Irrigation and Water Use

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For maximum yield potential, dry beans will need 14 to 18 inches of soil moisture during the growing season. With good management, irrigation can supplement rain to provide optimum soil moisture conditions throughout the growing season. With irrigation, dry beans are capable of producing 150 to 300 pounds for each inch of additional water, depending on bean class.

Daily dry bean water use or evapotranspiration (ET) depends on the stage of growth, local weather conditions, available soil moisture, disease pressure and soil fertility. Plant architecture (Type I, II, III and IV) also will affect the daily dry bean water use. Generally, the larger, bushier dry bean types will use more water than the shorter, narrow types.

The frequency and amount of irrigation depends on the growth stage of the dry bean (which determines the daily crop water use), the water-holding capacity of the soil in the root zone and the prevailing weather conditions.

Dry Bean Rooting Depth and Water Use

Dry beans are shallow-rooted. Typically, in deep soils, roots grow laterally 8 to 12 inches and downward to a depth of 3 feet or more. Root distribution is concentrated near the soil surface. About 90 percent of the roots will be found in the top 2 feet, which is considered the effective rooting depth for irrigation purposes. During the course of a growing season, only about 10 percent of the water used by the beans will be drawn from the soil below 2 feet.

Average dry bean water use rates will increase from about 0.05 inch per day soon after emergence to more than 0.25 inch per day during pod development (Figure 2). The dry bean water use amounts include

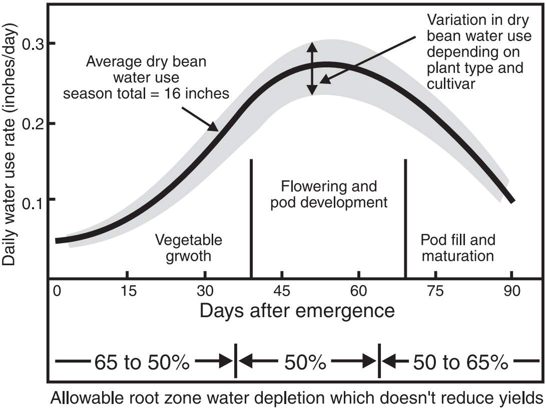

Figure 2. Average daily water use rates for dry bean.

the evaporation from the soil surrounding the plants. Water use is a depth measurement because the assumption is that the dry bean plants remove soil water from under every square foot of soil surface in the field.

Water-holding Capacities of Soil

The depth and water-holding capacity of soil has a great influence on when and how often irrigations are required. Soil texture determines the amount of available water in the root zone (Table 23), although other factors such as organic matter and soil compaction will modify these numbers. Note that the greater the water-holding capacity of the soil in the root zone, the less frequent the irrigation applications should be.

Knowing the soil texture and water-holding capacity of the dominant soil type in a dry bean field and using that information for making irrigation decisions are

Table 23. Approximate available soil water-holding capacities for various soil textural classifications.

	Available Moisture	
Soil Texture	**Inches/Inch**	**Inches/Foot**
Coarse sand and gravel	0.02 to 0.06	0.2 to 0.7
Sand	0.04 to 0.09	0.5 to 1.1
Loamy sand	0.06 to 0.12	0.7 to 1.4
Sandy loam	0.11 to 0.15	1.3 to 1.8
Find sandy loam	0.14 to 0.18	1.7 to 2.2
Loam and silt loam	0.17 to 0.23	2.0 to 2.8
Clay loam and silty clay loam	0.14 to 0.21	1.7 to 2.5
Silty clay and clay	0.13 to 0.18	1.6 to 2.2

important. However, if different soil types are in the same field, irrigation scheduling should be adjusted based on the most drought-prone soil type.

Irrigation Water Management

Having a soil profile that is near field capacity at planting, which occurs naturally with normal winter snow and spring rainfall, is desirable. Less than a full soil moisture profile to a depth of at least 3 feet at planting will hinder root development later in the season. Also, stored soil moisture in the root zone serves as a supplement during high water-use periods occurring during flowering.

Dry bean planted on shallow soils (12 to 18 inches of top soil) underlain by coarse sand and gravel will have a reduced root zone. A reduced root zone means less soil moisture is stored, thus requiring lower application amounts (0.75 inch per irrigation) more frequently, compared with soils with a greater water-holding capacity.

During the period prior to flowering and the period after the majority of the pods are full, dry beans are relatively drought-tolerant. They can withstand 50 to 60 percent soil water depletion without a significant impact on yields (Figure 2). However, during the flowering and pod-development period, soil moisture levels in the root zone should not be depleted more than 50 percent (preferably 40 percent) to achieve maximum yields.

The first irrigation should be applied when the soil moisture is between 50 and 60 percent depleted after emergence. With normal rainfall, this should take the beans almost to flowering. After flowering, irrigate before the soil moisture profile reaches 50 percent depletion.

