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Soybean

Growth and Management

QUICK GUIDE

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Growth, development and seed yield of soybeans are a result of a variety's genetic potential interacting with environmental and production management practices.

It is important for successful soybean production to understand plant growth staging and timing when making production decisions. Minimizing environmental stress, particularly during critical stages of soybean development, will optimize seed yield. Management practices that may influence crop growth include variety selection, field selection, seedbed preparation, plant establishment (planting date, rate, depth and row width), pest management (diseases, insects and weeds) and plant nutrition.

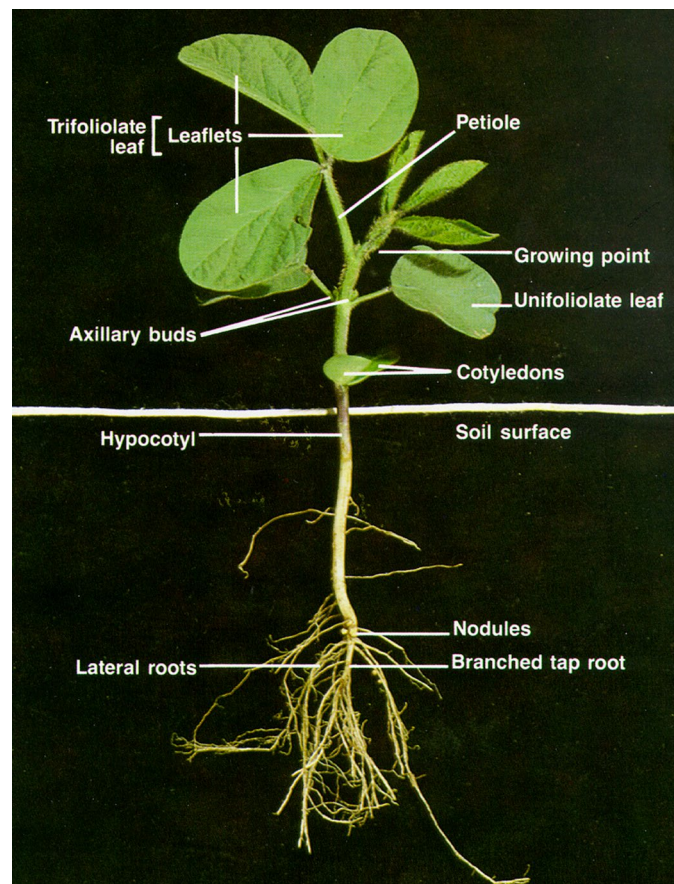


Figure 1.
Soybean plant.

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Soybeans are classified as either indeterminate or determinate in growth. Many southern varieties are determinate in growth and cease vegetative growth when the main stem terminates in a cluster of mature pods. Most northern (including North Dakota) varieties are indeterminate in growth habit. Indeterminate varieties develop leaves and flowers simultaneously throughout a portion of their reproductive period, normally ending during the early seed development growth stage. With soybean development being driven by photoperiod (interval in a 24-hour period during which a plant is exposed to light) and temperature, northern varieties have vegetative growth limited by the season length.

Shortening day length (increasing night length) and warm temperatures control soybean flowering. Soybeans in the northern U.S. have long minimum day-length requirements for the onset of flowering (often greater than 14 hours of daylight). However, even within a variety, variations in time of flowering may occur from year to year, with the same day length closely associated with temperature conditions.

Soybean maturity groups are based on adaptation within certain latitudes. These maturity belts run east to west in the U.S., with only about 100 to 150 miles from the north to the south of each belt. Maturity groups range from 00 in the extreme northern U.S. to VIII in the southern Gulf Coast states and most of Florida.

Planting a specific variety farther north than its adapted maturity range will extend the period of vegetative growth and delay flowering and maturity due to the extended summer day length and cooler temperatures. Likewise, planting a variety farther south than its adapted range will shorten the vegetative growth period, cause earlier flowering and result in an earlier maturity due to shorter summer day length and warmer temperatures.

