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Growing irrigated soybeans in the Pacific Northwest

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Why Consider Growing Soybeans?

In Oregon, soybeans are a relatively new crop, struggling to find local processors and a profitable market. Markets are currently available for soybean producers, including the identity-preserved food grade market for whole beans and food grade oil, biofuel, and feed markets. Except for the biofuel market, organic production increases the value of soybeans and processed components. The identity-preserved food grade market generally requires a nongenetically modified organism (non-GMO), clear hilum variety, with excellent quality characteristics. Recently, it appears the food grade market has potential to be exported to other countries if uncontaminated by GMOs and other crops and weeds. Soybeans, when crushed, are separated into oil and meal. The oil may be used for human consumption, as in cooking oil, or for making biodiesel fuel. Soybean meal has long been used in the livestock industry as a high-protein feed source. Through at least 2011, the State of Oregon will encourage soybean oil seed production by providing saleable tax credits of 5 cents per pound of grain produced and processed in Oregon into biodiesel (House Bill 2210 [74th Oregon Legislative Assembly 2007]). If yield is 55 bushels per acre, the credits could amount to as much as $165 per acre, making soybean production for biodiesel and meal more profitable and has encouraged contracts to producers.

Producers find growing soybeans offers many benefits, including ease of production, low production costs, a lower water requirement than corn or alfalfa, and ample market opportunities. The same machinery is used for raising soybeans as for wheat, and soybeans do not require nitrogen fertilizer if they have been inoculated. Soybeans, processed soybean meal, and soybean oil already have a well-developed international market.

History

Soybeans [*Glycine max* (L.) Merrill] were cultivated as early as the 11th century in China (Hymowitz and Shurtleff 2005). Soybeans were introduced to North America in 1765 by Samuel Bowen. He received a patent for making a sauce from Chinese vetches. Bowen obtained seed from China and referred to the plant as a Chinese vetch instead of soybean. The word “soybean” was not actually used until 1804, when Dr. James Mease began using it in the literature, calling it the bean from which soy sauce was produced. The world’s leading soybean-producing countries are the United States, Brazil, Argentina, China, and India (Soyatech 2009).

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Description

The soybean plant is a broadleaf summer annual, a broadleaf plant in the legume family (see figures 1 and 2). Being a legume, soybeans can have a symbiotic relationship with the bacterium commonly known as rhizobium (plural, rhizobia). Soybeans need no nitrogen fertilizer when grown with *Bradyrizobium japonicum*, a specific strain of rhizobium, which fixes nitrogen from air in the soil. Nitrogen from a soybean crop residue also provides considerable nitrogen to the following crop. Oregon has been slow to adopt commercial soybean production, since the temperatures in many of the growing areas are too cool. Research conducted at the Oregon State University Malheur Experiment Station has identified varieties that will grow in the Treasure Valley region of Idaho and Oregon. In the Treasure Valley and Columbia basin, where temperatures are higher than other parts of Oregon and Washington, excellent irrigated yields (65–80 bushels per acre) have been grown in research trials.

Photo by Clinton C. Shock, © Oregon State University.

Figure 1. Erik Feibert in a seed increase of high-yielding soybean lines at the Oregon State University Malheur Experiment Station.

Photo by O. Steve Norberg, © Oregon State University.

Figure 2. Soybeans grown on an organic farm near Vale, Oregon.

Growth and Development

Soybeans are considered a short-day plant, since they flower when the day length decreases. Some varieties will not produce flowers unless there are 10 or more hours of darkness. All varieties flower more quickly with more hours of darkness. A soybean variety has either determinate or indeterminate growth characteristics (see figures 3a and 3b). Determinate soybean varieties flower over a shorter period of time, whereas indeterminate varieties flower over a longer period of time. Determinate soybean plants have flowers clustered at the top of