Dry bean will mature properly if ample moisture is available during the vegetative growth stage (pre-flowering) and if the last irrigation occurs when the first pods are filling. Late-season irrigations can delay maturity. If the bean plant has begun to dry, irrigation will not be needed because the bean plants no longer are removing much water from the soil profile.

Most center pivots are managed to apply from 0.5 to 1 inch of water per revolution; therefore, during flowering, monitoring the soil moisture profile frequently is critical because keeping up with the dry bean water use during periods of high temperatures and wind may be difficult. However, if white mold is a concern with rainfall/irrigation occurring during flowering, another strategy could be to fill the soil profile with water prior to flowering and avoid irrigation until pods are set.

Some tips for good irrigation management of dry bean:

- Irrigations may need to be scheduled to minimize disease problems rather than maximize yield.
- Maturity may be delayed up to 15 days by letting the soil get too dry after planting, and yield potential also will decrease.

- Avoid excessively dry soil levels during the flowering stage. The shock of watering dry soil can cause flowers to fall off the plant.
- Do not irrigate when lower foliage on the plant is still wet from rainfall or irrigation.
- To avoid aiding the development of white mold, do not use light, frequent irrigations. Set your pivot timer to apply 1 inch each irrigation event. However, a wet soil surface contributes to white mold development, especially during flowering.
- Late-season irrigations may delay the final maturity date.

Irrigations can be terminated when at least 80 percent of the pods show yellowing and are mostly ripe. Another indicator is when 50 percent of the leaves are yellowing on the plant.

Irrigation Scheduling

Determining when to start and stop an irrigation system is a very important part of irrigation water management. Soil in the root zone is the reservoir that stores water for use by the crop. Soil moisture levels in the root zone are the criteria used to determine when to start and stop irrigations. Several soil moisture monitoring tools are available to estimate the soil moisture level at a particular time and location in the field.

Soil moisture estimates can be done several ways. The "soil feel" method is the most widely used. It involves using a soil probe to obtain a soil sample from specific depths in the root zone, and the amount of soil moisture is estimated by squeezing the soil in the palm of your hand. Accuracy of the soil feel method improves with experience.

Soil moisture also can be estimated using mechanical devices such as tensiometers and soil moisture blocks. When these are used, one or more of these devices are buried at different levels in the root zone. The soil moisture level is estimated by reading a gauge on the device or a portable meter. These devices only indicate the soil moisture status at that particular location. Devices that measure soil moisture based on the changes in electrical properties of the soil also are available.

Using only soil moisture estimates for irrigation scheduling requires a high level of dedication by the irrigation manager during the growing season. Informed irrigation decisions require reading soil moisture measurements two or three times per week. Measurements must be taken at several locations in the field and the readings recorded.

Another form of irrigation scheduling requires daily dry bean water-use estimates. This method, sometimes called the "crop water-use replacement method," is based on obtaining daily estimates of dry bean water use and measuring rainfall amount. Irrigations are scheduled to replace the amount of soil moisture used by the dry bean crop minus the amount of rain received since the last irrigation. Estimations of average water use for dry bean based on maximum daily temperature are shown in Table 24.

During the growing season, more precise estimates can be obtained by visiting this website: *http://ndawn.ndsu.nodak.edu/applications.html*. These estimates are presented in graphical format and as numerical tables for several emergence dates.

The best choice of tools for irrigation scheduling is a combination of in-field soil moisture measurement and a recorded daily soil water accounting procedure. This method, called the "checkbook" method, has been used successfully for many years in Minnesota and North Dakota. The checkbook method is a soil moisture accounting method based on daily dry bean water use and the soil water-holding capacity. Along with rainfall measurement, these two parameters are used to predict the time and amount of water needed to replenish the root zone to maintain proper soil moisture levels.

Table 24. Average dry bean water use based on maximum daily air temperature, week after emergence and growth stage (inches/day).

Maximum	Week After Emergence												
Temperature	1	2	3	4	5	6	7	8	9	10	11	12	13
(°F)													
From 50 to 59	0.02	0.03	0.04	0.05	0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.05
From 60 to 69	0.04	0.05	0.06	0.08	0.11	0.13	0.14	0.14	0.13	0.13	0.13	0.11	0.08
From 70 to 79	0.05	0.06	0.09	0.12	0.15	0.18	0.19	0.19	0.19	0.18	0.17	0.15	0.11
From 80 to 89	0.06	0.08	0.11	0.15	0.19	0.23	0.25	0.25	0.24	0.23	0.22	0.19	0.14
Greater than 90	0.08	0.10	0.14	0.18	0.23	0.28	0.30	0.30	0.29	0.29	0.27	0.24	0.17