Irrigating with Limited Water

Water allocations in drought years can be reduced in many irrigation districts due to limited runoff and storage. Some irrigators may have no water at all if they either bid back their power supply or sold their water. Some may have water early but not during grain fill, others may have limited water but can allocate throughout the entire small grain season.

There can be a variety of available water situations for individual operations. Each will present a unique challenge to maximize the effectiveness of the water available. The following was taken from an article prepared for Cereal Sentinel Issue 26.

Irrigation Scheduling

Irrigation scheduling using available soil water holding capacity and estimates of water used by crops can help producers use limited water supplies more effectively. The excessive use of water can be avoided and moisture stress can likewise be prevented with knowledge of available soil moisture and estimates of crop use.

If you don't already know, you need to determine the water holding capacity of the soils you farm. This is critical if you are to apply water sufficient to replenish that lost to evapotranspiration without over watering and wasting limited water supplies.

The rooting depth and texture alone give a reasonable approximation of water holding capacity. Silt loams generally hold well over 2 inches of available moisture per foot. Course sands or loamy sands may hold no more than 0.5 inches per foot. USDA Soil Surveys for individual counties frequently list the water holding capacity of soils that are mapped. The surveys are available at NRCS offices.

For estimating the moisture used by small grains, producers can access Bureau of Reclamation estimates of daily evapotranspiration calculated with local weather data from stations in the Treasure Valley. The information is available at the Agrimet website (http://mac1.pn.usbr.gov/Agrimet/).

The Agrimet ET values listed can be no more than estimates since actual conditions and crop growth stage may be somewhat different than the assumptions made in their model. Nevertheless, these estimates are reasonably accurate for most growth stages. If anything, they tend to overestimate ET at the latest growth stages when the crop is maturing.

Small Grain Growth Stage Stress Tolerance

Moisture stress is most damaging if it limits tillering and the number of heads produced, or it limits seed set during the jointing through flowering stage and reduces the numbers of seeds per head. How does this relate to the southwest Idaho environment and available moisture supplies?

Tillering

Usually we have sufficient rainfall in the fall and winter to satisfy the moisture required for adequate tillering. This is particularly true if the fall planted grain is pre-irrigated. Early fall planted wheat will produce it's most productive tillers in the fall and continue to produce additional tillers in the spring until late March or early April. Those last few tillers produced are seldom very productive and most can't be supported by the available light and resources and are aborted. Aborted tillers do not produce a seed bearing head.

For early to mid-fall planted grains, most irrigators don't have access to water during the tillering period since most districts, especially those with junior water rights don't provide water until the first to middle of April. Regardless of the snow pack or reservoir storage, if rainfall is below normal and above normal temperatures allow good growth during tillering in March , it is not unusual for sufficient stress to occur that lower leaves begin to senesce and tillering to be reduced before irrigation water is available in April. But for early to mid fall planted grain, the limited tillering in late March and early April probably has little effect on final yield because those later tillers in good stands are probably not seed bearing tillers anyway.

For late fall or early spring planted grain, tillering is more of an issue. For these plantings tillering occurs primarily in the spring during March and April. With little or no fall tillering, the grain is entirely dependent on spring conditions that can support tillering. Fall planted grain is typically more productive than spring plantings because of the greater tillering that occurs.

Spring plantings are limited in the tillering that occurs even under normal conditions. That's because most of our varieties are photoperiod sensitive and stop tillering when days reach a certain day length. Any early spring moisture stress exacerbates the tillering problem by limiting tillering even more.. Fortunately, available soil moisture can generally satisfy water required for tillering until water is available from the irrigation district.

Once water is available from the irrigation district or wells, producers should examine their grain for the tillers that have developed and whether moisture is limiting. If moisture is limiting, a light irrigation will promote additional tillers and increase yield, moreso in spring plantings than fall plantings.

Late spring (April) plantings are perhaps the most vulnerable. They are the least productive in part because the tillering period is so short But water is generally available during the tillering stage for late planted grain from wells or irrigation districts if producers choose to use it.

If there is an option as to which if any fields are abandoned due to lack of water, these later planted fields are the most likely candidates as they will be the least productive even if adequately watered. Earlier more productive plantings will make better use of limited moisture supplies.

In a practical sense then, there isn't much we can do in the spring for insuring adequate moisture during the tillering stage for early to mid fall planted grain. It is more of an issue for late fall planted and spring planted grain.