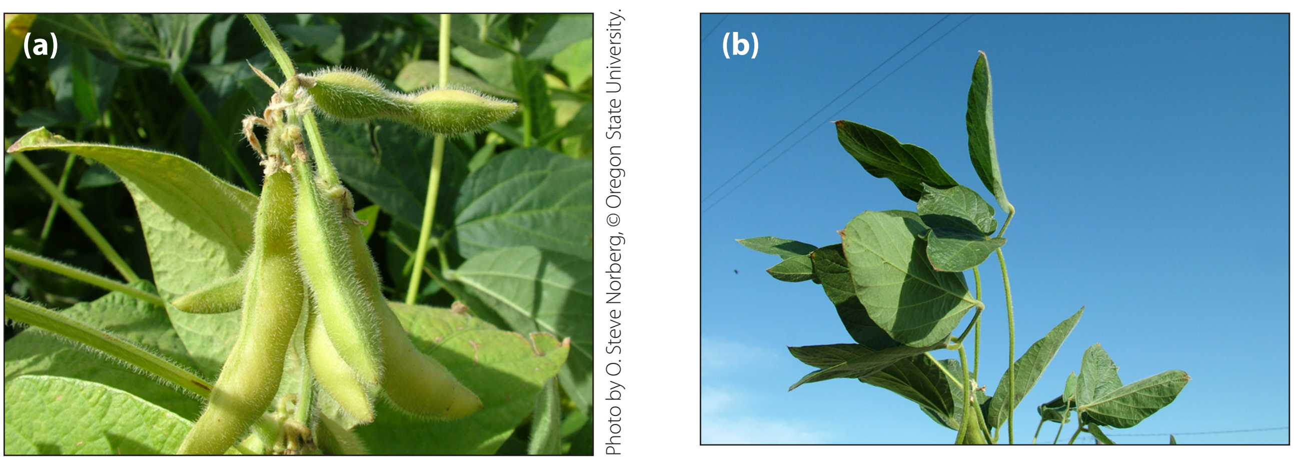

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Figure 3. (a) Determinate soybean variety. (b) An indeterminate soybean variety. Note the cluster of pods on the determinate variety on the left and not on the indeterminate variety on the right.

the stem. An indeterminate plant has flowers spaced evenly over the stem and is taller than a determinate of the same maturity. In all soybeans, the primary apical meristem (growing point) is close to the top of the plant. If the primary apical meristem is damaged by frost or mechanical removal, growth on that stem stops, which, depending on the time of the growing season, can be devastating to the plant. Growth stages of soybean can be found in table 1 (also see figure 4).

Photo by O. Steve Norberg, © Oregon State University.

Figure 4. Mature soybeans (left) and a pod at growth stage R6 (right; pod taken from 4th node down, where seeds filled the pod cavity).

Uses

Soybeans can be used for grain, seed, hay or silage. Soybean meal and soybean oil are made by crushing or extruding the grain. Soybean meal is a well-established protein source for dairy and other livestock. Soybeans can be fed whole to ruminant animals in small amounts. For feeding single-stomached animals, such as swine and poultry, soybeans must be heated to inactivate enzymes and enzyme inhibitors. Whole soybeans fed to cattle have 92% of the nutritional value of soybean meal (44% protein; Harris 2003).

Climate and Adaptation

Soybeans need adequate soil moisture for emergence and adequate irrigation for growth. Soybeans start reproductive growth sooner and fill seeds better when day and night temperatures are warm. The best locations in Oregon include the Treasure Valley and the Columbia Basin areas. Currently some soybean varieties have been experimentally planted in the Willamette Valley; their success will depend on their tolerance of cool conditions. Successful varieties would also have a high yield, low seed shatter, and lodging resistance.

Table 1. Description of soybean growth stages.

Stage	State name	Description
Vegetative stages		
VE	Emergence	Cotyledons above soil surface.
VC	Cotyledon	Unifoliate leaves unrolled so leaf edges are not touching.
V1	1st node	Fully developed leaves at unifoliate nodes.
V2	2nd node	Fully developed trifoliate leaf at node above unifoliate node.
V3	3rd node	Three nodes on main stem with fully developed leaves, beginning with the unifoliate node.
V(N)	*n*th node	*n* = number of nodes on main stem with fully developed leaves, beginning with the unifoliate node.
Reproductive stages		
R1	Beginning flowering	Open flower at any node on main stem. Indeterminate plants start at bottom and flower upward. Determinate plants start at one of the top 4 nodes and flower downward.
R2	Full bloom	Open flowers on one of the two uppermost nodes on main stem.
R3	Beginning pod	Pod 3/16 inch long at one of the four uppermost nodes on main stem.
R4	Full pod	Pod 3/4 inch long at one of the four uppermost nodes on main stem.
R5	Beginning seed	Seed (1/8 inch) long in one of the four uppermost nodes on main stem.
R6	Full seed	Pod containing a green seed that fills pod cavity on one of the four uppermost nodes.
R7	Beginning maturity	One normal pod on main stem has reached mature pod color.
R8	Full maturity	95% of pods have reached mature pod color. Approximately 5–10 days ahead of harvest.

