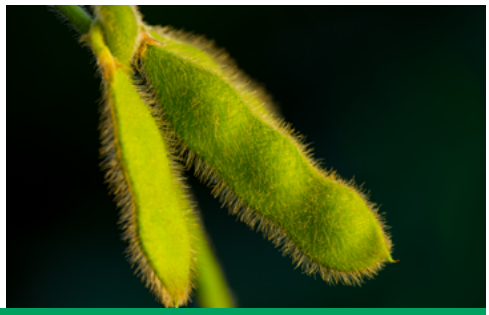
SDSU Extension

iGrow Soybean

BEST MANAGEMENT PRACTICES



Chapter 3:
Soybean Growth Stages

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Introduction

To optimize soybean yields, growers must provide the best management possible. Management practices that influence soybean growth and yield include variety selection, seedbed preparation, seeding rate, seeding date, planting depth, and pest management. Many of these practices are dependent on plant growth stage. Growers who understand how the soybean plant grows and develops are in better positions to use management practices for growing the crop more effectively. Highlights of this chapter are shown in Table 3.1.

Table 3.1. Selected highlights of soybean development.

1. At VE to VC, yields can be reduced 8-9% if cotyledons are lost.
2. Between VC and V5, a new trifoliate is added about every 5 days.
3. At R2, 50% defoliation reduces yield 6%.
4. At R4, plant is very sensitive to stress.
5. At R5, 100% defoliation can reduce yields 75%.
6. At R7, stress has a minimal impact on yield.

General characteristics of the development of a soybean plant

Soybean varieties are classified into maturity groups based on the length of growing season in which they are most adapted. The maturity groups range from 00 to IX with group 00 being for shortest growing season and IX being designed for the longest growing season. In the United States, maturity group 00 is grown in the most northern areas including Minnesota and North Dakota, while maturity group IX is grown in southern states. In South Dakota, maturity groups 0, 1, and 2 are commonly grown.

In general, soybeans have two growth habits: determinate and indeterminate. Determinate cultivars finish vegetative growth when the plant enters reproductive stages, whereas indeterminate growth habit cultivars have simultaneous vegetative growth and flowering during the reproductive phase. Most soybean varieties in the 00 to IV groups have an indeterminate growth habit, whereas varieties in the V to IX groups exhibit a determinate growth habit.

The biological cycle of the soybean plant is divided into the vegetative and reproductive phases. The vegetative phase starts when the seed absorbs water to induce germination process. The vegetative phase ends and the reproductive stage begins with the appearance of first floral buds in soybean varieties of determinate growth habit, or the appearance of the first raceme in varieties of indeterminate growth habit. The reproductive phase ends at harvest.

Stages of Development

Factors that influence duration of growth stages

A multitude of factors influence the duration of each growth stage but the most important factors are the characteristics of the soybean variety and climate (temperature and daylength [photoperiod]). Other factors that can contribute to developmental variation include: soil conditions, location, planting date, and planting pattern.

Maturity class

Maturity class influences the duration of the stages of development. Late maturing soybean varieties may develop more leaves and progress more slowly from one developmental stage to the next, while early maturing soybean varieties may develop fewer leaves and progress through the developmental stages faster. Additional information on selecting a maturity class to match the planting date and growing length is available in Chapter 6.

Temperature

The rate of plant development for any soybean variety, early or late maturing, is directly related to temperature. This means that the length of time between developmental stages will vary with temperature within and between growing seasons.

Photoperiod (daylength)

Soybean plants are sensitive to photoperiod or daylength, and the plant response to photoperiod regulates the timing of flowering. Soybean varieties differ in their response to photoperiod. Some varieties will flower under relatively shorter days while other require longer days to initiate flowering. Soybean varieties adapted to the northern region of the U.S. initiate flowering under longer days (e.g., daylength is nearly 14 hours during the summer in South Dakota) when compared

Table 3.2. Plant growth stages and time from one stage to the next. (Modified from Naeve, 2011; Pedersen, 2007; and Kansas State University, 1997)

Stage Number	Average Time Between Stages	Title	Description
Vegetative Stages	**# days**		
VE	Plt to VE 10d	Emergence	Cotyledons above soil surface.
VC	VE to VC 5d	Cotyledon	Unifoliate leaves unfold so leaf edges are not touching.
V1	VC to V1 5d	1st trifoliate	First trifoliate fully emerged and opened.
V2	V1 to V2 5d	2nd trifoliate	Plants have three nodes with two trifoliates unfolded.
V3	V2 to V3 5d	3rd trifoliate	Plants have four nodes with three trifoliates fully unfolded.
V4	V3 to V4 5d		
V5	V4 to V5 5d		
V6	V5 to V6 5d		
V(n)	V6 to Vn 3d	nth trifoliate	N= the number for the last fully developed trifoliate leaf.