Stem Extension Through Flowering

The period from end of tillering to the flowering stage is the growth period when stress most affects yield of small grains. In water short years we need to focus on this series of growth stages.

Maintaining moisture at no less than 50% of available from jointing through flowering will insure adequate spikelet formation, and good pollination of the florets developed. If conditions are not provided to insure seed set, then the lost yield potential can not be restored with subsequent management. Limited water supplies are best used during these growth stages.

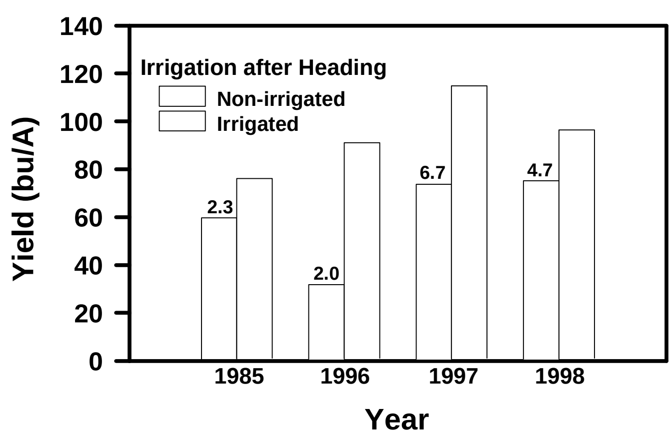

Figure 1. Yield of spring wheat as affected by irrigation after heading. Numerals above the non-irrigated columns are the inches of precipitation received in that year between jointing and maturity.

Grain Filling and Deficit Irrigation

Small grain yields are less sensitive to moisture stress during the grain filling period. Various irrigation studies have been conducted for our irrigated production system in the intermountain west. In studies at Parma we have evaluated various water treatments during the grain filling period. If spring wheat was fully irrigated prior to heading and no water was applied after heading (June 9-15 depending on the year), yields of spring wheat ranged from roughly 70% to 80% of maximum in a silt loam receiving from 0.78" to 2" of precipitation during grain fill (mid June to mid July). Yields were surprisingly good in this soil if moisture was not limiting through the flowering period and significant rainfall was received during grain fill (Fig. 1).

If soils were depleted prior to heading by as much as 3" as they were in 1996, yields without irrigation or significant rainfall during grain fill were only about 30% of the fully watered yields. Only 0.4 inches was received during grain fill.

Deficit irrigation refers to applying less water than is required to meet the full demand for evapotranspiration. A one year study on a loamy fine sand near Hermiston showed that yields were affected by less than 10% even though water provided from tillering to the end of the season was only 60% of the full predicted requirement.

On a loam soil near Prosser WA, wheat yields in two years of study did not differ significantly even though as little as 50% of the total requirement was applied on a daily basis from full canopy to maturity. In contrast, on a sandy soil with about half the water holding capacity, any moisture deficit from the full amount reduced yield.

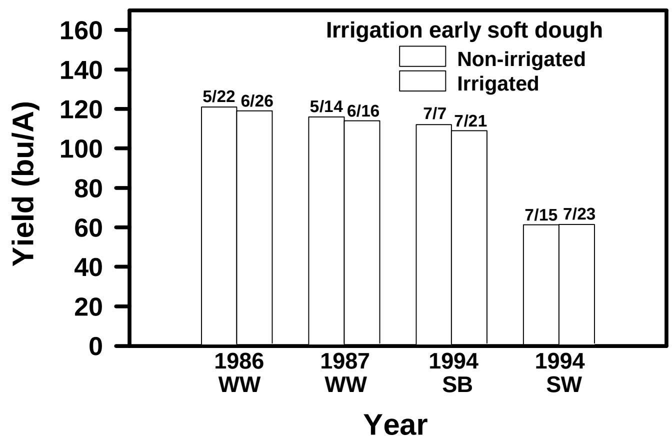

Figure 2. Yield of grain at Parma as affected by late season irrigation for winter wheat (WW), spring wheat (SW) and spring barley (SB). Dates above each column are the last irrigation for that treatment.

These studies suggest that wheat can be fairly tolerant of deficit irrigation provided there is a reservoir of soil moisture from which to draw from during the grain filling period. The lower the reservoir of stored soil moisture the greater the stress and yield reduction with deficit irrigation during grain fill.

