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IRRIGATION CAPACITIES IMPACT UPON LIMITED IRRIGATION MANAGEMENT AND CROPPING SYSTEMS

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INTRODUCTION

Irrigation capacity is an important issue for irrigation management. Having enough capacity to supplement precipitation and stored soil moisture to meet crop water needs during the growing season to maximize grain yield is important. However, declines in the Ogallala Aquifer have resulted in decreases in well outputs to the point where systems on the fringe of the aquifer can no longer meet crop water needs during average growing seasons and especially during drought years. Changing cropping practices can impact the irrigation management by irrigating crops that have different water timing needs so that fewer acres are irrigated at any one point during the growing season and concentrating the irrigation capacity on fewer acres while still irrigating the majority or all acres during the year.

Many producers have not changed cropping practices with marginal capacity systems due to management increases and the potential for an above average year. However, the risk of producing lower yields increases. Crop insurance has been used to offset those lower yields. However, the frequency of insurance claims has increased to the point where practices need to be changed on these systems.

System Capacities

System capacities are a function of soil type, crop water use and precipitation. The soil type acts as a bank where moisture reserves can be utilized during times when the irrigation system is not watering between cycles and during time periods when the system capacity is inadequate to meet crop water needs. Soils such as silt loams have a greater water holding capacity compared to sands which decreases the need for larger system capacities. Crop water use determines the total water utilized daily. Greater demand by the crop increases the amount of water needed for the crop over any time period. Precipitation is an important factor in irrigation capacity. A region with a greater probability of precipitation during the growing season will require less capacity to supplement crop growth.

Heermann determined the net design capacity for Eastern Colorado along with probabilities of meeting the crop water needs for the growing season for full water needs (Figure 1). As capacities decline the probability of meeting crop water needs declines. A 50% probability means that on average, you will meet crop water needs one out of two years and you will not meet crop water needs the other year. The result will be less than desired yields.

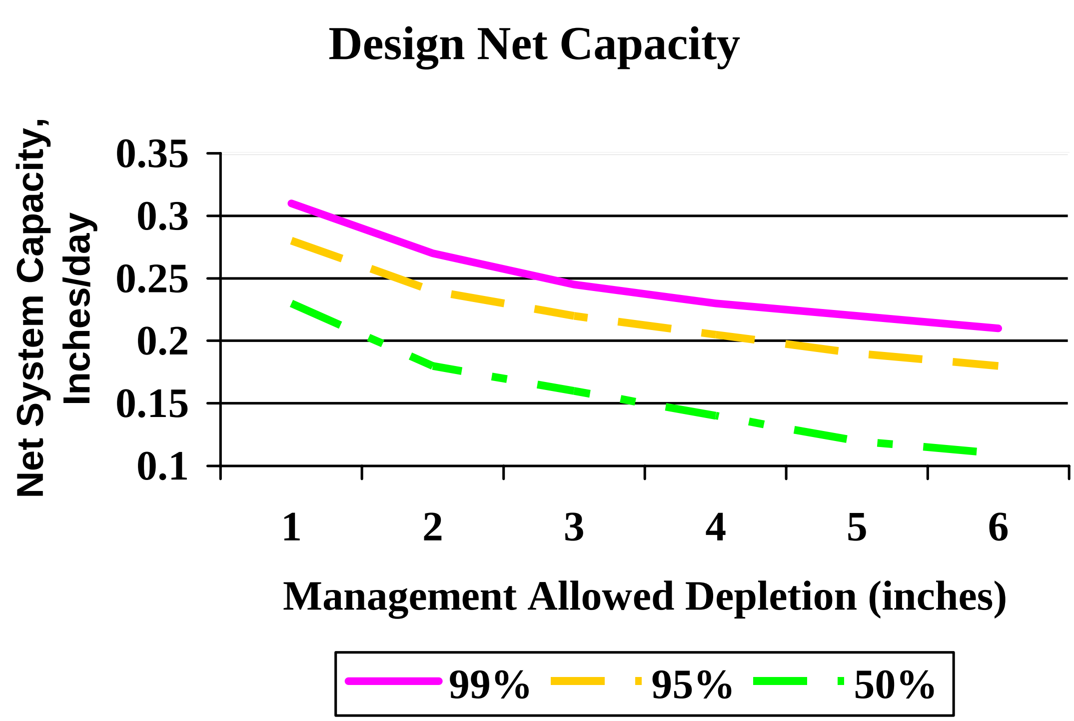

Figure 1. Net irrigation capacities for Eastern Colorado (Heermann).