Reproductive Stages	Average Time Between Stages	Title	Description
	# days		
R1	R1 to R2 3d	Beginning flowering	One open flower at any node on the main stem.
R2	R2 to R3 10d	Full bloom	Open flower at one of the two top nodes on the main stem with a fully developed leaf.
R3	R3 to R4 9d	Beginning pod	A pod on one of the four upper nodes in 3/16 inch (0.5 cm) long.
R4	R4 to R5 9d	Full pod	A pod ¾ inch (2 cm) long at one of the four uppermost nodes on the main stem
R5	R5 to R6 15d	Beginning seed	Seed is 1/8 inch (3 mm) long in one of the four uppermost nodes on the main stem.
R6	R6 to R7 18d	Full seed	A pod containing a green seed that fills the pod cavity at one of the four uppermost nodes on the main stem.
R7	R7 to R8 9d	Beginning maturity	One normal pod on the main stem has reached the mature pod color (tan or brown).
R8		Full maturity	95% of pods have reached mature pod color. Five to 10 days of dry weather are required to dry the seed to < 15% moisture.

to varieties adapted to the southern part of the country. Because of the change in photoperiod, if a southern variety is planted north of its adaptation zone, flowering will be delayed, whereas a northern variety planted south of its adaptation zone will have accelerated flowering.

Other factors

The environment in which a soybean plant grows strongly influences its development. Seed viability and enviromental stress may influence the length of time between plant growth stages. A soybean plant grown at low densities will branch profusely and develop into a large plant. Increasing plant density increases plant height, while reducing branching and pod number per plant.

Identifying Soybean Stages of Development

The stages of development are identified following Iowa State University and Kansas State University staging system that divides plant development into vegetative (V) and reproductive (R) stages (Table 3.2). The V stage has subdivisions that are designated numerically as V1, V2, V3 through V(n), with the exception of the first two stages that are designated VE (emergence stage) and VC (cotyledon stage). The reproductive stage begins with flowering (R1) and ends with full maturity (R8).

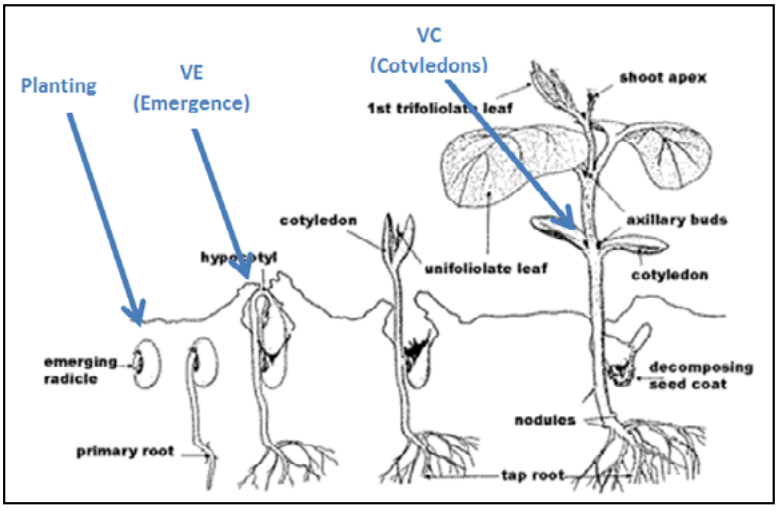

Figure 3.1. An overview of the vegetative growth stages. (Modified from Naeve, 2011; University of Minnesota Extension)

Emergence (VE) (Figure 3.2)

The soybean seed begins the process of germiation by absorbing water equal to about 50% of its weight. The radical or primary root is the first to emerge from the swollen seed, elongating downward to anchor in the soil. Shortly aftewards, the hypocotyl (stem) begins to elongate toward the soil surface pulling the cotyledons (seed leaves) upwards with it. Depending on temperature, moisture, variety and planting depth, emergence typically occurs one to two weeks after planting.