Late Season Irrigation

One of the more frequently asked questions during June and early July is how soon can I shut the water off. The questions generally arise due to concerns about moving wheel lines or other sprinklers through fully grown wheat or concerns about the costs of pumping and pressurizing the system. For those with water to use, increased power rates is an added incentive to closely scrutinize the need for water during late grain filling.

Several area studies have addressed the timing of the last irrigation. In our work at Parma on a silt loam, there was no advantage in two years (1986-87) to irrigating at the late milk-early soft dough stage, (June 26, 1986 and June 16, 1987) even though it had been over a month since the previous irrigation (Fig. 2).

Over two inches of rain were received in 1987 between the last uniform irrigation on May 14 and the date that the last irrigation treatments were applied on June 16. But less than 0.2 inches were received in 1986 between the last uniform wetting on May 22 and the last irrigation treatment on June 26 in 1986.

It is hard to imagine winter wheat making do with so little water added during grain filling in these trials, especially during 1986. We don't know if yield was actually sacrificed in either year from lack of moisture during grain fill. But we do know that adding water at the early dough stage had no effect on yield.

While yield was not affected, watering at early soft dough resulted in increased black point in both years and increased lodging and lower test weight in one year.

The canopy was still green at the early dough stage and the only indication of approaching maturity was a partial loss of green color from the head and kernels. With such green growth still evident, few irrigators would have guessed that no additional water was needed.

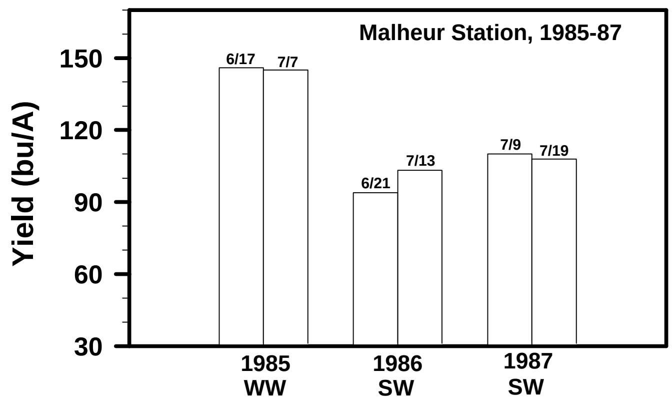

Figure 3. Winter or spring wheat yield as affected date of last irrigation at the Malheur Station during the 1985 - 1987 seasons. Date of last irrigation in shown

The soil continued to lose moisture beyond the early dough stage (2.4" in 1986 and 1.5" in 1987), but this moisture was not effectively used for increasing yield.

Spring wheat and barley responded similarly to late season irrigation at Parma in 1994. Barley yield, protein, and test weight were unaffected by last irrigations scheduled for mid milk stage (July 7) or early dough (July 15, 1993). Spring wheat yield, protein, and test weight were similarly unaffected by last irrigations applied at the mid milk stage (July 21) and early dough stage (July 23, 1993).

Similar studies were conducted by Clint Shock and others at the OSU Malheur Experiment Station near Ontario, Oregon. In 1985 Stephens winter wheat yield was unaffected by last irrigation dates ranging from June 17 (milk stage) to July 7 (soft dough) on a silt loam (Fig. 3). In 1986 and 1987 they evaluated similar treatments on spring wheat. Yield differed only about 10% between a last irrigation at the late watery ripe-early milk stage (June 21) and a last irrigation at the soft dough stage (July 13, 1986). There was no yield difference in last irrigations applied at the late milk-

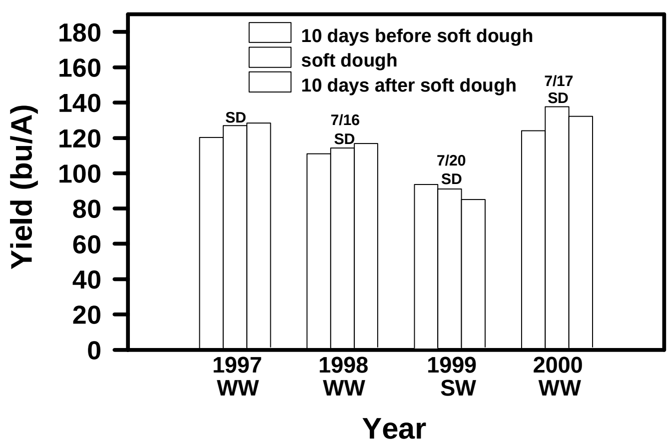

Figure 4. Wheat yield as affected by the timing of last irrigation relative to soft dough in the Magic Valley. The soft dough stage in each year is represented by the middle bar. The date of the soft dough stage is given where the information was available.

early soft dough stage (July 9) and late soft dough-hard dough stage (July 19) during the 1987 season.