Lamm (2004) found that irrigation capacities of 50% of needed to meet crop water requirements resulted in approximately 40 bu/acre less corn yields. In above average precipitation years, the yield difference is less and in drier than average years, the yield difference is greater. The economics of reducing irrigated acres until the irrigation capacity was equivalent to full irrigation capacities showed that irrigating those fewer acres was economically equal or greater than irrigating all of the acres for a single crop.

Lower capacity systems generally are inadequate for meeting crop water needs during the peak water use growth stages. This also coincides with the reproductive growth stages and less average annual precipitation during that time period of a summer crop. Water stress during that time period has more impact upon yield than during the vegetative and late grain fill growth stages (Sudar et al, 1981). Having water stress earlier or later is more desirable than during the reproductive growth stages of tassel, silking and pollination.

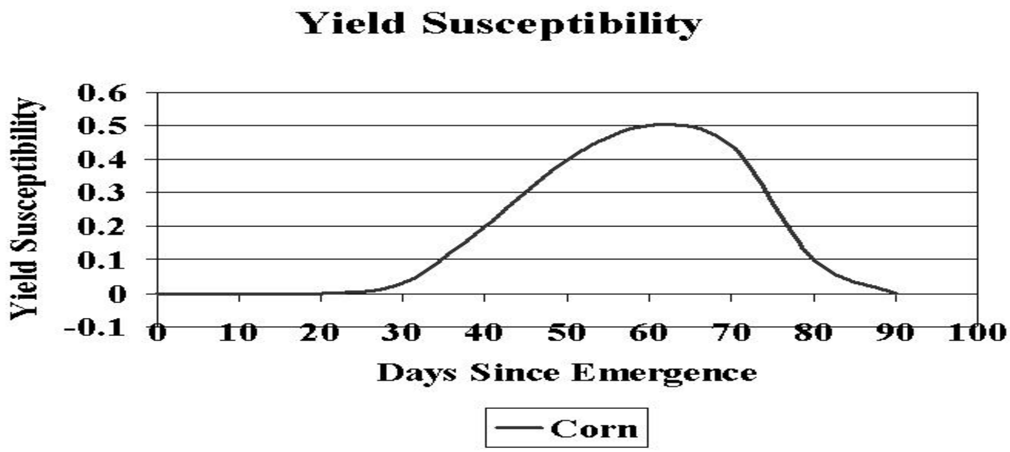

Figure 2. Yield susceptibility to water stress for corn (Sudar et al., 1981).

Management of low capacity systems generally entails by many producers running the system at times when it is not necessarily advantageous for water management but for the factor of “never wanting to fall behind and hope for the best”. This type of management generally applies more water than necessary during low water use time periods, can leach nitrogen and may not alleviate water stress during periods of little or no precipitation during the high water use growth stages.

SOIL MOISTURE SIMULATION

Two locations in Colorado were chosen for simulation of multiple irrigation system capacities. Wiggins in 2007 had below average precipitation and Burlington in 2005 had above average precipitation. Precipitation in Burlington may have been above average but was concentrated in the early growing season for corn. A water balance model was used to determine crop water use and soil moisture depletion using weather data from each location and predicted irrigation maintaining soil moisture depletion between 0 and 50% if possible. Irrigation was scheduled to minimize leaching during the growing season. Beginning soil moisture was assumed to be at field capacity either from off-season precipitation or pre-irrigation. Both sites have similar water holding capacities of 1.8 to 2.0 inches per foot.

Simulated irrigation capacities include: 1 inch every 4 days (4.7 gpm/acre), 1 inch every 6 days (3.14 gpm/acre), and 1 inch every 8 days (2.36 gpm/acre).   These capacities relate to a 600 gpm to a 300 gpm well for a 125 acre field. These are a typical range of well capacities within eastern Colorado.

