IRRIGATION

Irrigation of Winter Wheat no. 0.556

by M.M. Al-Kaisi and J.F. Shanahan [1]

Quick Facts...

Apply water in amounts that promote a deep, extensive root system.

Avoid irrigations during the early spring vegetative growth.

The most critical growth stages for irrigations are during fall when the soil profile should be filled to a depth of 4 to 6 feet and during the boot to heading stage.

Monitor soil moisture to aid in irrigation scheduling.

Growing irrigated winter wheat is more successful in a crop rotation rather than in continuous cropping.

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Winter wheat is predominantly a dryland crop in Colorado, but the importance of irrigated winter wheat has increased as farmers become concerned about reducing the costs of pumping water for production of other crops. Winter wheat responds to supplemental irrigation, but careful irrigation management is important to produce consistently high yields with minimum costs.

Wheat and Water Use

Wheat grows well under dryland conditions where adequate stored water promotes a deep, extensive root system. Irrigation practices that ensure ample soil water storage during early stages of crop development promote the development of this type of root system.

During fall growth, moisture is removed primarily from the top foot of soil. The wheat plant extracts most of its moisture from the 0- to 4-foot depth in the spring. As the plant develops and moisture needs increase, the root system continues to develop and competes in zones where soil moisture is present. If needed, the plant will use moisture from the 4- to 6-foot zone to meet its water needs. Total water use by winter wheat will vary but under optimum soil moisture conditions, total seasonal use may reach 23 to 24 inches (Figure 1).

Wheat crops need about 3 to 5 inches of water from seeding until April 1. Wheat will produce from two to six bushels for each additional inch of water, depending on water availability during the vegetative, heading and grain-filling periods.

Critical Timing of Irrigations

There are two growth stages during which irrigation promotes the greatest increase in yields. The first is the fall vegetative stage when a single irrigation should fill the soil profile to a depth of 4 to 6 feet on flood or furrow irrigated fields. With sprinkler irrigation, filling the profile becomes more difficult, because the amount of water necessary cannot be applied in a single application. Adjust the center pivot to turn very slowly and apply as much water as possible in a single pass, without causing runoff and erosion. A fall application of 4 inches on sandy soil or 8 inches on clay loam soil should be adequate to fill the soil profile about 4 feet deep. This level of irrigation provides adequate stored moisture for overwintering.

After growth resumes in the spring, base irrigation amounts on the amount of water used over the winter. If the soil profile is filled to a depth of 6 feet in the fall, additional water probably will not be necessary until the boot stage. Earlier irrigation will produce excessive vegetative growth and may cause lodging. Irrigations during early vegetative growth are only necessary if there has been a warm, dry winter or in case of very coarse sandy soils.

Table 1: Guide for judging available soil moisture for crops.

	Feel or Appearance of Soil and Water Deficit[1]			
Available soil water remaining	**Loamy Sand Coarse Texture**	**Sandy Loam Moderately Coarse Texture**	**Loam & Silt Loam Medium Texture**	**Clay Loam or Silty Clay Loam Fine & Very Fine Texture**
0 to 25 percent	Dry, loose, single grained, flows through fingers	Dry, loose, flows through fingers	Powdery dry, sometimes slightly crusted but easily broken down into a powdery condition.	Hard baked, cracked, sometimes has loose crumbs on surface.
	0-0.19[2] (0.75-0.56)[3]	0-0.38 (1.5-1.12)	0-0.50 (2.0-1.5)	0-0.55 (2.2-1.65)
25 to 50 percent	Appears to be dry, will not form a ball with pressure	Appears to be dry, will not form a ball	Somewhat crumbly but holds together from pressure.	Somewhat pliable
	0.19-0.38 (0.56-0.38)	0.38-0.75 (1.12-0.75)	0.50-1.0 (1.5-1.0)	0.55-1.1 (1.65-1.1)
50 to 75 percent	Appears to be dry, will not form a ball with pressure.	Tends to ball under pressure, but seldom holds together.	Forms a ball, somewhat plastic, will sometimes slick slightly with pressure.	Forms a ball, ribbons out between thumb and forefinger.
	0.38-0.56 (0.38-0.19)	0.75-1.13 (0.75-0.37)	1.0-1.5 (1.0-0.5)	1.1-1.65 (1.1-0.55)
75 percent to field capacity (100 percent)	Tends to stick together slightly, sometimes forms a very weak ball under pressure	Forms a weak ball, breaks easily will not slick.	Forms a ball, is very pliable, slicks readily, is relatively high in clay.	Easily ribbons out between fingers, has slick feeling.
	0.56-0.75 (0.19-0)	1.13-1.5 (0.37-0)	1.5-2.0 (0.5-0)	1.65-2.2 (0.55-0)
At field capacity (100 percent)	Upon squeezing, no free water appears on soil, but wet outline of ball is left on hand. 0.75	1.5	2.0	2.2

[1] Ball is formed by squeezing a handful of soil very firmly.
[2] This number represents the current available soil moisture in inches/foot.
[3] Parenthesis show inches of water deficiency per foot of soil depth.