Source: Fehr et al. (1971), reproduced by permission from the Crop Science Society of America.

Soil

Soybeans grow well on most soils. However, high-pH soils may cause iron chlorosis, also called "iron-induced chlorosis," "iron-deficient chlorosis," or "IDC," which is best prevented by selecting the variety to plant. Iron chlorosis in soybeans is most severe when calcium carbonate and soluble salts are high and when soil nitrogen is high. These soil conditions make iron less available to the plant, causing the leaves to yellow (figure 5). See the fertility section for remedies for iron chlorosis.

Photo by O. Steve Norberg, © Oregon State University.

Figure 5. Leaf of a Malheur Experiment Station advanced-line soybean variety taken from a soil alkali spot in a field near Vale, Oregon, showing iron chlorosis. Note the yellowing of the leaf except for the veins. No soybean varieties are tolerant of extremely alkaline soil.

Cultural Practices

Seedbed Preparation

Soybeans generally have excellent emergence, even when planted under conventional or no-till conditions. Seed treatments can be beneficial under cool, dry, or wet conditions. Soybeans emerge best when planted in moist soil, rather than when irrigated after planting, as increased seed decomposition often causes poor stands. Seedling diseases are more prominent in cool soils. Early soybean diseases, such as *Pythium* and *Phytophthora*, are called "damping off." When planting into dry soil and irrigating soybeans or planting early in cool soils, seed treatments may improve stands.

Timing of Planting

Soybeans should be planted so emergence occurs after the last frost of spring in early May. Yields drop only slightly when planting is delayed until late May. However in June, yield decrease due to delayed planting is significant and should be avoided, if possible. Soybeans should not be planted after June because soybeans may not mature and yield will likely be poor. As planting is delayed, it is not necessary to switch from a full-season variety to a short-season variety, since soybeans are sensitive to the length of the daylight hours and will naturally shorten the vegetative stages.

Seed Inoculation

For most successful inoculation, purchase only *Bradyrhizobium japonicum* inoculants and be sure that the inoculants use a sterile medium. Inoculate seed in fields where well-nodulated soybeans have not been grown in the past three years. When in doubt, using an inoculant is much cheaper than applying nitrogen fertilizer and increases soybean yield if the crop is nitrogen-deficient. Soybean seed can be treated with inoculant at planting, or pretreated seed can be purchased.

Planting, Seeding Rate, and Row Spacing

Soybeans ideally should be planted 1–1.5 inches deep into moist soil, no deeper than 2.0 inches in sandy soil. The deeper the soybeans are planted, the more likely seedlings will have diseases. If the soil is too dry for soybean germination, the field should be irrigated before planting. The rate of soybean seeding and drill and planter settings should be determined by calculating the number of seeds per acre. Information on the number of seeds to plant per acre is generally provided on the seed bag. A 40% difference in seed size can cause planting rate errors of 40%, which can result in higher seed costs or a low plant population. Under ideal conditions, soybeans should be drilled at 175,000 seeds per acre. Planting at higher rates is appropriate when planting early or late, or when an early canopy closure is needed for weed control. During these situations, planting at 200,000 to 250,000 seeds per acre or higher is appropriate. Lodging problems will likely be worse if the plant population is pushed beyond the ideal rate.

The Malheur Experiment Station has had good success in planting three rows 7 inches apart in a 30-inch bed. Approximately a 10%–15% increase in yield can be expected when switching from 30-inch rows to 7-inch rows.