Wiggins

Precipitation at Wiggins was below average for May and June and near average for July and August (Table 1). The majority of the precipitation in July and August was during the last 7 days of July and first 10 days of August. Average annual crop water use for corn is approximately 24 inches.

Table 1. Monthly and average precipitation for Wiggin, Co for 2007 and Burlington, CO for 2005.

	Wiggins		Burlington	
Month	Precipitation (inches)	Average (inches)	Precipitation (inches)	Average (inches)
May	1.65	2.41	4.03	2.88
June	0.31	1.98	5.08	2.50
July	2.29	1.93	2.36	2.77
August	2.49	1.58	3.15	2.28
September	0.52	1.21	0.80	1.04

Irrigation capacities had an impact upon soil moisture depletions (Figure 3). A capacity of 1 inch every 4 days was adequate for full irrigation. Soil moisture depletions did not approach 50% until the end of the growing season after the irrigation system was shut off. A system capacity of 1 inch every 6 days or less was inadequate with soil depletions greater than 50% occurring in late July.

Soil moisture depletions were critical in late July for the 1 inch in 6 and 8 days. Corn would have been in the critical growth stage of tassel and pollination during this time period. This is the time period of 60 to 80 days after emergence when Sudar determined that the greatest yield reduction would occur. This would limit yields dramatically compared to an adequate capacity that would maintain soil moisture less than 50% depletion.

Precipitation of 3.5 inches during late July and early August allowed soil depletions for both the 1 inch in 6 and 8 days to be less than 50%. However only the 1 inch in 6 days remained less than 50% depletion during the remainder of the growing season. The soil moisture depletion for the 1 inch in 8 days capacity was greater than 50% after mid-August during the grain fill time period. This water stress has less impact than during the tassel and pollination time period but still will reduce grain yields.

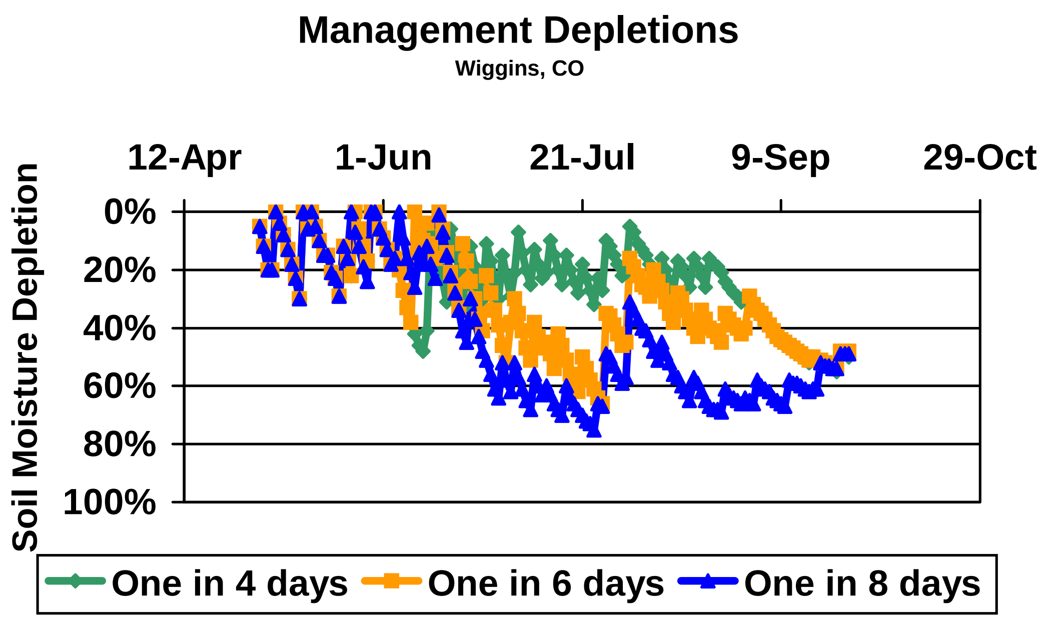

Figure 3. Soil moisture depletions for 3 irrigation capacities at Wiggins, Colorado for 2007.