Irrigation scheduling involves decisions of when to apply water and how much. Decisions are dictated by producer goals and strategies. Water availability, rainfall, yield goal, nutrient management, soil texture, crop water use, etc., play a role in how to schedule water application.

For example, the need for early spring irrigation is more likely with sandy soils because of their low water-holding capacity. The timing of water application is critical to yield and nutrient management. Checking soil moisture at different depths and different growth stages and knowing crop water needs at different critical growth stages (Figure 1) helps to avoid yield loss.

The feel and appearance method can be used to indicate soil moisture status. Table 1 illustrates soil moisture availability and deficit as related to soil texture and percent of moisture depletion. Soil sampling to determine water content should be done at different soil depths through the soil profile of the effective root zone. Estimate soil moisture status of each depth by firmly squeezing a handful of soil. Consult Table 1 for water application to replenish the depleted soil moisture. Use the management allowable depletion (MAD) in the root zone as a guideline for irrigation management (see fact sheet 4.715, *Crop Water Use and Growth Stages*). This publication is available at your Colorado State University Cooperative Extension county office or from the Cooperative Extension Resource Center, 115 General Services Building, Colorado State University, Fort Collins, CO 80523-4061; (970) 491-5061.

Table 2: Suggested N rates for irrigated winter wheat, as related to NO_3 -N in the soil and soil organic matter content (expected yield, 100 bu/A).

ppm NO_3-N in soil test*	Soil organic matter, % 0-1.0	1.1-2.0	>2.0
	Fertilizer N-lb/A		
0-6	125	95	75
7-12	105	75	55
13-18	85	55	35
19-24	65	35	15
25-30	45	15	0
31-36	25	0	0
>36	0	0	0

*Sum of ppm NO_3-N in 1-foot sample depths to 2 feet (for sample depths of 1 foot only, multiply the ppm value by 1.67 before using table).
To adjust N rate for expected yield different from 100 bu/A, add or subtract 20 lb N/A for each 10 bu/A difference.
Special Note: Increase the above recommendations by 40 lb N/A for irrigated wheat in Alamosa, Conejos, Costilla, Rio Grande, and Saguache counties.

Other methods can be used such as soil moisture sensors for irrigation scheduling (see 4.700, *Estimating Soil Moisture*). If the amount of irrigation water available for winter wheat production is limited, it is used more efficiently if applied to relieve stress during boot and heading stages than during grain filling. Water stress during boot and heading stages limits yield potential that is not regained when stress is relieved. Therefore, irrigation to prevent stress during boot and heading would be more advisable than delaying irrigation until grain filling. Adequate soil moisture from the boot stage through the bloom stage increases grain yield and test weight. Late irrigation near the dough stage may be beneficial, but the result may be a higher incidence of lodging.

Nutrient Management

Nutrient management is a critical factor for winter wheat production. Nitrogen is the most yield-limiting nutrient (see 0.544, *Fertilizing Winter Wheat*). Nitrogen management under irrigated conditions takes on added importance relative to other nutrients (P and K), due to the mobility of nitrogen in the soil profile and potential for groundwater contamination.

The nitrogen application methods and irrigation management strategies selected by the producer should strive to maximize crop nitrogen use efficiency and minimize nutrient loss due to over-irrigation. Nitrogen requirements depend heavily on the cropping system (e.g., wheat after fallow, wheat after corn, or continuous wheat), which greatly influences the residual nitrogen in the soil. The relationship between soil organic matter, residual NO_3-N in the soil from previous crops (based on soil testing), yield goal, and irrigation method determines nitrogen requirements for winter wheat.

Table 2 suggests nitrogen requirements based on soil testing for NO_3-N, organic matter and a yield goal of 100 bu/A. Apply nitrogen, phosphorus and other nutrients on the basis of soil tests.

Nitrogen application for irrigated winter wheat will be different under different irrigation methods. For example, split applications, consisting of an application prior to or at planting and the remainder applied in the early spring (see 0.544), will increase nitrogen use efficiency.