Variety Selection

University variety trials are a very useful tool for selecting varieties. In Oregon, this work has primarily been done at the Malheur Experiment Station and can be found in their annual reports and at http://www.cropinfo.net. Previous research at Malheur Experiment Station has shown that in general commercial cultivars bred for the Midwest needed to be improved to have low seed shattering, decreased plant height and lodging, increased seed set, and high harvest index (ratio of seed to the whole plant) to be successful in eastern Oregon (Shock et al. 2007). Plants also need to have the special ability to continue pod fill during cold weather. These attributes have been kept in mind when developing new cultivars, which are currently in the seed increase and commercial trial stages of development.

When selecting a variety, consider those in your maturity range. In most of the world, the commercial industry places soybeans into maturity groups graded 000, 00, 0, I, II, III, IV, V, VI, VII, VIII, IX, and X from shortest to longest maturity. Each maturity group is further divided into relative maturity groups with numerical ratings such as 1.5, indicating the middle of Group I. In 1986–1988, research at the Malheur Experiment Station showed that maturity groups 000 and 00 yielded less than 0 and I (Shock and Stieber 1988). Among the cultivars in the experiment, Group I did not yield any better than Group 0 soybeans. The Malheur Experiment Station has been developing soybean varieties that have a clear hilum (portion of seed that was attached to the pod) and now have varieties ranging from 93 to 108 days from planting to physiological maturity. A soybean variety trial is currently underway at Parma, Idaho, Ontario, Oregon, and Corvallis, Oregon, that has commercial soybeans with relative maturity groups ranging from 0.5 to 2.2 that will provide additional information on maturity groups and yield of some varieties currently available (see figure 6).

Tim Woodard at Columbia Basin Community College planted varieties with a range of soybean maturity groups near Pasco, Washington, for two years. For soybeans planted on May 8, 2007, the varieties that yielded 75 bushels per acre or higher were close to being mature on September 25 and belonged to the relative maturity groups ranging from 1.4 to 1.7 (Woodward 2007). For soybeans planted on May 23, 2008, the varieties that yielded 75 bushels per acre or higher were mature by October 6, 2008, and ranged from 0.0 to 1.5 in relative maturity group ratings (Woodward 2008).

Photo by O. Steve Norberg, © Oregon State University.

Figure 6. Soybean variety trial conducted at the Malheur Experiment Station in 2009.

Herbicide resistance comes in the form of GMO soybean varieties such as Roundup Ready (resistant to glyphosate), and Liberty Link (resistant to glufosinate), introduced in 2009, whereas STS (resistant to sulfonylurea herbicides) is not currently a GMO trait. Make sure that you use herbicides according to the label in your state. When selecting a cultivar, select within the correct maturity group for yield, seed shatter resistance, lodging resistance, and IDC score if your soil pH is above 7.7. In the Treasure Valley and Columbia Basin, probably a maturity group of 0 to 1.9 would be appropriate. Selecting too long a maturity will increase the risk of poor pod fill or frost damage to beans, thus reducing yields, whereas selecting a shorter than optimum maturity can reduce the potential for yield.

Fertilizer

As with other crops, soil tests should be conducted. Soybean fertilizer recommendations for Oregon have not yet been determined. Research from other states has shown that critical soil test levels (not fertilizer rates) for soybeans are similar to corn, except for nitrogen. As mentioned earlier, soybeans have a symbiotic relationship with a specific bacterium called *Bradyrhizobium japonicum*, commonly referred to as rhizobium. When the symbiotic relationship has been established, the nodules that form are easily visible (figure 7), and no nitrogen fertilizer is required. Nodules formed on the roots are pink inside when this relationship has been established.

Iron chlorosis in soybeans is most severe when calcium carbonate and soluble salts are high. In some situations, iron chlorosis can be prevented or reduced by applying an iron chelate (Fe-EDDHA) fertilizer to the seed or as a pop-up fertilizer. However, the first line of defense against iron chlorosis should be using IDC ratings from seed supplier to select the variety. If symptoms arise after planting, a foliar application of iron needs to be made as soon as the plant begins to turn yellow. Waiting too long may make the application less effective, because more damage to the plant occurs. Growing crops such as barley instead of soybeans may be a better choice in very alkaline soils (high sodic and/or saline soils). An IDC rating indicates how a soybean variety will perform in slightly and moderately alkaline soils.

