

# Soybean

## Growth and Management

### QUICK GUIDE

D.A. McWilliams  
D.R. Berglund  
G.J. Endres

North Dakota State University  
University of Minnesota

**G**rowth, development and yield of soybeans are a result of a variety's genetic potential interacting with environment and farming practices. Correct production decisions using plant growth staging and timing are important for successful soybean production. Minimizing environmental stress will optimize seed yield. Farmers who understand how a soybean plant grows and develops can establish their field practices to maximize the genetic potential of the varieties grown. Management practices that may influence crop growth include seedbed preparation, variety selection, planting rate, planting depth, row width, pest management (diseases, insects and weeds), fertilization and harvesting.

Soybeans are classified as indeterminate, semi-determinate or determinate in growth in the United States. Many southern varieties are determinate in growth and cease vegetative growth when the main stem terminates in a cluster of mature pods. Most northern varieties are indeterminate in growth habit. Indeterminate varieties develop leaves and flowers simultaneously throughout a portion of their reproductive period, with one to three pods at the terminal apex. With soybean development being driven by photoperiod,

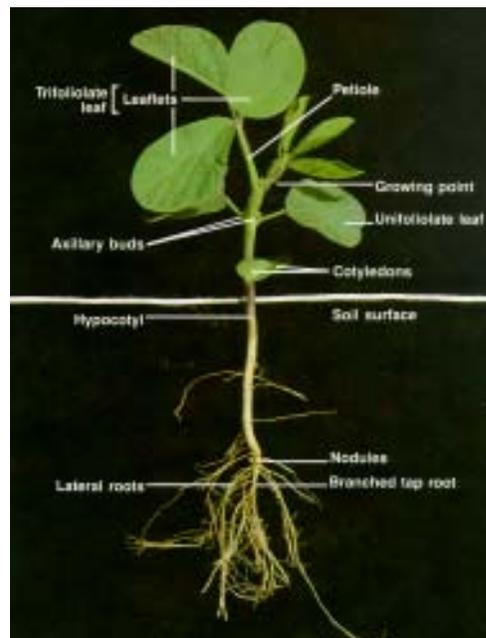


Figure 1. Soybean plant.



North Dakota State University  
Fargo, North Dakota 58105

JUNE 1999

Reviewed and Reprinted August 2004

northern varieties have vegetative growth limited by the season length. Semi-dwarfs, determinate varieties that are usually only 40-50% as tall as indeterminate varieties, are commonly grown in the Midwest. They were developed for their better standability (they are less susceptible to lodging) and are very appropriate for solid-seeding or drilled fields.

**Soybean maturity groups are based on adaptation within certain latitudes. These maturity belts run east to west in the United States with only about 100 to 150 miles from the north to the south of each belt. Maturity groups range from 000 in the extreme northern U.S. to VIII in the southern Gulf Coast states and most of Florida.**

Short daylength and warm temperatures control soybean flowering. Soybeans must reach at least the first trifoliolate in growth before they can be induced to flower. Soybeans in the northern U.S. have longer minimum daylength 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. Planting a specific variety farther north than its adapted maturity range will extend the period of vegetative growth, delay flowering and delay maturity due to the extended summer daylength 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 daylength and warmer temperatures.

### **Vegetative Stages**

VE (emergence)  
 VC (cotyledon stage)  
 V1 (first trifoliolate)  
 V2 (second trifoliolate)  
 V3 (third trifoliolate)  
 V(n) (nth trifoliolate)  
 V6 (flowering will soon start)

### **Reproductive Stages**

R1 (beginning bloom, first flower)  
 R2 (full bloom, flower in top 2 nodes)  
 R3 (beginning pod, 3/16" pod in top 4 nodes)  
 R4 (full pod, 3/4" pod in top 4 nodes)  
 R5 (1/8" seed in top 4 nodes)  
 R6 (full size seed in top 4 nodes)  
 R7 (beginning maturity, one mature pod)  
 R8 (full maturity, 95% of pods on the plant are mature)

A fully developed leaf node for the vegetative stages has a leaf above it with unrolled or unfolded leaflets. These unfolded leaflets have their edges no longer touching. Stages are counted from the unifoliolate leaf node and upward. All other stages have true leaves that are trifoliolate and produced singularly on different nodes with these leaves alternating on the stem. The reproductive stages are divided into 4 parts: R1 and R2 describe flowering; R3 and R4 describe pod development; R5 and R6 describe seed development; and R7 and R8 describe plant maturation.