Figure 3.2. The VE growth stage. At this stage, cotyledons are pushing through the soil surface. (Photo courtesy of Pedersen, 2007; Lenssen and Wright, 2013; Iowa State University Extension)

Figure 3.3. The VC growth stage. At this growth stage the unifoliate leaves unroll sufficiently so the leaf edges do not touch. (Photo courtesy of Pedersen, 2007; Lenssen and Wright, 2013; Iowa State University Extension)

Figure 3.4. The V1 growth stage. At this stage, there is a fully developed trifoliate. (Photo courtesy of Pedersen, 2007; Lenssen and Wright, 2013; Iowa State University Extension)

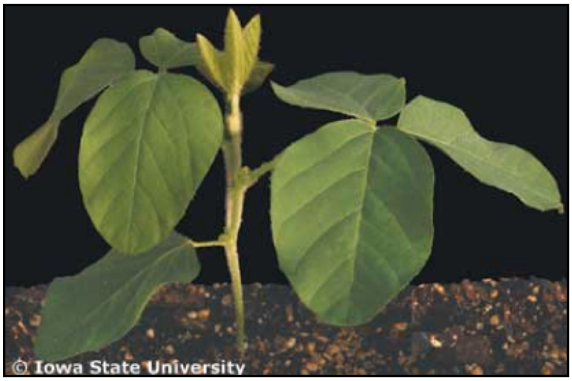

Figure 3.5. The V2 growth stage. At this stage, there are two fully developed trifoliate leaves. (Photo courtesy of Pedersen, 2007; Lenssen and Wright, 2013; Iowa State University Extension)

Figure 3.6. The V(n) growth stage. At this stage, there are n number of trifoliate leaves. The plant shown here is at V6, with six fully opened trifoliate leaves along the main stem. Note that the cotelydons and unifolitate leaves are no longer present on the stem. (Photo courtesy of Pedersen, 2007 Lenssen and Wright, 2013; Iowa State University Extension)

Cotyledon stage (VC) (Figure 3.3)
Shortly after emergence, the hypocotyl straightens out and discontinues growth as the cotyledons unfold. The epicotyl (young leaves, stem, and growing point located just above the cotyledonary node) is exposed at this stage. The expansion and the unfolding of the unifoliate leaves (Fig. 3.3) marks the initiation of the VC stage.

The cotyledons supply the nutrient needs of the young plant during emergence and for about seven to 10 days after emergence. The cotyledons lose about 70% of their weight during this time. If one cotyledon is lost during this time, the effect on plant growth rate is minimal, but if both cotyledons are lost either at VE or VC, seedlings are stunted and, ultimately, yields can be reduced by 8-9%.

First trifoliate (V1) (Figure 3.4)
The V1 stage is achieved when the 1st trifoliate is fully emerged and unfolded. The vegetative growth stages after VC are defined and numbered by the upper, fully developed trifoliate leaves on the main stem. Trifoliate leaves on branches are not counted when determining vegetative growth stages. New V stages appear about every five days from VC through V5 and then every three days from V5 to shortly after R5 for indeterminate cultivars, when the maximum number of nodes are developed.

Second node (V2) (Figure 3.5)
At the V2 growth stage, soybean plants are 6 to 8 inches (15 to 20 cm) tall and have two fully developed trifoliate leaf nodes. Most of nitrogen required by the soybean plant can be supplied through a process called N-fixation (Chapter 23). Through N-fixation, nitrogen fixing bacteria in the roots convert atmospheric N_2 to usable forms of nitrogen for the plant. The bacteria enter the plant through the root hairs. Nodules become visible shortly after the VE stage, but active N_2 fixation does not begin until V2 to V3 stages. Thereafter, the number of nodules formed and the amount of N_2 fixed increases with time until about R5.5. Nodules that are pink or red inside are heathly and actively fixing nitrogen whereas brown, white, or green nodules are not efficiently fixing nitrogen. Bacteria in the nodule are able to supply most of the plant's N requirements. Inherent nitrate in the soil, whether from N fertilizer or carryover from the previous crop, reduces nodule formation.

Third to fifth nodes (V3 through V5) (Figure 3.6)
At the V3 growth stage, soybean plants are 7 to 9 inches tall (18 to 23 cm) and have three fully developed trifoliate leaf nodes. At the V4 growth stage, plants are 8 to 11 inches (20 to 27 cm) tall with four fully developed trifoliate leaf nodes whereas at V5, plants are 10 to 12 inches (25 to 30 cm) tall with five fully developed trifoliate leaf nodes. For most varieties, the number of branches increases at wider row widths and lower plant densities. Typically, up to six branches develop under field conditions. At the V5 stage, the soybean plant normally has axillary buds in the top stem that will develop into flower clusters called racemes. At V5, the total number of nodes that the plant will potentially produce is set.