Under furrow irrigation, where irrigation efficiency is very low, apply nitrogen during or after irrigation to minimize the NO_3-N loss due to deep percolation. Using a surge valve with surface irrigation as a fertigation tool is very effective in increasing nitrogen use efficiency (see 0.508, *Fertigation Through Surge Valves*).

Winter wheat irrigated with a sprinkler system can be fertilized more efficiently by injecting liquid fertilizer through the system. The application of nitrogen through a center pivot can be controlled according to crop needs for various growth stages. For example, Eck (1988) found under sprinkler irrigated conditions that matching N application amounts with crop needs was key to maximizing nitrogen efficiency.

Other Management Factors

Grain yields under irrigated conditions are also affected by row spacing and seeding rate. Wheat yields will respond positively to narrowing row width from a 12-inch spacing (standard for dryland conditions) to a 6- inch spacing. At this narrower row spacing yields also respond dramatically to an increase in seeding rate. At a 6-inch row spacing the suggested seeding rate for irrigated winter wheat would be approximately 1 million seeds per acre (80 lb/A) versus the recommended rate of 540,000 seed per acre (40 lb/A) for dryland conditions.

Continuous Cropping vs. Rotations

Continuous irrigated wheat in a rotation is not usually a successful practice. Yield declines over a period of years have been observed. This decline occurs partly because of the difficulty in deep water penetration from center pivot sprinklers. Disease, insect or weed pressures also become significant problems in continuous irrigated wheat. Rotate irrigated wheat with other crops where possible. Wheat fits quite well in rotations because peak irrigation times for wheat do not coincide with peak demand times for other crops such as corn, beans and sunflowers.

Varieties

Use the results from irrigated variety trials located throughout Colorado to aid in selecting a variety for a particular location. For irrigated fields, the semi-dwarf varieties have had consistently high yields and are preferred to avoid lodging. Use varieties with adequate resistance to leaf rust, because leaf rust severity is usually more pronounced under irrigated conditions than under dryland conditions.

References:

Harold V. Eck. 1988. Winter wheat response to nitrogen and irrigation. *Agron. J.* 80:902-908.

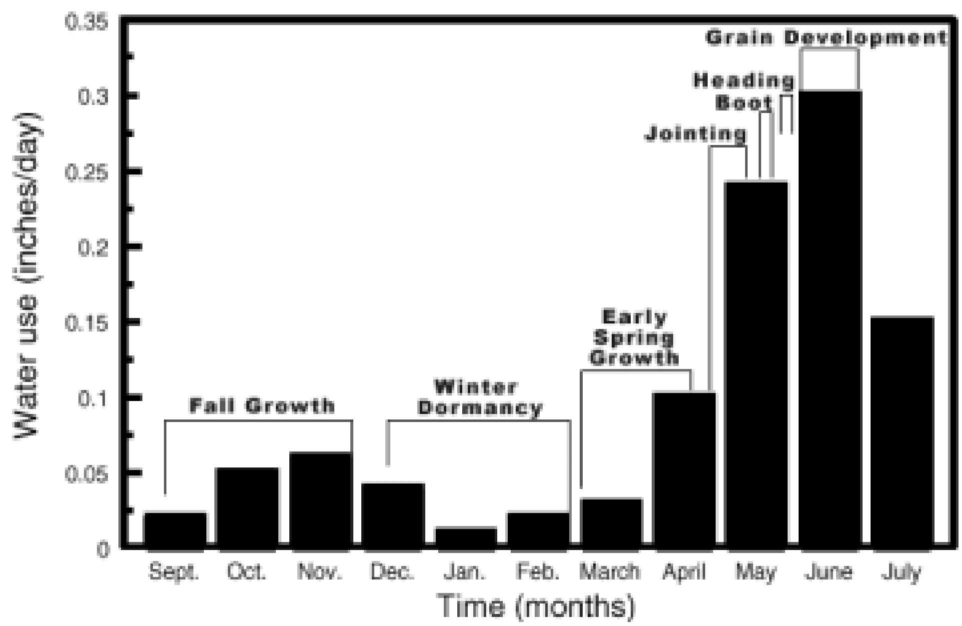

Figure 1: Winter wheat water use at different growth stages.

[1]*M.M. Al-Kaisi, Colorado State University Cooperative Extension regional water management specialist, Central Great Plains Research Station, Akron; and J.F. Shanahan, former Cooperative Extension crop specialist and professor, soil and crop sciences.*

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