Vegetative Stages

VE (emergence)
VC (cotyledon stage)
V1 (first trifoliolate)
V2 (second trifoliolate)
V3 (third trifoliolate)
V(n) (nth trifoliolate)

Reproductive Stages

R1 (beginning bloom, first flower)
R2 (full bloom, flower in top two nodes)
R3 (beginning pod, 3/16-inch pod in top four nodes)
R4 (full pod, 3/4-inch pod in top four nodes)
R5 (1/8-inch seed in top four nodes)
R6 (full-size seed in top four nodes)
R7 (beginning maturity, one mature pod)
R8 (full maturity, 95% of pods on the plant are mature)

The vegetative stages are defined by the number of nodes with fully expanded leaves. All V1 to Vn stages have true leaves (leaflet edges no longer touching) that are trifoliolate and produced singularly on different nodes, with these leaves alternating on the stem.

The reproductive stages are divided into four parts: R1 and R2 describe flowering, R3 and R4 describe pod development, R5 and R6 describe seed development and R7 and R8 describe plant and seed maturation.

Vegetative

Vegetative Growth Stages

1. Emergence (VE)

Soybean seed begins germination when the water absorbed is equal to about 50% of the seed's weight. The radical, or primary root, is first to emerge from the seed. Shortly afterward, the hypocotyl (stem) emerges and begins growing toward the soil surface, pulling the cotyledons (seed leaves) with it. This hook-shaped hypocotyl straightens out once emerged and as the cotyledons unfold. As the hypocotyl arch is exposed to light and straightens to pull the cotyledons out of the ground, epicotyl growth begins with expansion and unfolding of unifoliolate leaves. Auxiliary buds are located where the cotyledons or leaves are attached to the stem. Plant emergence normally takes 10 to 18 days, depending on soil temperature and moisture, variety and planting depth. During this time, lateral roots also begin to grow from the primary root. Root hairs also begin to emerge and provide the key nutrient and water-absorbing functions of the plant.

The primary root will continue growing and branching so that lateral roots can reach the center of a 30-inch row within five to six weeks. Eventually, **soybean roots normally reach a depth of 2 to 3 feet, with most of the roots in the upper 6 to 12 inches of soil.**

Soybeans should be **planted 1 to 1½ inch deep but not deeper than 2 inches.**

Low amounts of starter fertilizer (phosphorus, if at less than medium soil levels) in a band within 2 inches of the seed likely will promote early plant growth and seed yield. Do not place fertilizer directly in the furrow because salt (and ammonium, if fertilizer contains nitrogen) injury from the fertilizer is likely to result. Soybeans are very salt sensitive (about twice as sensitive as corn).

If fields have not been in soybeans during the previous three years or more, consider inoculating seed with *Bradyrhizobium japonicum* bacteria to form nodules on the soybean roots that later will provide much of the plant's nitrogen supply.

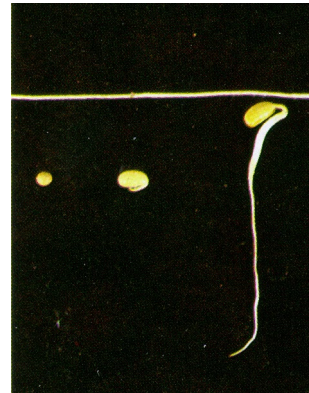


Figure 2. Germination.



Figure 3. VE soybean emergence.

Vegetative Growth Stages



Figure 4. VC soybean.



Figure 5. V2 soybean.

2. Cotyledon Stage (VC)

The VC stage is reached when the unifoliolate leaves are fully expanded. During the VC stage, the cotyledons supply the nutrient needs of the young plant (for about seven to 10 days). If one cotyledon is lost during this time, it has little effect on the plant's growth rate. However, losing both cotyledons at or soon after VE can reduce yields by up to 10%. Later, after V1, photosynthesis in the developing leaves allows the plant to sustain itself.

