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Soybeans

Irrigating soybeans

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Missouri's growing season is characterized by excessive moisture in the spring followed by inadequate moisture during the middle of the growing season. Because of the lack of moisture during the crops' peak demand, some producers have invested in irrigation systems. The cost of maintaining and using these systems is high, so it is imperative to manage moisture in the most efficient way possible. The following discussion should help Missouri soybean producers understand the crop's need, the soil's ability to hold and supply water, and the agronomic practices that can result in maximum economic yields under irrigation.

Soybean response to irrigation

Irrigation usually improves soybean yields on drought-prone soils and in exceptionally dry seasons. The amount of increased yield (and cost) fluctuates, depending on variety, geographic location, soil type, and fertility. An eight-year study of irrigated vs. nonirrigated soybean yields in southeast Missouri indicates yield increases are greater for short-season varieties under irrigation (See Table 1). Full-season varieties show almost no yield response, and medium-season varieties show an intermediate response to irrigation.

In central Missouri, a survey indicates that over a 10-year period, soybean growers obtained an average increase of 13 bu/A from irrigating full-season soybeans. In research sponsored by the grower check-off program, yields of 10 varieties grown in southwest Missouri during the dry years of 1983 and 1984 averaged 29 and 13 bushels more per acre respectively under irrigation. In 1985 when plentiful rains occurred during the seed-fill period, yields increased by only about 1 bushel per acre.

The economics of achieving these yield increases are of paramount importance. The type of irrigation system and the water source greatly affect cost. Flood or furrow irrigation with a cheap water source may cost as little as $25 per acre per year, while a center pivot system with a deep well could cost as much as $100. A prospective irrigator should weigh potential costs against returns he can expect from the increased yields and reduced risks created by irrigation.

In addition to influencing yields, irrigation may alter other characteristics of importance to soybean growers, such as maturity and lodging. Irrigation delays the maturity of short- or mid-season varieties only a few days. Full-season varieties usually show no difference in maturity unless extended drought or charcoal rot infection occurs. Plant height normally increases under irrigation which increases the chance of lodging. However, proper variety selection may reduce this problem.

Table 1. Responses of soybeans to irrigation in southeast Missouri 1967-1974

	Average of 3 sites		
Maturity	Nonirrigated	Irrigated	Difference
	-Bu/A-		
Early	27.1	33.8	6.7
Medium	32.0	35.7	3.7
Late	32.9	33.7	0.8

(Adapted from Shannon and Duclos.)

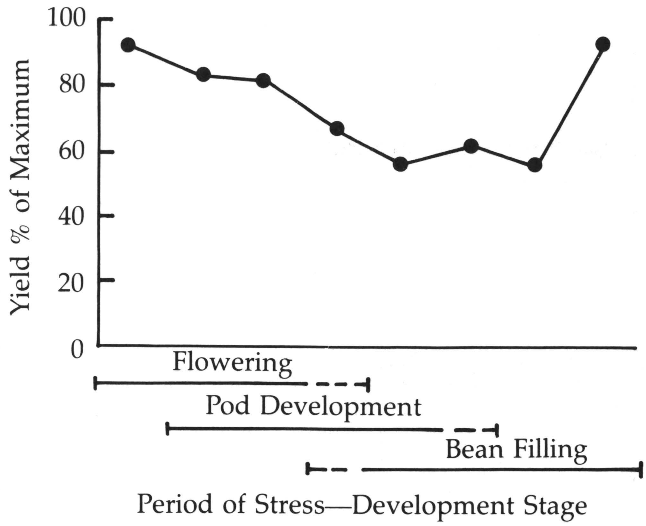


Figure 1. The effect of a moisture stress on soybean yield at various growth stages. From Shaw and Laing, 1966. Iowa State University.

Table 2. Potential available water storage capacity for various soil types

Soil type	Available soil moisture inches/foot of depth
sands	0.5
loamy sands	1.0
sandy loam, clay loam	1.5
loams, silty clay loam	1.8
silt loams	2.5
silt	3.0
clays	1.0

Adapted from Kiniry, Scrivner, and Keener, 1983.