Sixth node (V6) (Figure 3.6)
At this stage, soybean plants are 12 to 14 inches (30 to 36 cm) tall with six fully developed trifoliate leaf nodes. The cotyledons and the unifoliate may have senesced and fallen from the plant. New vegetative growth stages are appearing every two to five days. At this stage, lateral roots have grown completely across inter-row spaces of 30 inches or less.

Reproductive Stages of Development

Beginning bloom (R1) (Figure 3.7)

At this stage, there is at least one open flower at any node on the main stem. Soybean plants at this stage are 15 to 18 inches (38 to 46 cm) tall. Flowering initiates on the third to sixth nodes of the main stem, depending on the vegetative stage at the time of flowering, and progresses up and down the plant. Flowers at branch nodes appear a few days later. Within each raceme, flowering occurs from the base to the tip, meaning that basal pods are always more mature. At this stage, vertical roots grow at a fast rate and continue this rate through R4 to R5 stage. Secondary roots and root hairs proliferate near the soil surface.

Figure 3.7. The R1 (Beginning Bloom) growth stage. At the R1 growth stage, one flower is open at any node. (Photo courtesy of Pedersen, 2007; Lenssen and Wright, 2013; Iowa State University Extension)

Full Bloom (R2) (Figure 3.8)

At this stage, the soybean plant has one open flower at the two top nodes on the main stem (Fig. 3.8) and a least one of the two upper nodes shows a fully developed leaf. Plants are 17 to 22 inches (43 to 56 cm) tall. The soybean plant has accumulated 25% of its total dry weight, about 50% of its mature height, and has about 50% of its total mature node number. The R2 stage also marks the beginning of the very rapid nutrient and dry matter accumulation that continues until the R6 growth stage. The rate of N_2 fixation by root nodules is also increasing rapidy at this stage. At R2, roots can reach across a 40-inch inter-row space. The major lateral roots have turned downward in the soil and these, along with the taproot, continue to elongate deeply into the soil profile until late into the R6 stage. Fifty percent defoliation at this stage reduces yield by about six percent.

Figure 3.8. The R2 (Full Bloom) growth stage. At this stage, the plant has at least one flower on the two uppermost nodes. (Photo courtesy of Pedersen, 2007; Lenssen and Wright, 2013; Iowa State University Extension)

Beginning pod (R3) (Figure 3.9)

Soybean plants are about 23 to 32 inches (58 to 81 cm) tall. One of the uppermost nodes has a pod 3⁄16 inch (0.5 cm) long. At this stage, a plant has developing pods, open flowers, withering flowers, and flower buds. Developing pods are located on lower nodes where flowering began. Temperature and soil moisture stress at R3 can affect yield through reduction of one or more yield components. A reduction in one component may be compensated by increases in others such that yields may not be significantly changed. As the soybean plant matures from R1 to R5, the plant's ability to compensate after stressfull conditions decreases.

Figure 3.9. Soybean at the R3 (Beginning Pod) growth stage. At this stage, the plant is beginning pod development and the pods in one of the upper most nodes is 3/16" (0.5 cm). (Photo courtesy of Pedersen, 2007; Lenssen and Wright, 2013; Iowa State University Extension)

Full pod (R4) (Figure 3.10)

At this stage the soybean plant has a pod ¾ inch long (2 cm) at one of the four top nodes on the main stem. Plants are 28 to 39 inches (71 to 100 cm) tall. This stage is characterized by rapid pod growth and the beginning of seed development. Pods show rapid growth and dry weight accumulation between R4 and R5. Pods on the lower nodes of the main stem are full size or close to full size, but most pods will be full size by R5 stage.

At the R4 growth stage, the soybean plant is very susceptible to stress (moisture, light, temperature, nutrient deficiences, etc). Any major stess occuring anytime from R4 to R6 will reduce yield more than the same stress at any other period of development. This is because flowering is complete and no new flowers can be produced to compensate for aborted young pods and seeds under stressful conditions.

