PB 1912-B

TENNESSEE SOYBEAN PRODUCTION HANDBOOK

CHAPTER 2: Growth Stages of Soybean

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CHAPTER 2: Growth Stages of Soybean

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The purpose of this chapter is to describe basic growth and development of the soybean plant in order to enable accurate staging of a soybean field during scouting. Herbicide application, timing and termination of irrigation, and insecticide and fungicide timing decisions are based on key growth stages. Therefore, understanding how the soybean plant develops and what some of those key growth stages are is critical to managing the crop effectively.

"Staging" a soybean field means to determine current crop growth progress. Crop staging should be part of the scouting process along with checking leaves for diseases or using a sweep net to gauge insect populations. Staging involves evaluating growth of about 10 plants in three or more *representative locations of the field.* **If at least 50 percent of plants checked are at one specific stage, then the entire field is considered to be at that stage.**

Soybean growth occurs in a series of *vegetative* and *reproductive* development phases. Following emergence, soybeans are considered to be vegetative while leaves are produced on the main stem until the initiation of flowering, at which time they are considered to be reproductive for the duration of the season. The soybean plant is a "short day" plant, meaning flowering is triggered when plants are exposed to shorter days with longer nighttime or dark periods of a critical length. The actual trigger date when flowering starts will depend on the planting date, temperature and the maturity of the variety. This response to daylength allows soybeans planted on different dates to reach physiological maturity before a hard freeze in the fall. Mid-April planted soybeans need five months or longer to fully mature; however, mid-June planted soybeans mature in about four months.

BASIC PLANT TERMINOLOGY

The soybean plant is a dicot meaning two cotyledon or "seed" leaves emerge first. The **growing point** or **apical meristem** is located above ground at the top of the main stem. New leaves develop at the apical meristem on main stem **nodes**. Each leaf attaches to the main stem by a **petiole**. An axillary bud develops where petioles connect to the main stem and is the source of flowering racemes, pods and branches (***Figure 2-1***).

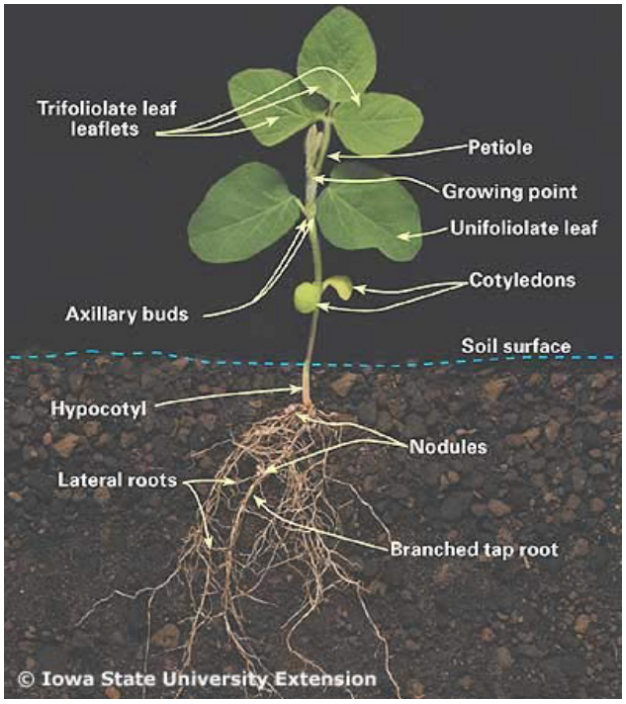

Fig. 2-1. *Source: Pedersen, 2009.*

The soybean root system consists of a branched taproot and lateral roots. The soybean is a **legume**, and it forms a symbiotic relationship with soil *Bradyrhizobium japonicum* or "rhizobia" that results in the formation of nodules on the roots. Three to four weeks after emergence, nodules begin converting atmospheric nitrogen (N) into a form used by the plant, which eliminates dependency on N-containing fertilizer. Tiny nodules grow and fix N for about 2 months, then die and are replaced by new nodules throughout the season. Nodules that are actively fixing N are pink to red on the inside.