Weather patterns and crop water use

Missouri rainfall patterns are characterized by sufficient winter and early spring rainfall that maintains the soil at or near saturation capacity until almost the first of June. During late June, July and August, the crop's need for moisture usually exceeds that available from either the soil or rainfall. Water requirements are a function of the plant's metabolic needs, the quantity needed for transpiration (to cool the plant), and the quantity lost by evaporation from the soil. This combined demand is called "evapotranspiration."

The peak water use period for soybeans occurs during reproductive growth when they may need as much as 2.5 inches of water per week. The average rainfall during this period is less than 0.6 inch per week. Available soil moisture is depleted by the time reproductive growth begins, so unless you provide supplemental irrigation, the plant will be subjected to moisture stress.

Short-season varieties complete flowering and pod filling during the period of greatest evapotranspiration. This results in decreased yields if you don't irrigate. Full-season varieties normally reach their critical growth period after the period of the highest evapotranspiration passes.

Soybeans are most sensitive to moisture deficits during the late pod development/early bean filling periods. Figure 1 depicts the yield response of northern soybeans relative to the time at which moisture stress develops. Lack of water during flowering and podding causes flower and pod abortion. Stress during pod development and early seed fill reduces the number of seeds per pod. Drought conditions during seed fill reduce seed size and thus final yield. The critical period of water need for indeterminate varieties occurs from late flowering through mid pod fill. For determinate varieties, such as those grown in the Bootheel, the period of greatest water need begins earlier in flowering. The new determinate semi-dwarf (short-statured) varieties often show critical water needs through most stages of growth.

Availability of soil moisture

Specific soil types have varying abilities to hold moisture. The available soil moisture, in terms of inches of water held per foot depth of a soil, is described in Table 2. Sandy soils retain the least amount of water, while silt loam and clay loam soils hold the most. Note that clay soils have less available water than do clay loam soils. Clay soils hold more water, but less of that water is available for plant growth because water adheres strongly to the clay particles.

You must also consider the rooting depth of the crop in a particular soil. The effective rooting depth of soybeans ranges from a few inches after emergence to 2 to 3 feet during the early reproductive stages. However, some Missouri soils are compacted and some acid sublayers restrict the effective rooting depth to that depth of topsoil above the compacted layer. In these soils, it is wasteful to supply more water than is necessary to wet the upper zone.

You can measure or estimate soil moisture by a variety of methods. Each has its advantages and limitations. Irrigators who use soil moisture measurements for scheduling purposes usually establish an allowable soil moisture depletion level. For soybeans, the limit is about 70 percent depletion in the vegetative stages and 50 percent for reproductive stages. You should irrigate if you reach these levels. To maintain the soil moisture content above the allowable depletion level, you should start irrigating sooner on sandy soil which has a lower moisture storage capacity.

Feel method

One of the quickest and most popular methods of determining soil moisture is based on feel and appearance of the soil. Charts to aid inexperienced irrigators are available. The method is not quantitative and requires individual judgement. Thus, it lacks the precision of other methods.

Moisture blocks

Electrical resistance instruments, commonly called moisture blocks, measure the moisture content of the soil indirectly. They sense a change in electrical properties of the blocks which correlates with block moisture content and, in turn, the soil moisture. These devices consist of two electrodes mounted in blocks made of plaster-of-paris, fiberglass, gypsum or other materials (See Figure 2). Wires from the electrodes attach to a meter that measures electrical conductivity, a function of the water content of the soil.

To install moisture blocks, dig a hole with a soil auger and place the block in it. Pack soil around the block to ensure good capillary action between the sensor and the soil. Calibrate blocks in each field to ensure accurate prediction.

Moisture blocks are not recommended for sandy soils.

Tensiometers

Tensiometers are well-adapted to sandier soils. Tensiometers measure the soil moisture tension—how tightly the soil particles hold the water. This is directly related to the tension required for plant roots to extract water from the soil.