Weed Control

A large variety of preplant and post-emergence herbicides are available for conventional and Roundup Ready soybeans. Follow labeled directions and check crop rotation intervals when making herbicide selections. When yellow nutsedge is a problem, a herbicide program using the herbicides Outlook, Dual, and Basagran would make sense. Basagran can be replaced by Roundup when a Roundup Ready variety is grown. Herbicide guides from Midwest universities will help you select the herbicide you need, but make sure that the herbicide you select is labeled in your state.

Disease Control

Under cool moist conditions soybean seeds can decompose in the soil and seedlings can get "damping off" caused by *Pythium* or *Phytophthora*. Seed treatment may help under wet and cold conditions. White mold (*Sclerotinia* stem rot) can be a problem in cool areas (<85°F at flowering and early pod development), especially if soils are excessively irrigated. Temperatures above 90°F at flowering and early pod development reduce white mold problems. Soybean rust has become a problem in most soybean-growing areas, but has not reached Oregon yet. In the Midwest, most outbreaks have been minor.

Insect Control

Very little is known about the impact of insects on soybeans in Oregon. Some pests of concern include lygus bugs and spider mites. Lygus bug damage to soybeans is likely to be similar to damage seen on dry, edible beans, but no research on the impact of lygus bugs on soybeans has been conducted. In dry beans, early lygus damage comes from bud and flower loss. Later, lygus damage to dry beans is cosmetic to the pod and seed, possibly reducing seed germination. In the Pacific Northwest, a suggested lygus treatment threshold for dry edible beans is an average of one-half adult or one-half fourth or fifth instars, per sweep (Hollingsworth 2009). One practice to reduce or control the movement of lygus adults from alfalfa into nearby

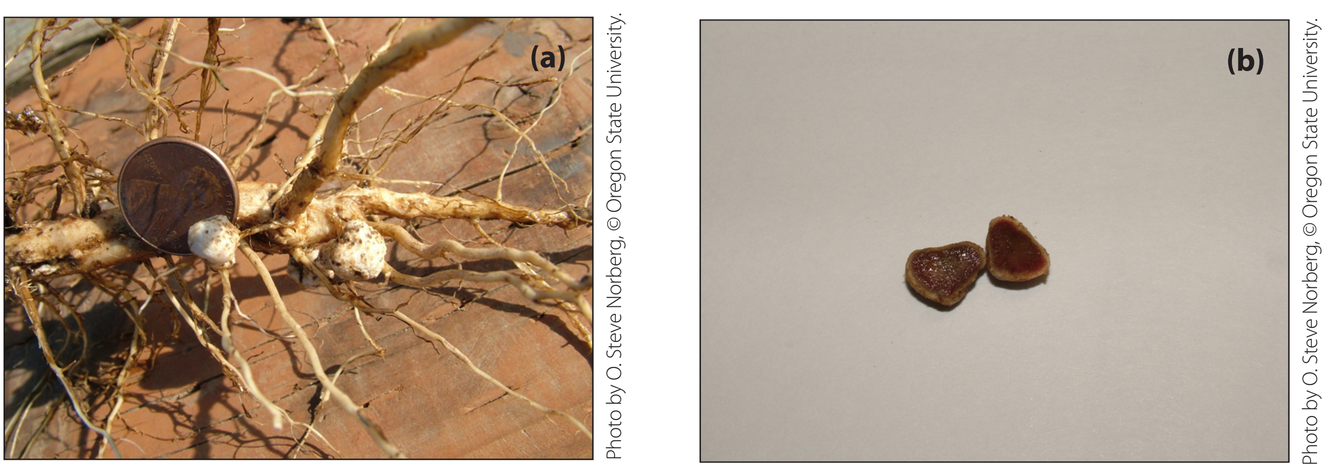

Figure 7. (a) Root of a soybean plant showing good rhizobia nodulation. A penny is shown for size. (b) A functioning rhizobium nodule cut in half shows a pink or red color inside.

bean fields is to leave tall, uncut alfalfa (attractive to lygus bug adults) within or near the cut area.