More recently, Howard Neibling, the Cooperative Extension Irrigation Specialist, has evaluated last irrigation dates in the Magic Valley. There was no advantage to watering beyond soft dough (mid July) in any of the four years (1997-2000). Cutting the water off 10-12 days prior to soft dough resulted in yields that ranged from 90 to 103% of yields of winter wheat fully watered through the soft dough stage.

The results from several studies suggest that water should be applied no later than the soft dough stage and in many years yields will not be affected by cutting the water off as early as 10 days prior to soft dough or during the late milk stage. And in soils that hold sufficient moisture yields may not respond to water applied after flowering. Late grain filling is clearly a time when added water has the least effect on yield.

If sprinkler irrigation is used, pumping costs may be higher than in the past and growers should carefully consider the economics of applying their last wetting if at the soft dough stage.

Abandoned Winter Wheat?

In some cases winter wheat is planted in the fall and receives no additional water. For our dryland production this is the norm and seeding rates and fertilization practices are adjusted accordingly. But where agronomic practices for irrigated wheat were used and then the water is not available, the results can be disastrous. Pre-irrigated fall grain will have an advantage under these conditions.

Seeding rates for dryland wheat are typically just a fraction of the rates for irrigated wheat. This is because producers want to minimize soil moisture use during vegetative growth so that enough will be available during the flowering and grain filling period to at least support some production. Wider row spacings are used for the same reason in dryland systems.

Where two to three fold higher seeding rates were used than would otherwise be used for non-irrigated winter wheat, soil moisture reserves can be so seriously depleted that yield is reduced even from what it would be if optimum seeding rates were used.

If N fertilizers are applied preplant or during winter before it became apparent that water would not be available, this will exacerbate the problem. The extra N can promote excessive vegetative growth and additional soil moisture depletion that will likely reduce yield. If N fertilizer was not applied earlier, all the better, as there can be savings of the unnecessary expense as well as reducing vegetative growth and minimizing soil moisture depletion. Any reduction in vegetative growth will help reduce soil moisture depletion and importantly, the demand for moisture during grain filling.

Forage Alternatives

In the event that there is no water available for fall grain, and the likelihood of a breakeven grain crop is questionable, producers have a forage option that they might consider. The wheat is an excellent forage and is routinely used in the southern plains for over wintering beef.

The livestock is generally removed by the end of tillering and the crop is then allowed to re-grow and a grain crop is later taken. In some years the proceeds from leased grazing exceed the returns from the grain harvested.

In some years the expected returns from grazing wheat are attractive enough that the wheat is grazed throughout the spring and they forego a grain crop altogether. This typically occurs in years when grain prices are low and beef prices are good.

Dry matter yield in the crop will range depending on the stand and planting date but can easily measure 0.5 tons per acre at jointing. At the boot stage it can measure as much as 2.5 to 3 tons per acre depending on the planting date. This is a considerable forage resource.

There are a couple concerns with wheat pasture. One is grass tetany. Although grass tetany can be a problem with pastured rapidly growing cereal forages, ensiled cereal forages fed with other feed stocks are seldom a problem.

The other problem is nitrates. Even if excessive N from fertilization is not available, wheat, and other cereals can accumulate nitrates under moisture stress conditions. Nitrate concentrations can be high enough to kill livestock. Nitrates typically accumulate more in oats than wheat or barley. If pasturing grain in the vegetative stage, be aware of the nitrate content if they are moisture stressed. Ensiled cereal forages should not have problems with nitrates as the nitrates can be assimilated by microbial activity and the ensilage is seldom fed by itself. With pastured, hayed, or ensiled drought stressed forages, a nitrate test is recommended so that the feed can be fed appropriately.

There may be some advantages to grazing out the crop rather than taking off a poor grain crop. Grazing will minimize the residues that would normally need to be dealt with following a grain harvest. There is little stubble to contend with. With little stubble to return to the soil, there is little N required to compensate for it's decomposition. There is also some re-cycling of nutrients from the readily decomposable manures that remain on the field.

Desirability of renting wheat pasture and the price livestock producers are willing to pay depend on a number of factors. Fencing is not the issue it used to be what with the portable fencing available. Providing water to the animals is not uncommon where it is not otherwise available. But availability of water, the amount and quality of forage and duration of grazing can be significant issues. Potential renters may prefer enough forage resources to justify trucking the livestock to the resource and setting up the fencing.