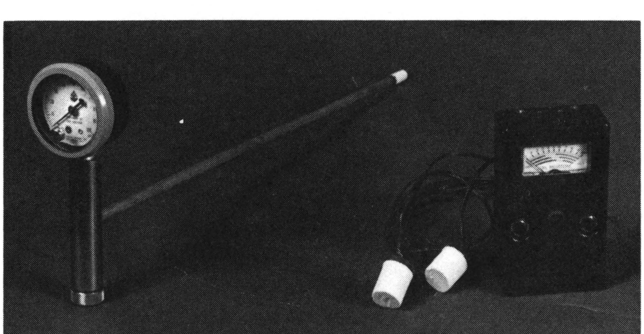


Figure 2. Soil moisture measuring devices include a tensiometer (left) and a gypsum moisture block.

Tensiometers consist of a tube with a porous ceramic cup at one end and a gauge at the other (See Figure 2). To install, place in the soil to the depth of plant rooting. Fill with water. The water will move from the cup into the soil until the water content reaches equilibrium (equal proportions of water in the soil and in the cup). As the soil dries, the tension increases, indicating water is more difficult to extract from the soil.

Although tensiometers indicate when you should begin to irrigate, they do not indicate how much water you should apply.

Missouri irrigation scheduling charts

Extension centers in Missouri can provide irrigation scheduling charts for soybeans and other crops. A computer develops a customized chart (see example in Figure 3) for each field depending on crop, soil type, planting date, variety (maturity), location in the state, and any moisture deficit at planting time.

The chart projects the cumulative minimum and maximum amounts of water you should provide (as the season progresses) to optimize crop yield, assuming average weather conditions for the site. You use the scheduling chart to maintain the total water added (rainfall + irrigation) during the season between the minimum and maximum water needs.

Usually, a 1- to 2-inch range exists between the minimum and maximum cumulative totals of needed water application, depending on the available water holding capacity of the soil. Thus, the chart is well suited for sprinkler irrigation because sprinklers usually apply less than 2 inches of water per application.

A planned linear depletion of two-thirds of the total soil moisture storage by crop maturity is planned with a starting date of June 1, at which time the profile is assumed full. For years when temperatures exceed the normal, you can modify charts to account for increased evapotranspiration. Use of the charts should minimize irrigation operating costs and water use and reduce runoff and leaching.

Plant response to timing of irrigation

If you can irrigate only once during the growing season, do so during the late pod development to early seed-filling period if soil moisture levels are low. This timing maximizes seed yield and seed size and minimizes lodging problems and maturity delays.

A detailed study of irrigation timing with indeterminate soybeans was conducted in Nebraska. Irrigation was applied in single applications (flowering, podding, seed-fill) and in split applications (flowering and podding; flowering and seed-fill; podding and seed-fill; and flowering, podding, and seed-fill). Researchers evaluated plants and their responses in height, lodging, and yield. Plant height and, in turn, lodging

Name: Smith
Location: Columbia **Latitude:** 39 degrees
Crop: Soybeans
Planting date: June 15 **Season length:** 105.7 days
Soil moisture storage: 6.0 in. **Depletion at planting:** 1.0 in.

Date permanent depletion began: June 1

Date	Daily Water Use	Rain + Irrig.	Total Water Added	Min. Water Needs	Max. Water Allow
	Inches				
June 15	0.04	(....................)	(....................)	0.0	1.0
June 21	0.05	(....................)	(....................)	0.0	1.0
June 27	0.06	(....................)	(....................)	0.0	1.1
July 3	0.07	(....................)	(....................)	0.0	1.2
July 9	0.08	(....................)	(....................)	0.0	1.4
July 15	0.08	(....................)	(....................)	0.0	1.7
July 21	0.09	(....................)	(....................)	0.0	2.0
July 27	0.11	(....................)	(....................)	0.4	2.4
Aug. 2	0.13	(....................)	(....................)	0.9	2.9
Aug. 8	0.15	(....................)	(....................)	1.5	3.5
Aug. 14	0.16	(....................)	(....................)	2.2	4.2
Aug. 20	0.17	(....................)	(....................)	3.0	5.0
Aug. 26	0.17	(....................)	(....................)	3.7	5.7
Sept. 1	0.16	(....................)	(....................)	4.5	6.5
Sept. 7	0.14	(....................)	(....................)	5.1	7.1
Sept. 13	0.10	(....................)	(....................)	5.6	7.6
Sept. 19	0.09	(....................)	(....................)	6.0	8.0
Sept. 25	0.07	(....................)	(....................)	6.2	8.2

Instructions:
1) Record rainfall each day.
2) Keep running total of rainfall and irrigation (**Total Water Added**).
3) Irrigate to maintain **Total Water Added** between **Maximum** and **Minimum** limits.