Probably a bigger concern in soybeans is spider mites, especially under furrow irrigation and in dusty areas. Scouting for spider mites should be done during flowering and continue through the growing season. Spraying for lygus could kill beneficial insects and make spider mite problems worse. When selecting an insecticide, consider price, efficacy and impact on beneficial insects. Sprinkler irrigation helps to keep spider mites under control, but scouting is still required. Iowa State University Extension specialists have suggested that mite control may be warranted when infested plants have substantial spotting or leaf yellowing and live mites, but before mites cause browning and leaf drop (Wright et al. 2006).

The soybean aphid has caused significant problems in some soybean-growing areas, but has not reached Oregon yet. Cucumber beetles have damaged soybeans in the Willamette Valley.

Irrigation

Soybeans will likely use less water than corn and sugarbeets, and more water than winter grain. Water use is about 26–27 inches of evapotranspiration per year. Soybeans are a relatively drought-tolerant crop and produce a root system that will extend to 6 feet deep if not restricted by the soil. When scheduling irrigation, it is recommended that the top 2 feet of soil be monitored during the vegetative stages and during flowering, and the top 3 feet be monitored during pod elongation and seed fill (Kranz et al. 2005). The Malheur Experiment Station furrow irrigates soybean variety trials when the soil water tension at 8-inch depth reaches 60 centibars (cb) by using granular matrix sensors (Shock et al. 2005). Guides from Kansas and Nebraska suggest maintaining at least 50% available water in the soil when irrigating soybeans, and until further research is conducted, we recommend 65%–70% available water for production in Oregon because of low probability of rain. Maximum plant water use per day peaks at early pod stage (figure 8; Rogers et al. 1997).

Harvest for Grain

Harvest soybeans when moisture content of grain is below 12% and stems are dry enough to pass easily through the combine. Delaying harvest beyond this time may increase harvest losses due to seed shatter in some varieties. Combine cylinder speeds need to be slowed down considerably from wheat and corn