# Vegetative

## Vegetative Growth Stages

### 1. Emergence (VE)

Soybean seed begins germination when water is absorbed 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. **Emergence (VE) normally takes five to ten days** depending on temperature, moisture conditions, variety and planting depth. During this time, lateral roots are also beginning to grow from the primary root. Root hairs can be visible within five days of planting and provide the key nutrient and water absorbing functions of the plant in this early stage. The taproot will also continue growing and branching so that lateral roots can reach the center of a 30-inch row within five to six weeks. Eventually the soybean root will reach a depth of 4 to 8 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**. Because the soybean must often push through crusted soil, deeper planting can limit viability of seed and final stand number. Rotary hoeing can help seed push through crusted soil as well as help in early weed control. Very small amounts of fertilizer (P or K if needed) in a band to the side and slightly below the seed may help early plant growth, especially if soils are still cool. Do not place fertilizer too near the seed or directly in the furrow as salt injury from the fertilizer can result. **Soybeans are very salt sensitive** (about twice as sensitive as corn). If fields have **not been in soybeans in the last four years or the field has been flooded, seed should be inoculated** with *Rhizobium japonicum* bacteria (such as Brady) to form nodules on the soybean roots that will later provide much of the plant's nitrogen supply. As the hypocotyl arch is exposed to light and straightens to pull the cotyledons out of the ground, growth called epicotyl growth begins with expansion and unfolding of unifoliolate leaves.

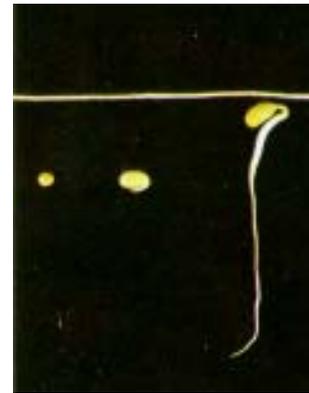


Figure 2. Germination.

# Vegetative Growth Stages

## 2. Cotyledon Stage (VC)

The VC stage is begun when these 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). The cotyledons will lose about 70% of their dry weight to this nutrient reallocation. If one cotyledon is lost during this time, there is little affect on the plant's growth rate. However, loss of both cotyledons at or soon after VE will reduce yields 8-9%. Later, after V1, photosynthesis in the developing leaves allows the plant to sustain itself. **New V stages will now begin appearing around every three to five days** through V5 and then every two to three days from V5 to shortly after R5 when node number usually reaches a maximum.

## 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 (the stage is numbered by fully-developed trifoliolates). Trifoliolate leaves on branches are not counted when determining V stages, only the trifoliolates off the main stem are used in the count.



Figure 3. V2 soybean.

## 4. Second node (V2)

Plants are 6-8 inches tall and have three nodes with two unfolded leaflets. **Active nitrogen fixation** from the bacteria 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. A minimal amount (50 pounds of nitrogen in North Dakota and the Red River Valley of Minnesota, no addition in the rest of Minnesota) of nitrogen fertilizer can be supplied to soybeans as a starter fertilizer. The plant will use bacteria-produced nitrogen and the applied or intrinsic soil nitrogen. Too much nitrogen fertilizer will cause the plant to use this supply rather than develop nodules and fix nitrogen. The top 6 inches of soil have soybean lateral roots developing rapidly now. **Any cultivation for weed control should be no deeper than absolutely necessary** to minimize root pruning.

# Vegetative

## Vegetative Growth Stages

### 5. Third to Fifth nodes (V3-V5)

Soybean plants are about 7-9 inches tall with four nodes (three unfolded leaflets) at V3 and will be about 10-12 inches tall with six nodes of unfolded 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 variety grown. Up to six branches are normally developed under field conditions in branched (rather than upright) varieties with the largest branch being the main stem. At V5, the plant normally has axillary buds in the top stem that will develop into flower clusters (racemes). **V5 is about one week from R1 or first flower.** At V5, the total number of nodes that the plant can produce is established. With indeterminate soybeans, this total is higher than the number of nodes that will actually fully develop. However, these extra axillary buds allow the plant to recuperate from any hail or wind that may damage some of the buds. Although the stem apex (main growing point) is dominant, damage to this growing point will allow axillary buds lower on the plant to suddenly branch and grow profusely. Thus, soybeans are capable of producing new branches and leaves after hail destroys almost all the above ground foliage as long as some (at least one) axillary buds remain intact. **If the plant is broken off below the cotyledonary node, however, the plant is killed** as no axillary buds are below this node.



Figure 4. V5 soybean.