The desirability of wheat pasture may also be influenced by the availability of other forage resources. Grass pastures will all be growing in the spring at the same time that the wheat is available, unlike grazing corn stalks in the fall or overwintering cattle in the southern plains when fewer alternatives are available.

In the southern Plains, wheat that is grazed out in lieu of a grain crop can support, with significant rainfall, an additional two months of grazing. But rainfall is more common and significant during this time in the southern Plains than in southern Idaho.

Cereal forages cut at the boot stage or later are routinely used by livestock in some areas. These forages are pastured, hayed or ensiled. The feed quality and quantity of the cereal forages changes from boot and soft dough stages. Protein is highest and fiber content lowest at the boot stage. But the quantity of forage is two to three-fold higher at the dough stage though protein is lowest and fiber content is higher.

In drought years Idaho hay prices may be higher than in other years so the hayed cereal forage may bring a better price than usual. In addition, water supplies may not be adequate to grow silage corn, or as much of it, and dairymen historically using corn silage in the ration may look to cereal forage silage as a replacement. This may be another alternative marketing opportunity for drought stressed small grain producers.

To facilitate the marketing of all forages, there is a University of Idaho Cooperative Extension website available for both the listing of available forage stocks as well as livestock producers needing the forages. This electronic clearing house for forage supplies and needs is available at http://www.ag.uidaho.edu/pasture/. The website address suggests that only pasture resources are listed but cereal forages can be listed as well. Those with forages or in need of forages can list that information by contacting your local Cooperative Extension Educator, or Wilson Gray, the website Coordinator and Extension Ag Economist at 208-736-3622, or at pasturelist@uidaho.edu, or enter the information themselves on the interactive website.

Grain Quality and Market Class Considerations?

In addition to reducing yield, grain quality can be affected with moisture stress during the later grain filling period. Any stress which reduces grain filling can reduce test weight, plumpness, and increase protein. Stresses which commonly reduce test weight during grain filling include foliar diseases such as stripe rust, high temperatures, and of course the lack of moisture. Late season moisture stress will affect small grain market classes differently.

The least concern is probably with hard wheat, especially hard red spring wheat. Although lower test weight can reduce the USDA grade, the higher protein would normally result in a reduced low protein discount or even a protein premium. In this case the stress conditions during grain fill could actually increase the end use quality and market price of the harvested crop.

Soft white wheat requires a higher test weight (60 lb/bu) for USDA No. 1 Grade than hard red spring wheat (58 lb/bu). Whereas higher protein is desirable for hard wheat, higher protein is undesirable for many soft white uses. Although high protein soft white wheat is typically not discounted locally, exporters do contend with buyers who have specific protein limits. Japan, for one, will not accept soft wheat with protein above 10.5%.

Feed barley quality is directly related to test weight, especially when test weight falls below 48 lb per bushel. Low test weight barley is sometimes either discounted by feed buyers or not acceptable at all. Although feed buyers might welcome the higher protein associated with lower test weight, it is not enough to compensate for the poorer feed quality resulting from the higher hull (fiber) and lower starch (energy) content.

Malting barley contracts frequently specify plumpness above 80 or 85%. This specification may be difficult to meet if barley is well watered through flowering but stressed during grain filling. Likewise, some contracts may have upper limits on the protein that is acceptable. Fertilizing with N for maximum yields and then limiting the moisture available during grain filling can increase protein to unacceptable levels.

If producing small grains for seed, seed quality could be affected by late season available moisture. Thinner and lower test weight seed may not have the vigor of larger higher test weight seed. Seed quality may not be the issue with some dealers that it is with others.

Seed Certification does not imply that the seed is anything other than genetically pure. The germination percentage is a better indication of seed quality but even poor test weight seed may germinate but lack the vigor of larger seed. There is no seed quality standard other than germination for Idaho small grains. Thus individual seed dealers may have differing policies on seed acceptability if test weight is reduced significantly by late season stress.

Therefore, the allocation of limited water could depend on the market class grown. Of the market classes mentioned, stress conditions during grain filling would probably have the least negative effect on grain quality and market price of hard wheat. Malting barley producers probably have the most to lose from reduced quality from limited water during grain fill.

Of course the locked in or projected prices for each market class would also influence a watering allocation. The difference in malting and feed barley prices and hard red and soft white wheat prices could easily influence whether limited water supplies are allocated to one market class or another..