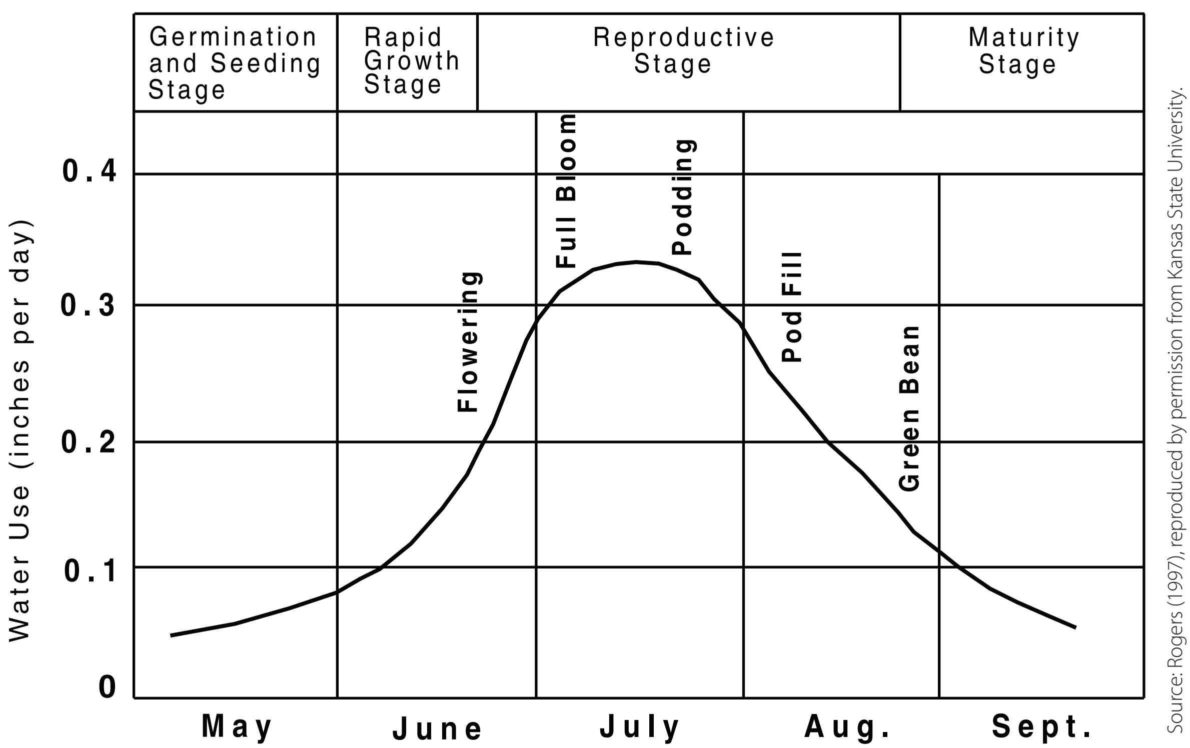

Figure 8. Water use of soybean in Kansas at different growth stages.

Table 2. Effect of harvest date on soybean forage quality and quantity.

		Dry matter yield		Crude protein		Fat	NDF*	IVDOM†	
Days of age	Growth stage	%DM	lb/acre	%DM	lb/acre	%DM	%DM	%DM	lb/acre
75	50% bloom	24	3,668	17.8	647	2.1	54.5	59.0	2,164
82	75% bloom	27	4,005	17.0	676	2.2	53.9	58.2	2,331
89	95% bloom	27	4,506	16.7	750	2.4	56.7	59.8	2,695
96	Pods 0.5 full	26	5,222	18.4	961	2.9	50.8	60.3	3,149
103	Pods 0.66 full	26	5,067	19.4	983	3.7	50.2	61.4	3,111
110	Pods 0.75 full	26	5,527	20.8	1,148	5.4	48.9	60.2	3,327
117	Pods 0.90 full	27	7,113	20.9	1,485	6.2	46.6	60.8	4,325
124	30% leaf drop	29	6,136	21.3	1,309	7.4	43.0	61.0	3,743
131	85% leaf drop	35	5,796	22.3	1,295	8.5	43.9	60.3	3,495
138	100% leaf drop	56	4,362	24.6	1,073	9.2	41.9	60.0	2,617

Source: Data from Johnson et al. (1977), reproduced by permission from the University of Georgia.

Notes: Bragg variety soybeans planted June 6, 1977, Tifton, Georgia. DM = dry matter.

* Neutral detergent fiber (NDF) is the percentage of the fiber in a forage sample that is not soluble in neutral detergent solution.

† The in vitro digestible organic matter (IVDOM) was determined by artificial rumen technique.

settings to prevent splitting grain when harvesting. Check your owner's manual for the proper adjustments for your combine.

Harvest for Silage

Soybeans are different from other forages in that protein percent, the quantity of protein and digestible energy material per acre, increases after flowering until near maturity (table 2). The best stage to harvest soybeans for silage is when seeds are about full size, but before any leaf loss (Johnson et. al. 1977). At this stage, carbohydrate in the silage will be low, and grain such as corn will have to be added to get proper fermentation. Corn grain or molasses should be added at a minimum of 10% on a dry matter basis. Another option is to blend corn or sorghum silage at a 50 to 50 ratio. A number of improved inoculants are commercially available for making legume silage (Blount et al. 2009). Silage inoculants are added when filling the silo and contain lactic acid bacteria, which produce lactic acid. Lactic acid production is important to ensure good fermentation, which improves dry matter recovery from the silo and improves animal performance.

The weight of the soybean dry forage is about 3 times the mature seed weight or 5.4 tons per acre for a 60 bushel per acre seed yield.

Yield

Soybean varieties have been grown at the Malheur Experiment Station with modest inputs. The best variety had an average yield of 67.3 bushels per acre from 2005 to 2008 (Shock et al. 2008). Research from the Columbia Basin and the Malheur Experiment Station has occasionally shown yields in excess of 80 bushels per acre in a given year. What the long-term average will be on farms across the Treasure Valley and Columbia Basin is too early to tell, but will likely be at least 10% below research yields. In the Willamette Valley commercial GMO soybeans yielded as much as 53 bushels per acre in 2008, and Malheur Experiment Station varieties yielded as much as 68 bushels per acre in 2009. Monitoring of producers' fields needs to be done to determine county averages.

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