NOTE:
During periods of heavy rain, record **only** that amount of water which will not exceed **maximum**. Precipitation beyond this amount is assumed to have run off and is unusable.

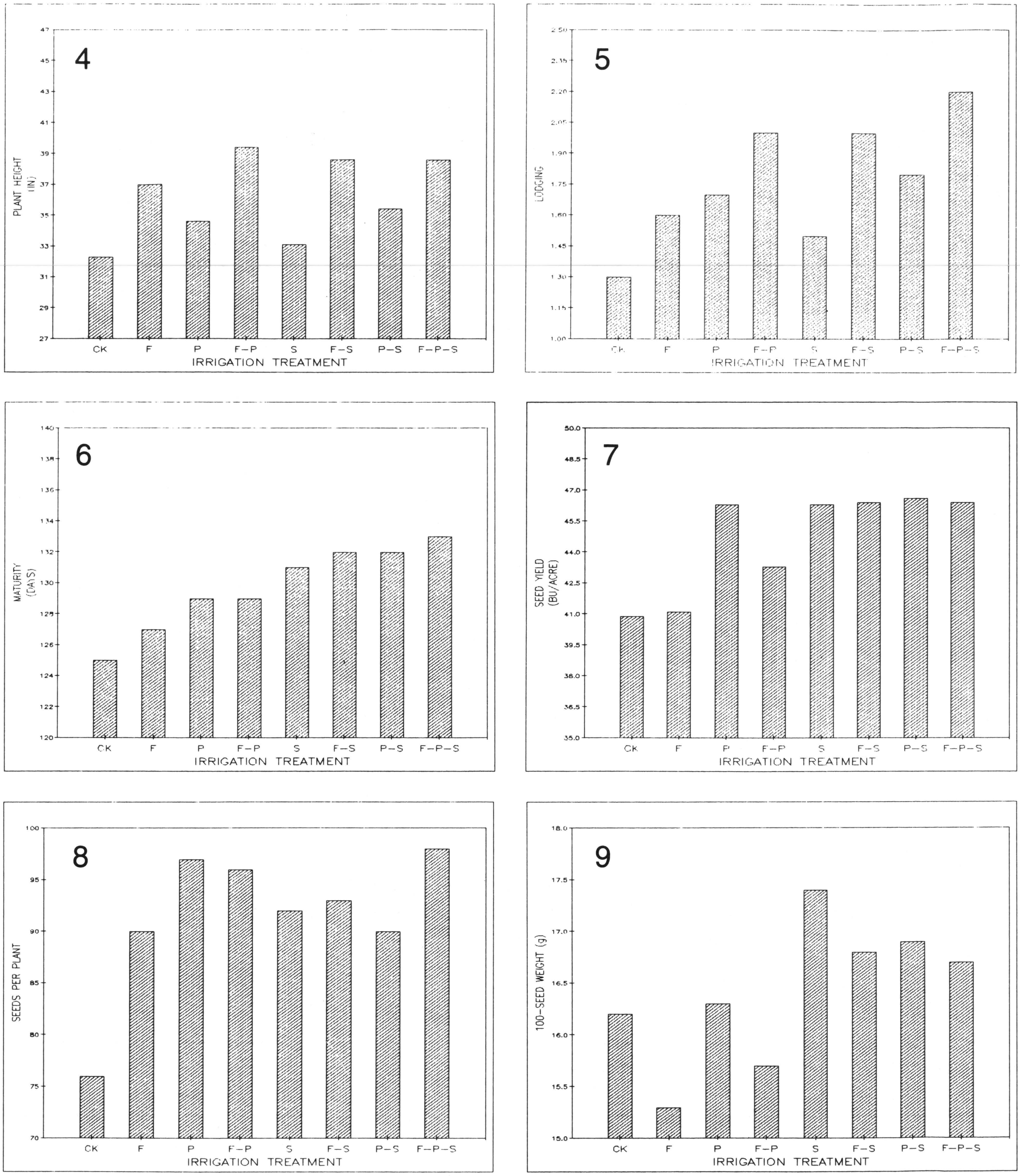
Figure 3. Use this chart to develop an irrigation schedule.