Drought Websites

There are drought related websites that you may find useful in dealing with the limited water supplies. Many of these sites are related to coping with drought from a livestock perspective, so they deal with forages to a large extent.

Montana State University
Agadsrv.msu.montana.edu/Extension/Beef-JP/Drought/DroughtMngt.htm

Washington State University
http://drought.wsu.edu

Stretching Available Water

Alternating Furrow Irrigation

Furrow irrigation, with the associated runoff, is less efficient than sprinkler irrigation. Frequently every furrow is wetted during each irrigation. This results in considerably more water applied than is necessary to fill the profile.

Assuming furrows are spaced 30" apart, one method to stretch available water is to irrigate every other furrow, and alternate the furrow wetted with each set. Alternating the wetting of every other furrow in three irrigations was evaluated for winter wheat in 1992 at the OSU Malheur Experiment Station. Water was shut off in the 1/8 mile runs when water reached the end of the run in nearly all furrows.

The every row furrow irrigation resulted in a total application of 33.8 acre inches of water per acre, roughly twice the amount applied with alternating the wetting of every other furrow. Grain yield and test weight were unaffected by the furrow wetting treatments. Yield averaged 127 bu/A.

The researchers also found that soil N was used more effectively by the wheat if furrows were alternately wetted. Watering every furrow apparently resulted in significant leaching of soil nitrates. Another potential advantage of alternate wetting of furrows is that the crop may be less susceptible to lodging.

There were substantial water savings by irrigating alternate furrows with no loss in yield. This is perhaps the easiest and most convenient means to stretch available water in furrow irrigation systems. In addition, only half the siphon tubes are utilized for the irrigation. More details of this research are available in Oregon State University Special Report 936, "Malheur County Crop Research Annual Report, 1993."

Soils differ in their infiltration rate and moisture holding capacity and not all soils will be fully replenished by the time water reaches the end of the field. But many of our silt loam soils will likely behave similar to the soil at the Malheur Station.

It is not unusual to find some small grain fields corrugated with spacings wider than 30". If the wetting front advances well enough into the bed during the set, furrow spacings can likely be extended beyond 30" without sacrificing yield or quality.

Reducing Flows and Shortening Sets

In most furrow irrigated fields runoff occurs during most of the irrigation set. Without question most of the infiltration occurs during the first half of the set. Runoff can be reduced and limited water supplies stretched by reducing the flow rate into each furrow after the water reaches the end of the furrow. This entails more labor and a closer watch during the set. But it can reduce wasteful runoff if irrigators have the time.

Some runoff from each furrow may be necessary to insure adequate wetting if the water supplied to the field fluctuates. Fluctuating water occurs for a variety of reasons; plugged weed screens, altered diversions upstream. Even given a uniform water supply to the field, infiltration in the furrow may change if earth worms open up large channels during a set.

Shortening the irrigation set can also extend limited water supplies. The savings will depend on the relative inefficiency of the normal set. The more inefficient the set length in terms of water that runs off and is not utilized, the greater the potential water savings. This also entails more labor intensive water management. For some it may be possible to change from two 12 hour sets a day to three eight hour sets. It will lengthen the work day and many will not have the option. But it can spread limited water supplies over more acres.

Polyacrylamide or PAM is commonly used to reduce sediment loss from furrow irrigation. PAM can also increase infiltration rates and reduce runoff. PAM usage may be particularly appropriate on soils where slope reduces infiltration and excessive runoff occurs.

Surge Irrigation

Surge flow is the intermittent use of flow to reduce runoff. Surge flow was evaluated at the Malheur Station in 1993 on spring wheat. Surge flow using alternating surges ranging in time from 39 to 60 minutes was compared with continuous flow over five irrigations ranging from 24 to 28 hours.

Surge irrigation reduced by half the amount of water applied. Surge resulted in only 53% as much infiltration but grain yields were as high with surge irrigation as with the conventional furrow irrigation. Runoff from the surge irrigated treatment was only 30% of the runoff from the continuous flow treatment.

Surge flow systems are commercially available that automatically switch flows. Not all fields lend themselves to this system, especially if soils are non-uniform or the field is irregularly shaped.

Pump back systems for returning runoff to the head ditch are another means to extend limited water supplies. This and other water saving capital improvements may be eligible for cost sharing funds. Check with your local NRCS office for details regarding these cost sharing possibilities.