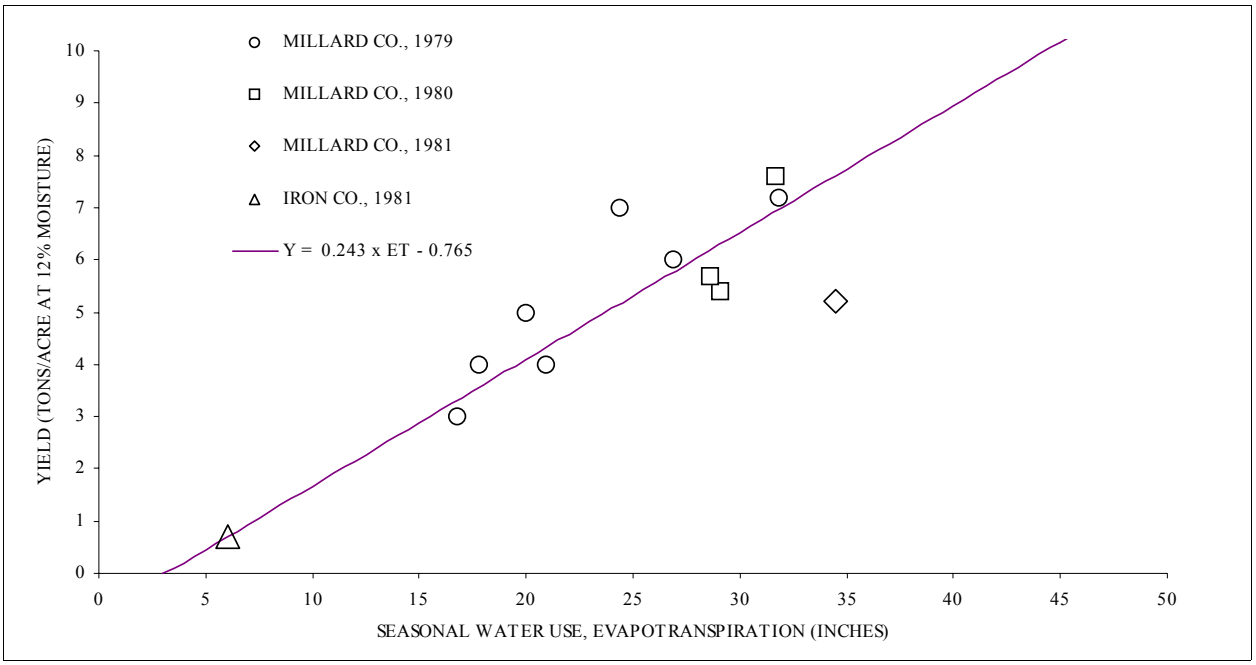

Figure 1. Alfalfa Yield and Water Use, Millard and Iron Counties, Utah, 1979-1981. The solid line represents the yield/Et relationship described in Equation 1.

Expected yields for various amounts of applied irrigation water and selected levels of existing soil moisture are shown in Table 1. The value of 0.45 tons per acre is found at the intersection of 0.0 inches of applied irrigation water and 5.0 inches of soil water in Table 1.

GIVEN A LIMITED AMOUNT OF WATER FOR ALFALFA, HOW SHOULD IT BE ALLOCATED?

Table 1 shows estimated yields for a single cutting for four levels of available soil moisture and for varying amounts of applied irrigation water. As can be seen, if available moisture in the soil is 3 inches or less, there will be no yield without additional water from irrigation or rain. As an example of how to use the table, assume a farm with 100 acres of alfalfa. Assume also that only 350 acre-inches of water are available. The decision is how to allocate the

limited amount of water to maximize benefits. Should 3.5 inches be applied to the full 100 acres, 7 inches to 50 acres or some other combination? The two cases that follow will show how one might approach this problem.

Table 1. Alfalfa Yield Response to Selected Amounts of Applied Irrigation Water, Based on Equation 1.

Applied Irrigation (Inches)	Net Irrigation (Inches)[a]	Available Soil Water Prior to Irrigation (Inches) 2.0	3.0	4.0	5.0
		Estimated Tons of Alfalfa Per Acre			
0.0	.00	.00	.00	.21	.45
1.0	.70	.00	.13	.38	.62
3.5 [b]	2.45	.32	.56	.80	1.05
5.0	3.50	.57	.81	1.06	1.30
7.0	4.90	.91	1.15	1.40	1.64
8.6 [b]	6.02	1.18	1.43	1.67	
10.0	7.00	1.42	1.67		
11.5 [b]	8.05	1.68			

Note: Estimated alfalfa yield values given only for combinations of soil water and net irrigation less than 10 inches.
[a]Assumes 70 percent irrigation application efficiency.
[b]Value selected to match example used herein.

CASE 1

Assume that existing soil moisture is only 2 inches. If 3.5 inches are applied to the full 100 acres, the total expected yield would be 32 tons (0.32 tons per acre × 100 acres). The critical question is whether the stand would be too short to harvest mechanically. If the full 350 acre-inches is applied to 50 acres, each acre receives 7 inches. The expected yield would be 45.5 tons (0.91 tons × 50 acres + 0 tons × 50 acres). Clearly, this is better than spreading the available water over the entire 100 acres. Is there even a better alternative? Recall that the water-holding capacity of the soil is 10 inches. What would be the total expected yield if enough water was applied to bring the soil moisture to 10 inches on as many acres as possible?