With an irrigation capacity of 1 in 4 inches per day, the system was rarely turned off. Only during the time period of above average precipitation of late July and early August could the system been turn off. If irrigated acreage for corn were reduced to this capacity per acre, the only irrigation option for the remainder of the acres would be an early spring crop with the need for irrigation done by early June.

Burlington

Precipitation at Burlington in 2005 was above average for May and June and near average for July and August (Table 1). Precipitation in May and June totaled more than 9 inches which is 3.5 inches greater than average. During July, there was a 21 day period where little precipitation occurred. Less than 1 inch of precipitation occurred during the first 21 days of August. Average water use for corn is approximately 27 inches at Burlington.

Although precipitation was above average at Burlington, irrigation capacities had a significant impact upon soil moisture depletion (Figure 4). An irrigation capacity of 1 inch in 4 days was adequate to maintain soil moisture depletions of less than 50% during the growing season. However, soil moisture depletions during late July and early August were greater than 40%. System capacities of 1 inch in 6 days or less were inadequate with soil moisture depletions greater than 50% in late July and to late August.

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Soil moisture depletions for system capacities of 1 inch in 6 days or less were greater than 50% during the entire reproductive growth stage. During a majority of this time period, soil moisture depletions were greater than 60% and approached 80% for the 1 inch in 8 days capacity. Soil moisture depletions were less than 50% in late August only after two precipitation events totaling more than 2 inches occurred.

Although total precipitation for the entire growing season was above average by almost 4 inches, timing of that precipitation was critical. Precipitation during July and August was near average showing the importance of adequate system capacities during the time period when crop water use was almost 14 inches.

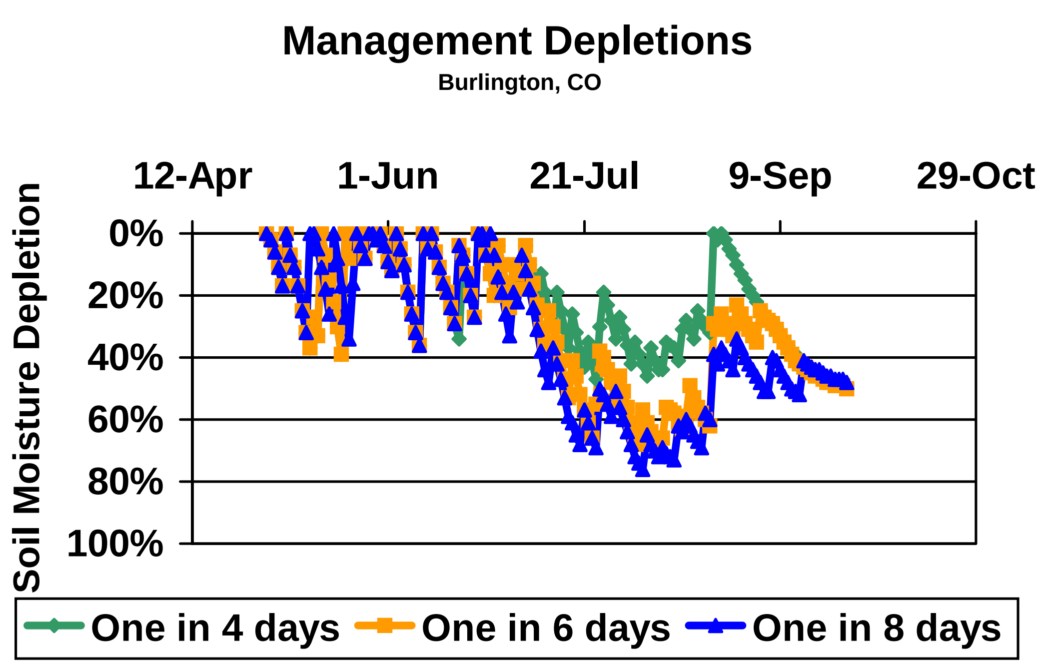

Figure 4. Soil moisture depletions for 3 irrigation capacities at Burlington, Colorado for 2005.