increased the most by multiple-applications of water (See Figures 4 and 5). The addition of water allowed the plants to prolong their vegetative growth, thereby increasing plant height. Delays in maturity were progressively longer as the frequency of irrigation application increased (See Figure 6). The greatest maturity delay, however, was six days, which is unlikely to cause crop loss from early frost.

Several irrigation treatments produced comparable yields (See Figure 7). Irrigating at flowering did not result in optimum water use. At flowering, soybeans use water to produce flowers which they usually abort. They don't use the water to fill the beans. In the Bootheel where determinate varieties are grown, however, adequate water during flowering is important because of the shorter duration of this initial reproductive period.

Seeds per plant were greatly enhanced with all irrigation treatments (See Figure 8). However, the greater numbers of seeds did not result in higher yields for some treatments. This component of yield indicates irrigation promotes the retention of pods and perhaps increases the number of seeds per pod compared to a nonirrigated situation.

The recommendation to irrigate during late pod development and early seed-filling is largely based



Figures 4 through 9. These charts show the response of various soybean plant and seed characteristics to timing of irrigation application. Figure 4 shows plant height; 5, lodging; 6, maturity; 7, seed yield; 8, seeds per plant; and 9, 100-seed weight. (L.L. Korte and J.H. Williams, Nebraska.)

CK = Check, no irrigation.
F = Irrigation at flowering.
P = Irrigation at podding.
S = Irrigation at seed-fill.
F-S = Irrigation at flowering and seed-fill.
F-P = Irrigation at flowering and podding.
P-S = Irrigation at podding and seed-fill.
F-P-S = Irrigation at flowering, podding, and seed-fill.

on its impact on seed size (See Figure 9). Seed sizes resulting from irrigation during seed-filling were clearly superior to those achieved when water was supplied at other times during reproductive development. This occurs because of the plant's enhanced ability to completely fill the seeds with photosynthetic products.

Maximizing irrigated yields

When attempting to maximize yields under irrigation, consider four factors. Because lodging is frequently a problem, you should select genetically **lodging resistant varieties.** In the north, the new determinate semi-dwarf varieties are useful for high-yielding environments, such as those that exist under irrigation where lodging is a severe problem.

Second, consider **reducing plant populations by 10 to 15 percent.** This allows the plants to develop more branches and sturdier stems which reduces lodging. Again, the goal is to reduce yield losses associated with down plants at harvest. Less seed also reduces seed cost/acre.

Third, because yields are higher with irrigation, the soil needs more fertilizer to accommodate the greater demands plants make on it. On average, **increase fertility about 20 percent** over the amount you would apply under nonirrigated conditions. You can get more specific recommendations by matching soil test results to yield goals.

Finally, **monitor soybeans closely.** Irrigation provides a better growing environment not only for soybeans but for weeds, insects, and some diseases as well.

Research at the University of Missouri-Columbia indicates that when soybeans have adequate water, little if any yield loss occurs as long as the tops of the weeds are shorter than the tops of the soybeans.

Insects may increase because of the lush vegetation that develops. However, these insects normally cannot keep up with the rapid growth of the plant. By adequately watering plants, you can greatly reduce the number of insects like grasshoppers and spider mites, which are severe pests in dry years.

Root rots and leaf diseases may increase if soybeans receive too much water, particularly early. However, the effects of many soybean diseases are abated because irrigated plants are healthier.

Increased input costs for irrigation necessitate the need for careful monitoring and management if you are to realize positive net returns.

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