3. First trifoliolate (V1)

This stage is achieved when the first trifoliolate is fully emerged and opened. The V stages after VC are defined and numbered by the upper, fully developed leaf node on the main stem above the unifoliolate leaves (the V1 to Vn stages are numbered by fully developed trifoliolates). New V stages will begin appearing about every three to five days through V5 and then every two to three days from V5 to shortly after R5, when the node number usually reaches a maximum. Trifoliolate leaves on branches are not counted when determining V stages; only the trifoliolates off the main stem are used in the count.

4. Second node (V2)

Plants have two nodes above the unifoliolate node, with trifoliolate leaves having unfolded leaflets. **Active nitrogen fixation is just beginning to occur.** Most of these root nodules are within 10 inches of the soil surface, with millions of bacteria in each nodule.

Nodules that are pink or red inside are active in nitrogen fixation. White, brown or green nodules are not efficiently fixing nitrogen and are probably parasitic on the plant. The plant will use bacteria-produced nitrogen and the applied or intrinsic soil nitrogen. Too much soil nitrogen will cause the plant to use this N supply first, delaying nodulation and/or reducing nodule size and number.

Lateral roots are developing rapidly in the top 6 inches of soil.

Vegetative

Vegetative Growth Stages

5. Third to Fifth nodes (V3-V5)

Soybean plants have three nodes above the unifoliolate node at V3, and five nodes of fully expanded leaflets at V5. The number of branches seen on the plant may increase at this point in wider row spacings and under lower plant densities, depending upon the variety grown.

Normally at V5, the plant's axillary buds in the top stem will develop into flower clusters (racemes). V5 is about one week or less from R1, or first flower. At V5, the total number of nodes that the plant can produce is established.

Although the stem apex (main growing point) is dominant, damage to this growing point will allow axillary buds lower on the plant to branch and grow profusely. Thus, soybeans are capable of producing new branches and leaves after hail destroys almost all of the above-ground foliage as long as at least one axillary bud remains intact. However, **if the plant is broken off below the cotyledonary node, the plant is killed** because no axillary buds are below this node.

6. Sixth node (V6)

Soybeans at this stage have six nodes containing trifoliolate leaves with fully unfolded and expanded leaflets. The unifoliolate and cotyledons may have senesced from the plant. The plant can readily recover from damage; a 50% leaf loss at this stage will reduce yield less than 5%.



Figure 6. V5 soybean.



Figure 7. V6 soybean.

Reproductive

Reproductive Stages



Figure 8. R1 soybean.

1. Beginning Bloom (R1)

At least one flower is on the plant at any node on the main stem. Soybean **flowering always initiates on the third to sixth node** on the main stem, depending on vegetative stage when flowering begins. This flower initiation will progress up and down the plant. Branches eventually also flower. Within each raceme, the flowering will occur from the base to the tip, so basal pods are always more mature.

Dominance of the primary racemes is seen over secondary racemes on the plant; however, secondary racemes can develop just to the side of primary racemes on the same axil. Vertical roots are rapidly growing and will continue until R4 to R5, as are secondary roots and root hairs nearer the soil surface.



Figure 9. R2 soybean.

2. Full Bloom (R2)

An open flower is seen at one of the two top nodes of the main stem. At least one of these two upper nodes shows a fully developed leaf. At this stage, **the soybean has accumulated about 25% of its total dry weight and nutrients** and has obtained about **50% of its mature height**. About 50% of the total mature node number has been established. **Very rapid nitrogen, phosphorus, potassium and dry-matter accumulation is occurring and will continue through R6.**

The appearance of new flowers on the plant begins to slow between R2.5 and R3 and **will be complete by R5**. Major lateral roots have turned downward in the soil and nitrogen fixation by root nodules is increasing rapidly. Defoliation of the plant of 50% at this stage will reduce yield less than 10%.



Figure 10. R3 soybean.