With the existing soil-moisture reserve at 2 inches, a net of 8 inches of water is needed to bring the soil up to capacity. Looking at columns 1 and 2 in the table, it can be seen that, at 70 percent irrigation efficiency, about 11.5 inches of water would have to be applied per acre. With only 350 acre-inches available, there is enough water for only 30 acres. But the expected yield would be 50 tons (1.68 × 30 acres). This appears to be the "best" strategy since the total yield is higher than either of the two earlier examples, and fewer acres have to be irrigated and harvested.

CASE 2

Assume (as in Case 1) that 350 acre-inches of water are available, but there is a reserve of 4 inches of moisture in the soil. Would a different strategy be chosen? If 3.5 inches were

applied to the full 100 acres, the total expected yield on the entire 100 acres would be 80 tons (.80 × 100). If 7 inches were applied to 50 acres, the expected yield would also be 80 tons (1.4 × 50 + 0.21 × 50). However, the 0.21 tons per acre on the unirrigated portion would probably be too short to harvest mechanically. Only 70 tons could be harvested. The other 10.5 tons would probably have to be harvested by grazing. The question is, would the value of the extra 10.5 tons more than offset the variable costs of irrigating and harvesting the other 50 acres? Finally, what would be the total expected yield if as many acres as possible were brought up to a full 10 inches of moisture? With existing moisture at 4 inches, a net of 6 inches would have to be applied. From Table 1, it can be seen that it would take about 8.5 inches of water. There is enough water for about 41 acres. With an expected yield of 1.67 tons per acre, approximately 68 tons could be harvested. There would still be about 12 tons (0.21 × 59) that could be grazed, making a total of 80 tons.

WHAT IS THE BEST STRATEGY?

In Case 1, where moisture reserves are low, it appears that the appropriate strategy would be to apply a full irrigation to as many acres as possible and let the rest go.

The "best" strategy is not so clear where the soil moisture reserves are not severely depleted, as in Case 2. Where the water is spread evenly over the entire acreage, 80 tons could be harvested. At $80 a ton, the total value of the crop would be $6,400. If 7 inches were applied to 50 acres, the value, including 50 acres of pasture at $9 an acre would be $6,050. Unless the other 50 acres can be irrigated and harvested for under $350, the "best" choice of these two alternatives is to irrigate only 50 acres and graze the remaining 50 acres.

Where a full irrigation is given to only 41 acres, the value of the hay and pasture would be $6,009. This is $41 less than expected by irrigating 50 acres. It is doubtful that the additional 9 acres could be irrigated and harvested for $41. So it appears that irrigating fewer acres is the more profitable alternative in this situation as well.

COMMENTS

When water is scarce, crops that offer the highest net return should be watered first. For a particular crop, one must then determine whether to lightly irrigate a large acreage or apply large amounts to a smaller acreage.

Not all crops respond the same to water. Moreover, the same crop may respond differently under different climatic or soil conditions.

Depending on field conditions, alfalfa that is severely stressed one year may not yield well the following year due to poor stands, and may need reestablishment sooner. Crop-response curves or production functions are best estimated by research, but producers may have to rely on experience and judgment. However, some generalizations can be made. If there is enough soil moisture without irrigation to produce a crop that can be harvested mechanically, total harvestable yield could be increased by spreading the water more or less equally over the entire acreage. If the crop would not be tall enough to harvest without irrigation, costs could probably be minimized by applying all existing water to fewer acres. The example discussed herein is based on the response of alfalfa to water in the Millard County area. There is a linear response to water in this case that might not hold in all areas. Still, the principles discussed may be helpful to producers faced with decisions on the best way to allocate a limited supply of water.

Other Considerations For Agricultural Water Conservation

- Stop irrigating - revert back to rain-fed or dryland cropping. (This would not make sense in a drought year if soil moisture levels are too low to produce any crop.)
- Apply only what is necessary to meet crop water requirements - use weather, soils and crop information to estimate crop needs. Estimates of crop water use in Utah can be found in the county specific electronic fact sheets "Sprinklers, Crop Water Use, and Irrigation Time" at http://extension.usu.edu/publica/engrpub2.htm (see also Hill, 1994).
- Evaluate your irrigation system - know how much water you are applying and how uniformly it is distributed. Adjust hardware and management if necessary to improve uniformity and scheduling. As a general rule, field crops should be irrigated whenever the soil water depletion approaches 50% of the available water in the root zone. This minimizes crop stress and keeps yields high.

Many factors influence irrigation system application efficiency. For sprinkler systems, these include operating pressure, nozzle size and spacing, wind, air temperature (day versus night), interval between irrigations and maintenance condition. In some cases, more water savings may be realized by management changes than by hardware repairs.

In many ways agricultural water conservation, where water is being pumped, is synonymous with irrigation energy conservation. A worksheet on irrigation energy conservation is available at:
http://extension.usu.edu/publica/engrpub2.htm Then select "BIE/WM-02." This worksheet guides an irrigator through a basic assessment of his system.

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References

Hill, R.W. 1983. Alfalfa Yield and Water Use in Commercial Fields. ASCE Irrigation and Drainage Division Specialty Conference. Jackson, Wyoming, July 20-22.

Hill, R.W. 1994. Consumptive Use of Irrigated Crops in Utah. Utah Ag. Exp. Stn. Research Report #145. Utah State University, Logan, UT. This may be found on the web at: http://nrwrtl.nr.state.ut.us/manuals/consumpt/cfwea.htm.

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