Figure 3.10. The R4 (Full Pod) growth stage. At this stage, a full pod, ¾» (2 cm) in length, is located at one of four uppermost nodes. (Photo courtesy of Pedersen, 2007; Lenssen and Wright, 2013; Iowa State University Extension)

Beginning seed (R5) (Figure 3.11)

At this stage plants are 30 to 43 inches (76 to 109 cm) tall. The plant has seeds at least ⅛ inch (3 mm) long in a pod at one of the four top nodes on the main stem. The R5 stage is characterized by rapid seed growth and and redistribution of dry weight and nutrients within the plant. Root growth slows down when seed development begins. At about halfway through this stage, the soybean plant:

- Attains its maximum height, node number, and leaf area.
- Nitrogen fixation rates peak and begin to drop rapidly.
- Seeds gain weight rapidly.

Midway between R5 and R6, dry weight and nutrient accumulation in the leaves, stems, and petiole peaks and the process to redistributing to the seed begins. The process of seed dry weight accumulation continues until the middle

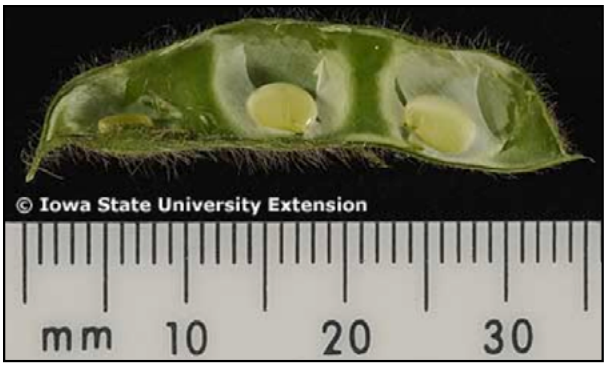

Figure 3.11. The R5 (Beginning Seed) growth stage. At this stage, seeds are beginning to develop and seed size in one of the four uppermost pods is at least ⅛" (3 mm) long. (Photo courtesy of Pedersen, 2007; Lenssen and Wright, 2013; Iowa State University Extension)

of R6. Stress may influence both the rate and length of time that dry weight accumulates in seeds. During this rapid seed filling period, demand for water and nutrients is high. Soil moisture stress may reduce nutrient availabilty by inhibiting root growth in dry soil. One hundred percent leaf loss at this stage can reduce yields by 75%.

Full seed (R6) (Figure 3.12)

At R6 the soybean plant is 31 to 47 inches (79 to 120 cm) tall. This stage is initiated when plants have a pod containing a green seed that fills the pod cavity on at least one of the four top nodes on the main stem. Total pod weight maximizes at this stage. Growth rates of the seeds and the whole plant are still very rapid, but will begin to slow down in the whole plant shortly after R6. Leaf yellowing begins shortly after R6 and continues rapidly to about R8. Root growth is complete midway between R6 and R7.

Figure 3.12. The R6 (Full Seed) growth stage. At this stage, the seed fills the pod capacity in one of the four uppermost nodes. (Photo courtesy of Pedersen, 2007; Lenssen and Wright, 2013; Iowa State University Extension)

Beginning maturity (R7) (Figure 3.13)

At this stage, the soybean plant has one normal pod on the main stem that has reached mature color (tan or brown). Dry matter accumulation for individual seeds peaks at this stage. The soybean plant is visually yellow as all green color is lost from seeds and pods. Soybean seeds contain about 60% moisture at maturity. At this stage and later, the possibility of yield reduction due to stress is much lower.

Figure 3.13. The R7 (Beginning Maturity) growth stage. At this growth stage, one normal pod on the stem has reached its mature pod color. (Photo courtesy of Pedersen, 2007; Lenssen and Wright, 2013; Iowa State University Extension)

Full maturity (R8) (Figure 3.14)

At this stage, 95% of pods have reached their mature color (tan or brown). Five to 10 days of dry weather are required after R8 before soybean seeds have less than 15% moisture. Timeliness of harvest is very important for soybean. Ideally, seed moisture content at harvest and for storage should be 13% (see Chapter 46 for additional information). Harvesting at higher moisture will increase drying costs. Delaying harvest to moisture contents of less than 13% may reduce yield due to pre-harvest shatter, sickle-bar shatter loss during harvest, and split seeds.

Figure 3.14. The R8 (Full Maturity) growth stage. At this growth stage, 95% of pods on the plant have reached their mature color. (Photo courtesy of Pedersen, 2007; Lenssen and Wright, 2013; Iowa State University Extension)

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