GROWTH HABIT

Soybean growth habit or growth type is either **determinate** or **indeterminate** and describes the amount of overlap between vegetative growth and reproductive

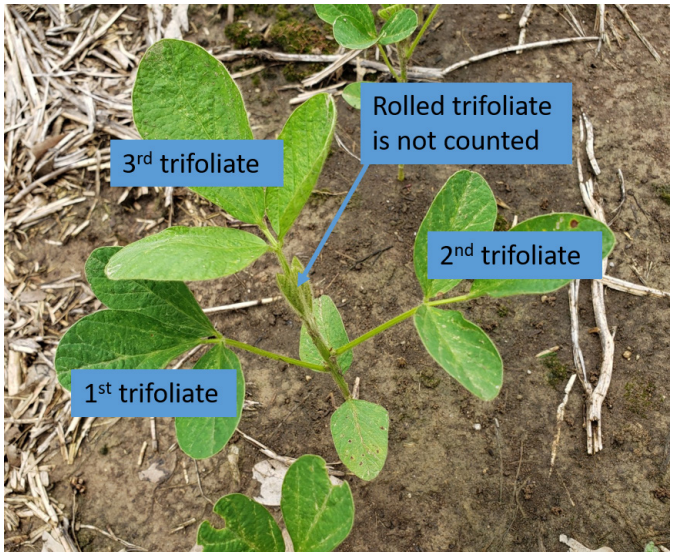

Fig. 2-2. Example of a V3 soybean plant. Plant has 3 fully developed trifoliates and 4 nodes. Source: McClure, 2022.

development. Most varieties in maturity group (MG) 00 through 4 are indeterminate; early MG 5 varieties may be indeterminate or determinate; and late MG 5 through MG 8 varieties are primarily determinate. Maturity groups 00 through 4 were bred for production in northern states. Northern-adapted MGs grown at southern latitudes will bloom before the summer solstice in response to the daylength and warmer nights at more southern latitudes.

Determinate soybeans produce trifoliate leaves at alternating nodes on the main stem until day length triggers flowering, whereupon the production of at terminal raceme (flowering structure) at the top of the main stem ceases new leaf production and the plant enters reproduction. For determinate growth habit beans, vegetative growth on the main stem overlaps very little with reproductive development.

Indeterminate soybeans produce trifoliate leaves for a period of time until flowering is triggered by daylength and temperature. Upon flowering, the plant continues to produce new nodes and leaves from the growing point while also producing blooms and pods at the older (lower) nodes. For indeterminate varieties grown in Tennessee, there is strong overlap between vegetative and reproductive development and a potentially wider flowering and pod set window.

Both determinate and indeterminate varieties can recover from short-term drought events during flowering and early pod stages by replacing blooms aborted during stress with new flowers when conditions improve. The wider flowering window for indeterminate varieties means they can potentially do this longer.

VEGETATIVE DEVELOPMENT

The resource section contains links to publications that describe in detail the process of seed germination and seedling emergence. Staging soybeans begins when seedlings have emerged. ***Table 2-1*** contains vegetative growth stage descriptions beginning at emergence of the seedling (VE) through leaf development on main stem nodes.

A soybean plant can produce as few as 12 to more than 20 nodes on the main stem. Full season soybeans growing under good conditions have more nodes (and potential leaf and pod sites) than June-planted double crop beans or soybeans growing under frequent stress. New nodes appear about every 4 days under favorable conditions, but production slows down considerably if temperatures are too cold and will cease while plants are growing under drought stress.

A fully developed leaf is one in which leaf or leaflet edges have unrolled to where the edges do not touch one another. At VC, a pair of *unifoliate* leaves are unrolled and are opposite at the first node of the main stem. All leaves that follow are single *trifoliate* leaves (contain three leaflets) that are produced at a node on **alternate** sides up the length of the main stem. After VC, a "V" number is assigned to each fully developed trifoliate leaf node. A soybean field is at V3 stage when 50 percent

Table 2-1. Descriptions of soybean vegetative stages[1] and their importance for timing management decisions. Source: Adapted from Pedersen, 2009.

STAGE	ABBREVIATED STAGE DESCRIPTION	DESCRIPTION
VE	Emergence	Cotyledons appear above the soil surface.
VC	Cotyledon	Unifoliate leaves unrolled so that the leaf edges do not touch.
V1	1st trifoliate leaf	Fully developed (leaflets unrolled so edges do not touch) trifoliate leaf.
V2	2nd trifoliate leaf	Two fully developed trifoliate leaves. Early N-fixing root nodules becomes functional.
V3	3rd trifoliate leaf	Three fully developed trifoliate leaves. V3 is the cutoff stage for some post herbicides.
V(n)	(n) trifoliate leaf	"n" number of fully developed trifoliate leaves.

[1] Note: Although the descriptive term for soybean leaves is "unifolioate" and "trifolioate," the more commonly used "unifoliate" and "trifoliate" will be used in this publication.

Table 2-2. Description of soybean reproductive stages and importance for timing management decisions. Source: Adapted from Pedersen, 2009.