3. Beginning Pod (R3)

A pod on the upper four nodes is $\frac{3}{16}$ inch long. Temperature or drought stress **at this time can affect yield through total pod number, bean number per pod or seed size**. Partial compensation with only temporary stress can occur in soybeans, but as the plant matures from R1 to R5.5, this ability to compensate will decrease.

Very favorable conditions will result in greater pod numbers per plant at this time. Any stress at this stage will increase pod and flower abortion, impacting yield greatly. However, the long flowering period of soybeans is one reason the plants can compensate so well.

4. Full Pod (R4)

This stage shows rapid pod growth and the beginning of seed development at the beginning of the full-pod stage. The dry weight of pods increases greatly from R4 to R5. The plant has a pod at this stage that is at least 3/4-inch long on at least one of the four upper nodes of the main stem. The last flowering will occur at the main stem tip (through R5).

This stage is the most crucial period for seed yield. Any stress from R4 to R6 causes more yield reduction than at any other time. Late pod formation at R4.5 to early seed fill at R5.5 is most critical. Yield reduction at this time is mainly from fewer pods. This is a critical period to have implemented all management practices for preserving yield.

5. Beginning Seed (R5)

Seed development during this stage requires much water and nutrients from the plant. Redistribution of nutrients in the plant occurs with the soybean providing about half of the needed N, P and K from the plant's vegetative parts and about half from N fixation and nutrient uptake by the roots from the soil.

Leaf loss of 100% at this stage will reduce yield by 50-80%; the plant is less able to compensate for stress and vegetative damage. Stress can lower yields by reducing pod numbers and the number of beans per pod, and to a lesser extent, by reducing seed size.

This stage has a pod on one of the four upper nodes of the main stem with a seed at least 1/8 inch long. **About halfway through this stage, the plant attains its maximum height, node number and leaf area. Nitrogen fixation peaks and begins to drop, and the seeds continue a steady period of dry weight accumulation.** Toward the end of this stage, the nutrient accumulation in the leaves peaks and then begins the process of redistributing to the seed.

Seed nutrient accumulation will continue until shortly after R6.5, with about 80% of total seed dry weight being accomplished.

6. Full Seed (R6)

This stage is also known as the “green bean” stage or beginning full-seed stage, and total pod weight will peak during this stage. Within this stage, three to six trifoliolate leaves may fall from the lowest nodes on the plant prior to leaf yellowing. This stage initiates with a pod containing a green seed that fills the pod cavity on at least one of the four top nodes of the main stem. **The growth rate of the beans is rapid but will slow by R6.5 and peak at R7.**

Root growth is complete at about R6.5.



Figure 11. R4 soybean.



Figure 12. R5 soybean.



Figure 13. R6 soybean.

Reproductive Stages



Figure 14. R7 soybean.



Figure 15. R8 soybean.

7. Beginning Maturity (R7)

This stage begins with one normal pod on the main stem, which obtains the mature color (brown or tan). Dry matter begins to peak in individual seeds. This is visible when all the green is lost from the seeds and pods (they appear yellow). **Leaf yellowing and loss begins at this stage.**

Seeds contain about 35% moisture at physiological maturity. Stress at this stage or later has almost no effect on yield unless pods are dropped to the ground or seeds are shattered from the pods. Also, any lodged plants may reduce actual yield (due to reduced light interception) and harvested yield (harvest losses). **At this stage, the crop is safe from a killing frost.**

8. Full Maturity (R8)

On the soybean plant, 95% of the pods have reached their mature color. Generally, 5 to 10 days of good drying weather after this stage will be required to have the soybeans at less than 15% moisture, or harvest moisture. Soybeans will lose moisture rapidly with warm and dry weather at this point and should be timely harvested to prevent losses.

This publication was authored by D.R. Berglund, professor emeritus and former Extension agronomist; D.A. McWilliams, former Extension agronomist; and G.J. Endres, Extension area agronomist, NDSU, 1999.

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