MANAGING A POTATO CROP WITH REDUCED WATER SUPPLIES

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Potatoes have a relatively shallow root zone and a lower tolerance for water stress than most other crops grown in Idaho. The preference for producing this drought sensitive crop in coarse-textured soils with limited water holding capacity makes precise irrigation management a necessity to obtain optimum yield and quality. When restricted water availability reduces potato production potential, options for increasing water use efficiency need to be considered.

Management strategies for dealing with water shortages are relatively limited and are often controlled by decisions made at the irrigation or water district level. However, producers can partially mitigate these effects by preparing for anticipated water shortages before the crop is planted. In addition to deficit irrigation management, producers should also consider changing other cultural practices under their control, including extent of potato acreage, field choice, variety selection, and seed condition and spacing.

Irrigation System Efficiency

The first step in optimizing the efficiency of any irrigation management program is to make sure the irrigation system is designed, maintained, and managed properly. Increasing irrigation efficiency to derive the most crop yield from every increment of water available will generally produce greater economic return than any other change in management. Irrigation scheduling and irrigation uniformity are two key management factors affecting irrigation efficiency. Irrigation scheduling involves determining the correct timing and amount of water necessary to maintain root zone moisture within the optimal range for crop growth. Irrigation uniformity is related to how evenly water is distributed over the field area.

An additional course of action is to evaluate possibilities for increasing the amount of available water per acre of potatoes produced. Potential courses of action include purchasing additional water from surrounding water users, selecting other crops that are drought tolerant or reducing acreage of other crops and transferring the water to the potato crop and reducing or eliminating potato acreage. If possible, the soil profile should be filled to field capacity during the fall or early spring prior to planting when water supplies are usually greater than later in the growing season.

Research has shown that potato tuber yield and quality will be impacted by even short periods of water stress. The extent of the damage to tuber yield and quality will depend upon the severity, timing, and duration of water stress during the growing season. Several studies have shown that water stress during the tuber set and early bulking growth stages causes the greatest reductions in tuber yield and quality relative to other growth stages. Water deficits spread over the latter part of the growing season generally have less impact on tuber yield and quality than an equivalent reduction in crop water use over a shorter period of time.

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Nitrogen Fertilization

If deficit irrigation management is going to be implemented, the nitrogen management plans need to be adjusted accordingly. The degree of yield response to nitrogen fertilizer decreases markedly as crop water use is reduced by water stress. Specific gravity is also greatly affected by water and nitrogen management. Specific gravity generally decreases when water stress and high N application rates are combined. High nitrogen availability during late tuber bulking also often delays tuber maturity. However, these effects are dependent on duration and amount of nitrogen and water availability, location, environment, variety, and other stresses on the crop. Research in Idaho has shown that for every 15 to 20 percent reduction in water application from the optimum amount during the growing season, nitrogen requirements for maximum yield decline by 40 lb N per acre (Table 1). Applying large amounts of pre-plant nitrogen should also be avoided since it likely will delay tuber bulking and make the impact of late season water stress more pronounced.

Field Choice

If possible, potatoes should be grown on fields that have the greatest potential for maintaining adequate soil moisture under deficit irrigation management. Coarse-textured soils such as sands and sandy loams have low water-holding capacities and will lead to rapid development of water stress under deficit irrigation. In comparison, soils with relatively high water-holding capacities, such as loams and silt loams, allow water stress to develop at a slower rate, reducing its impact on yield and quality. Fields with serious compaction problems or hardpans should be avoided because they limit root development making it more difficult for the crop to obtain adequate water supplies from the deeper part of the root zone. Tillage practices should be used that limit the development of restrictive layers in the root zone and allow full development of the crop root system.

Variety

Variety choice can be an important tool in dealing with irrigation water deficits. Potato varieties vary widely in maturity and in ability to withstand water stress. One or both of these traits can help with avoidance of serious losses in short water situations. Planting an early maturing variety can help a grower avoid crop damage resulting from a late-season loss of water supply. Planting a drought resistant variety will minimize losses caused by any condition imposed by water shortage.

Varietal differences in drought resistance are illustrated by results of a study wherein potato varieties were exposed to five different water deficit scenarios (Table 2). Treatments included 1) application of irrigation water to provide 100% ET replacement for the full season, 2) providing 100% ET replacement until Aug 10 with no application thereafter, 3) providing 75% of ET replacement for the full season, 4) providing 75% of ET replacement until Aug 10 with no application thereafter, or 5) providing 100% of ET replacement until July 20 with a reduction to 75% of ET until Aug 10 and then decreasing to 50% ET replacement until vine kill.

Results of this study show that providing full irrigation through mid-bulking followed by a slow reduction in irrigation amounts was the best scenario in a water short situation. Second, a late maturing, stress susceptible variety like Russet Burbank, is subject to large losses of

marketable tubers under either moderate season-long stress, or sudden severe water stress caused by termination of irrigation. Third, an early maturing variety like Russet Norkotah can withstand late season loss of water with little or no loss of yield as long as there is sufficient water during tuber bulking. Fourth, a variety like GemStar Russet, although affected by water deficits, can maintain high yields of marketable tubers, even under fairly severe stress. Results from this same study show that even varieties within a similar maturity class are affected differently by water stress. Alturas, for example, is a late maturing variety like Russet Burbank and Ranger Russet, but is even more affected by late season loss of water supply. This is likely due to a high water demand late-season, and its tendency for late tuber bulking. Below is a limited list of current varieties that may be used when irrigation deficits are likely:

Early Maturing Varieties
Russet Norkotah
Shepody (on early delivery contract)
Ranger Russet (on early delivery contract)
Many red varieties including Red Norland, Red LaSoda, NorDonna, Mazama, Modoc

Drought Tolerant Varieties
Ranger Russet
GemStar Russet
A93157-6LS

Varieties that can be used in water deficit situations may require specific management considerations to produce a high-quality crop. For the most common varieties produced in Idaho, here are some useful irrigation management tips:

Ranger Russet: Although relatively resistant to drought stress from the standpoint of yield loss, Ranger Russet is prone to tuber quality problems if stressed during tuber set and early bulking. Stress during this critical early period results in sugar ends and long, narrow shaped tubers. Consequently, even when water is in short supply, full water use requirements should be met during the period from tuber set through early tuber bulking. Ranger Russet also is susceptible to blackspot bruise and should not be handled when tubers are dehydrated or when soils are dry and hard. Adequate moisture should be made available to allow harvest under ideal soil moisture conditions.

Russet Norkotah and Strains: Russet Norkotah has a relatively shallow root system and therefore is relatively susceptible to early season drought stress. However, Russet Norkotahs would be a good choice in drought situations where water supplies were likely to run out much earlier than normal because of its early development. There are several line selections of Russet Norkotah including medium maturing strains (CO#8, TXNS112, TXNS223, TXNS278, and TXNS296) and a late maturing strain (CO#3). If a water shortage is expected during the later stages of the season, the standard Russet Norkotah should be planted. The medium maturing lines may produce adequately in this situation, but the late strain(s) should be avoided.

Alturas: This variety is not a good choice where drought is anticipated. Alturas is a heavy water user during most of the growing season and is especially susceptible to late-season

water deficits. If a water shortage does develop during production of an Alturas crop, it is better to let the water supply decline gradually rather than to abruptly cut it off.

GemStar Russet: This variety has excellent drought tolerance characteristics and is a good choice during water shortage situations. It seems to respond better to a season-long, moderate water stress, rather than a sudden loss of supply, if the loss occurs prior to 1 month before harvest. If a water deficit can be controlled, GemStar Russet will produce a nearly normal crop if a late-season shortage can be applied as a gradually decreasing supply rather than a sudden cut-off.

A93157-6LS: This clone has shown good tolerance to drought over a wide range of moisture levels. It maintains good external and internal tuber characteristics when stressed.

Seed Condition and Spacing

Physiological aging of potato seed often results in earlier plant emergence and tuber development. If water shortages are anticipated late in the season, accelerating tuber development by planting seed that has been aged by warming during storage may be advantageous. This may reduce the magnitude of yield reduction from early irrigation cutoff by completing more of the tuber bulking growth stage before water stress develops. Seed piece spacing can also be modified to partially mitigate the effects of water stress on tuber yield and quality during tuber bulking stress. Research with Alturas has shown that widening seed spacing can improve yield and quality during drought.

Summary. Potato production with marginal water supplies is quite risky and should be avoided if possible. However, in situations where regional water shortages are prevalent, appropriate adjustments in crop management strategies should be implemented to minimize exposure to drought risk. Timing of water stress is important in order to maximize yield and quality under restricted water availability. Spreading water deficits over the latter part of the season will result in the least reduction in tuber yield and quality. Unfortunately, decisions made at the irrigation district level may limit the flexibility of deficit irrigation management. If possible, irrigation deficits should be avoided during tuber initiation and mid-bulking to minimize reductions in yield and quality. Modification of irrigation, variety selection, fertility, and other cultural management practices according to anticipated water availability can partially mitigate tuber yield and quality reductions.

Table 1. Russet Burbank yield response with five nitrogen application rates and four seasonal water application amounts at the Aberdeen Research and Extension Center. The highest water application amount was 100% of crop water requirement

	Seasonal Irrigation Applied (inches)			
N Rate	13.0	15.4	16.8	18.2
lb/ac	---------- Relative Yield (%) ----------			
0	87.4	89.5	86.0	89.6
40	100.0	100.0	97.0	95.9
80	98.6	100.0	100.0	98.8
120	93.5	96.8	97.0	100.0
160	91.3	95.6	93.6	95.9

Adapted from Ojala, J.C., J.C. Stark, and G.E. Kleinkopf. 1990. Influence of irrigation and nitrogen management on potato yield and quality. *Am. Potato J*. 67:29-43.

Table 2. Comparison of relative U.S. No. 1 yields of six potato varieties under five irrigation deficit scenarios, Aberdeen Research and Extension Center, averaged over 2002-03. Data is presented as the percent yield in comparison with the control treatment (full evapotranspiration ET replacement, season-long).

	Irrigation Treatment[1]				
Variety	100% ET	100% Cut Off	75% ET	75% Cut Off	100-75-50%
Alturas	100	71	71	37	77
GemStar Russet	100	76	80	58	82
Ranger Russet	100	72	78	53	82
Russet Burbank	100	80	76	68	96
Russet Norkotah	100	97	84	81	98
Summit Russet	100	79	83	54	83

[1] 100% ET = application of irrigation water to provide 100% ET replacement for the full season; 100% Cutoff = 100% ET replacement until Aug 10 with no application thereafter; 75% ET = 75% of ET replacement for the full season; 75% Cut Off = 75% of ET replacement until Aug 10 with no application thereafter; 100-75-50% = 100% of ET replacement until July 20 with a reduction to 75% of ET until Aug 10 and then decreasing to 50% ET replacement until vine kill