STAGE	ABBREVIATED STAGE DESCRIPTION	DESCRIPTION
R1	Beginning bloom	One flower opens at any node on the main stem.
R2	Full bloom	A flower opens at one of the top two nodes on the main stem with a fully developed trifoliate. *Beginning of rapid nutrient accumulation to vegetative parts.*
R3	Beginning pod	Pod 3/16 inch long at one of the four uppermost nodes with fully developed trifoliate. *Fungicide application timed at R3-R4.*
R4	Full pod	Pod 3/4 inch long at one of the four uppermost nodes with fully developed trifoliate.
R5	Beginning seed	Seed 1/8 inch long in a pod at one of the four uppermost nodes with fully developed trifoliate. *Apply insecticide when economic thresholds are reached.*
R6	Full seed	Green seed fills pod cavity in a pod on one of the four uppermost nodes with fully developed trifoliate. *Irrigation terminated at R6.5.*
R7	Early maturity	One normal pod on main stem turns mature brown color.
R8	Full maturity	95 percent pods on main stem reach mature brown color.

of the scouted plants contained three fully developed trifoliate leaf nodes (***Figure 2-2***).

Branching is also vegetative growth, but it is not considered when staging a field. A branch contains nodes, leaves and meristems capable of producing blooms and pods. Side branches sprout from lower main stem axillary buds following damage to the growing point. At lower populations, more sunlight reaches lower leaves and can stimulate branching. All soybean plants can branch; however, genetics and the environment control the intensity of branching. Varieties with a bushy type canopy will branch extensively at low populations compared to a straight line or medium canopy variety. Branch pods usually add very little to yield as sunlight is limited in the lower canopy.

REPRODUCTIVE DEVELOPMENT

Consider only plants with intact main stems when staging soybean reproductive development. Stages R1-R2 describe flowering, R3-R4 describe pod development, R5-R6 describe seed development and R7-R8 describe plant maturation (***Table 2-2***).

Soybeans become reproductive at **first bloom or R1** when 50 percent or more of plants in a field have at least one flower somewhere on the main stem (***Table 2-2***). Flowers develop on "racemes" or flowering structures at the apical meristems. For indeterminate varieties, flowering usually begins on the third to sixth trifoliate node of young beans, while determinate varieties begin blooming on the upper third of the main stem of mostly fully grown plants. The soybean plant will produce many more blooms than actually develop into pods, as a means to overcome short-term stress. In general, the last flowers produced are those at the very top of the main stem and the tip end of any branches.

Both indeterminate and determinate varieties reach **full bloom or R2**, when flowers appear on **one of the two uppermost nodes** with a fully developed trifoliate leaf. The time difference between R1 to R2 varies between 3 to 10 days depending on maturity group and planting date. After flowering begins, indeterminate plants continue to grow vegetatively, producing new nodes on the main stem and branches. Under drought conditions, indeterminate varieties may remain at R2 for two or more weeks.

Once a field reaches full bloom, monitor pod and seed development by focusing on the top four nodes with a fully developed trifoliate leaf node until the onset of maturity. This means ignoring the lower nodes on indeterminate varieties where pod and seed development may be more advanced compared to the top of the plant. By returning each time to the upper four nodes, management for diseases and insects becomes about protecting

Fig. 2-3. Soybean pod example at R3, R4 and R5 stage (from left to right). Source: Photographer unknown, 2022.

Fig. 2-4. Seed size difference between soybean stages R5, R5.5 and R6. Source: Pedersen, 2009.

the middle and upper canopy pods that contribute the most to yield. **Scout soybeans regularly for pod-feeding insects and diseases beginning at R3 with regular checks made through seed fill.**

The number of days between R2 and R3 or early pod depends on planting date and growth habit as well as temperature and environmental stress. Full season indeterminate varieties growing under stress may cease main stem growth for a period of time, then resume node and leaf production, sometimes making field appear to "go backward" in development.

At **R3 or early pod**, a tiny pod 3/16 inch long is visible on at least one of the top four fully developed trifoliate nodes of half the plants checked during staging (***Figure 2-3***). At early R3, new pods, new flowers and dying flowers can be found at the same node. Under stress, R3 pods may abort or lengthen slowly when plants lack adequate moisture to elongate pods, meaning plants sometimes remain at R3 for several days. Pod loss at R3 has a lesser impact on yield, as the plant can still generate new pods or make adjustments to seed numbers per pod or seed weight during later stages.

At **R4 or full pod**, a pod has elongated to 3/4 inch (***Figure 2-3***) on at least one of the top four fully developed trifoliate leaf nodes. Rapid pod growth and the initiation of seed occurs during R4, making this stage critical for seed yield determination. Pods normally reach their full length and width before seeds begin to develop. With stress at R4, there may be some impact on seed number per pod, and plants are less able to produce new pods to compensate for aborted pods, potentially reducing total pod numbers.