Alternate Strategies

Although an irrigation capacity of 1 inch in 4 days was adequate for irrigating corn during the growing season. The options for irrigating another summer crop are limited since the system rarely was off for long periods of time during July and August. The only practical option would be to irrigate an early spring crop on those acres. A second scenario was simulated including the capacity of 1 inch in 3 days and the potential to divert irrigation to the remainder of potentially irrigatable acres. Crops such as sunflower respond well to limited amounts of irrigation during critical time periods (Schneekloth). Schneekloth found that irrigating oil sunflowers during the early flower to pedal drop yielded similarly to fully irrigated sunflowers. This time period is a two to three week period that occurs in early August when sunflowers are planted in late May.

Simulating a 1 inch in 3 days system capacity, irrigation to a summer crop such as corn could be reduced during the first 3 weeks of August and with the majority of irrigation being diverted to a crop such as sunflowers (Figure 5). Soil moisture depletions increased during that time period but were still less than 50% before primary irrigation of the corn resumed.

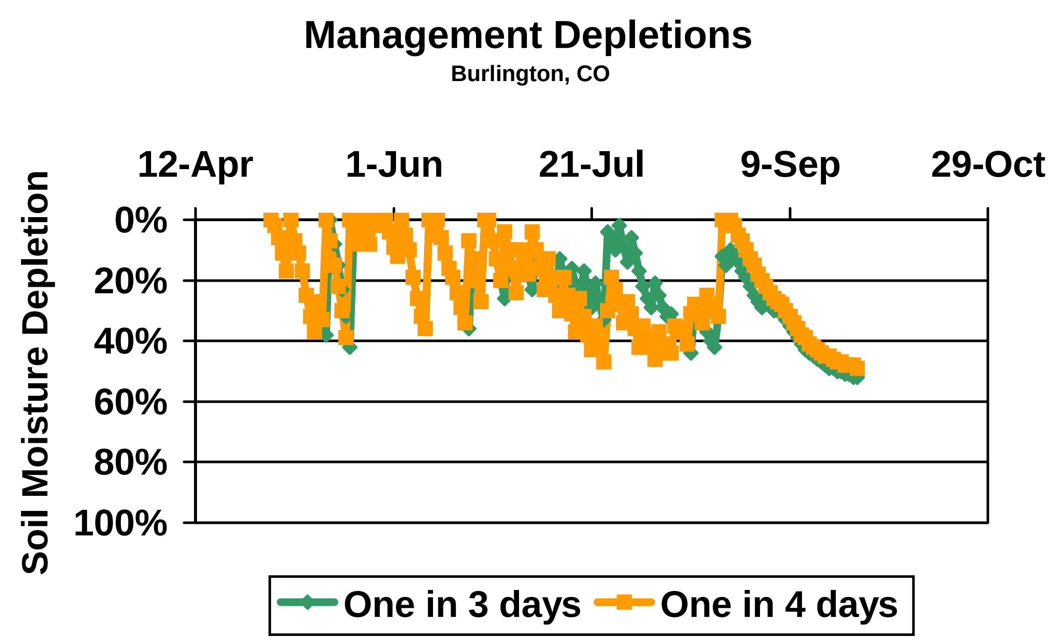

Figure 5. Soil moisture depletions for an irrigation capacity that would allow diverting irrigation to a secondary summer crop compared to an adequate capacity for full irrigation at Burlington, Colorado for 2005.

This strategy would allow for more total acres to be irrigated with more diversity but fewer acres of any one single crop.

CONCLUSION

Although both Wiggins and Burlington had dramatically different weather conditions, the minimum acceptable system capacity was similar at 1 inch in 4 days. However, this capacity may require diverting water from acres to achieve this capacity for a limited number of acres. However, spreading water over more acres with lower capacities generally will have water stress at the critical growth stages that will impact yield potential the greatest.

When dealing with system capacities that are not adequate for full irrigation management of the system, the potential for less than optimum yields increases, as does the risk involved. Alternative cropping practices must be included that diversify crops and reduce the irrigated acreage of any one crop. However, the critical time periods should not overlap unless alternative water capacity strategies are investigated.

Irrigating all of the acres with a marginal system capacity increases the reliance upon crop insurance to minimize the risk when precipitation is either below average or the distribution is not uniform. However, crop insurance in the future may limit this due to their increase exposure for risk.

References:

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