### 6. Sixth node (V6)

Soybeans are often 12 to 14 inches tall at this stage with seven nodes with unfolded leaflets. The unifoliolate and cotyledons may have senesced from the plant. New stages are quickly unfolding every two to three days. Lateral roots have crossed over the row underground in any rows 30 inches or less. The plant is still capable of recovering from damage; a **50% leaf loss at this stage will only affect yield about 3%.**



Figure 5. V6 soybean.

# Reproductive Stages



Figure 6. R1 soybean.

## 1. Beginning Bloom (R1)

At least one flower is located on the plant at any node on the main stem. Plants have lengthened to 15-18 inches tall and are vegetatively structured as a V7-V10 plant. 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. Once again 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-R5, as are secondary roots and root hairs nearer the soil surface.



Figure 7. R2 soybean.

## 2. Full Bloom (R2)

Soybeans are around 17-22 inches and are seen as V8-V12 in vegetative growth at the beginning of full bloom. 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 have been established. Very rapid N, P, K and dry matter accumulation is now occurring and will continue through V6. Roots can reach across 40-inch rows. The appearance of new flowers on the plant begins to slow between R2.5-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 by 6%.**



Figure 8. R3 soybean.

## 3. Beginning Pod (R3)

Plants can be up to 23-32 inches tall and can be at the V11-V17 stage. A pod on the upper four nodes is 3/16 inch long. Temperature or moisture **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 number per plant at this time. Since **60-75% of most flowers typically abort** on soybean, any stress that increases this abortion will greatly influence yield. Half of most flowers are lost before pods begin developing and the other half are due to pod abortion. However, the long flowering period of soybeans is one reason these 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. Dry weight of pods is greatly increased from R4-R5. There is a pod at this stage which is at least  $\frac{3}{4}$  inch long on at least one of the four upper nodes of the main stem. **This stage is the most crucial period for seed yield.** Any stress from R4-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 consider irrigation, if needed, to reduce yield losses. The last flowering will occur at the main stem tip (through R5).

## 5. Beginning Seed (R5)

Seed filling during this stage requires much water and nutrients from the plant. Redistribution of nutrients in the plant occurs with the soybean providing about a half of needed N, P and K from the plant's vegetative parts and about a half from N fixation and nutrient uptake by the roots. **Leaf loss of 100% at this stage will reduce yields by 80%**; the plant is less able to compensate from stress and vegetative damage. Stress can actually lower yields by reducing pod number and the number of beans per pod, and to a lesser extent by reducing seed size. This stage has seed at least  $\frac{1}{8}$  inch long in one of the pods on one of the four upper nodes of the main stem. **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 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. Growth rate of the beans is rapid but will slow by R6.5 and peak at R7. 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. Rapid leaf yellowing will begin right after this stage until R8, or all leaves have fallen. Within this stage, three to six trifoliolate leaves may fall from the lowest nodes on the plant prior to leaf yellowing. **Root growth is complete at around R6.5.**



Figure 9. R4 soybean.



Figure 10. R5 soybean.



Figure 11. R6 soybean.

# Reproductive Stages



Figure 12. R7 soybean.



Figure 13. 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 visually seen when all green color is lost from both the seeds and pods (they appear yellow). Seeds contain about 60% 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 and **only five 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 but should be harvested soon to prevent losses. **Long-term storage of soybeans should be at 13% or less moisture.** When harvesting leave short stubble to ensure full harvest. **A 3½ inch stubble still leaves 5% or more of the crop and a 6½ inch stubble, 12% or more.**

For more information on this and other topics, see: [www.ag.ndsu.nodak.edu](http://www.ag.ndsu.nodak.edu)

Photography for this publication was provided through Iowa State University Photo Service, J.C. Herman, editor. Stage designation format was derived from the Iowa State Extension special report no. 53, "How a Soybean Plant Develops" prepared by S.W. Ritchie, J.J. Hanway, H.E. Thompson and G.O. Benson. Also, qualification on production management suggestions were summarized from lectures from J.R. George through Iowa State University. Special thanks to the suggestions and editorial review from T. Helms, Associate Professor, NDSU.



NDSU Extension Service, North Dakota State University of Agriculture and Applied Science, and U.S. Department of Agriculture cooperating. Duane Hauck, Director, Fargo, North Dakota. Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. We offer our programs and facilities to all persons regardless of race, color, national origin, religion, sex, disability, age, Vietnam era veterans status, or sexual orientation; and are an equal opportunity employer. 3M-6-99, 1M-5-01, 1M-8-04

This publication will be made available in alternative format upon request to people with disabilities (701) 231-7881.