At **R5 or early seed**, rapid seed growth and seed fill begins with tiny 1/8 inch seed "shapes" that can be seen through the pod wall (***Figure 2-3***) on at least one of the four upper trifoliate leaf nodes. At early R5, it is possible to find a few flowers and young pods on the plant as well as pods with seed. By late R5, plants have usually reached maximum height and leaf area, and flowering has ceased. During R5, the soybean plant mobilizes water and nutrients to the developing seed from the leaves and stems. **In Tennessee, irrigation is typically initiated at early R5 if soil moisture is lacking in order to meet the demands of the developing seed**. Seed weight and therefore yield is strongly impacted by stress during R5. Stress can shorten the rate and duration of seed fill as well as reduce pod and seed number per pod.

At **R6 or full seed**, seed reaches maximum size in one or more pods on at least one of the upper four trifoliate leaf nodes of half the plants checked during staging (***Figure 2-4***). **By mid R6 (R6.5) about 80 percent of seed dry weight has accumulated and irrigation may be terminated.** At R6.5, a few leaves may be turning, and some pods may be lighter in color. Upon examining the upper four nodes, **seed should separate fairly easily from the pod wall when a pod is pulled apart on about half of the plants that are checked** (***Figure 2-5***). Stress during R6 impacts the seed size/weight component of yield.

At **R7 or early maturity**, maximum seed dry weight is reached. Leaves are turning, seed begin to reduce in size, turning mature light brown color, and at least one healthy pod has turned its mature brown color on at least 50 percent of the plants in the field. At **R8 or full maturity**, 95 percent of pods have turned their normal brown color. Seed moisture is still high, but the field is typically 10-12 days away from harvest.

Moisture or heat stress during reproduction will affect yield components differently. During R1 through R5, a soybean plant can adjust the number of flowers, pods or seeds according to amount and duration of stress. Plants at R1 through R3 have a greater ability to compensate for flower and pod loss than plants at R5. Stress during R1 through R4 could reduce the total number of pods. Stress at R4 through R6 may cause beans to abort in the pod and stress at R5.5 to R6.5 can affect seed size at harvest.

Fig. 2-5. At R6.5, upper node pods may be light green to slightly yellow, seed shrink down slightly and pull apart from pod wall. Source: McClure, 2022.

DAYS BETWEEN GROWTH STAGES

There is no perfect alternative to routine checking of fields; however, when time is limited, a crop development model can provide an estimate for when key soybean growth stages are likely to occur. Crop development models (SoyStage, Soybean Maturity Date Calculator) use long-term weather data for a specific geographic area to estimate soybean development when the MG and planting date are known. Nevertheless, most data used to create crop growth models are from irrigated studies and therefore predict *optimal* rate of development. Dryland fields may be a few days to weeks earlier depending on the timing and duration of seasonal moisture stress.

Table 2-3 includes approximate days from planting to key growth stages for different MG soybeans planted in April, May and June under irrigated Tennessee conditions. More planting dates and MG are at UT's Soybean Development Estimator web tool. Planting date and MG determine the number of days from planting to reach key growth stages. Planting date alters the daylength hours and the temperature to which plants are exposed, which will impact rate of development. Within a MG, soybeans planted in April and early May, true "full season beans," tend to maximize the amount of time spent at each stage. Soybeans planted in June have shorter intervals between growth stages as a way to hasten maturity before a freeze.

SUMMARY

Nothing replaces boots in the field when managing a soybean crop. Periodic checking of beans is critical to monitor growth, time herbicide application and identify insect and disease problems. Remember the 50 percent rule that a field progresses in development when at least half the plants checked during staging have moved into the next stage. Know where on the plant to look when staging flowering plants versus plants that are at pod or seed stages, and always remember that drought will affect the rate of development compared to what crop models might predict.

REFERENCES AND RESOURCES

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"Soybean Maturity Date Calculator - Soy Pheno." Mississippi State University Extension. https://webapps.msucares.com/deltasoy/

Table 2-3. *Approximate days to key reproductive (R) stage for irrigated soybean MG[1] planted on different dates. Source: Soybean Development Estimator, McClure and Verbree, 2016.*

MATURITY GROUP	PLANTING DATE	DAYS FROM PLANTING TO "R" STAGE				
		R1	R3	R5	R6	R8
3.9	*Apr 24*	47	63	82	103	142
	May 8	35	55	73	91	125
	June 17	33	51	60	78	110
4.2	*Apr 24*	48	65	85	108	144
	May 8	40	63	74	97	135
	June 17	38	52	64	81	117
4.8	*Apr 24*	47	68	90	107	144
	May 8	34	66	78	103	132
	June 17	35	55	68	82	114
5.3	*Apr 24*	50	68	85	111	147
	May 8	41	67	76	98	132
	June 17	39	53	67	83	123

[1] Note: All varieties were indeterminate growth habit.

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