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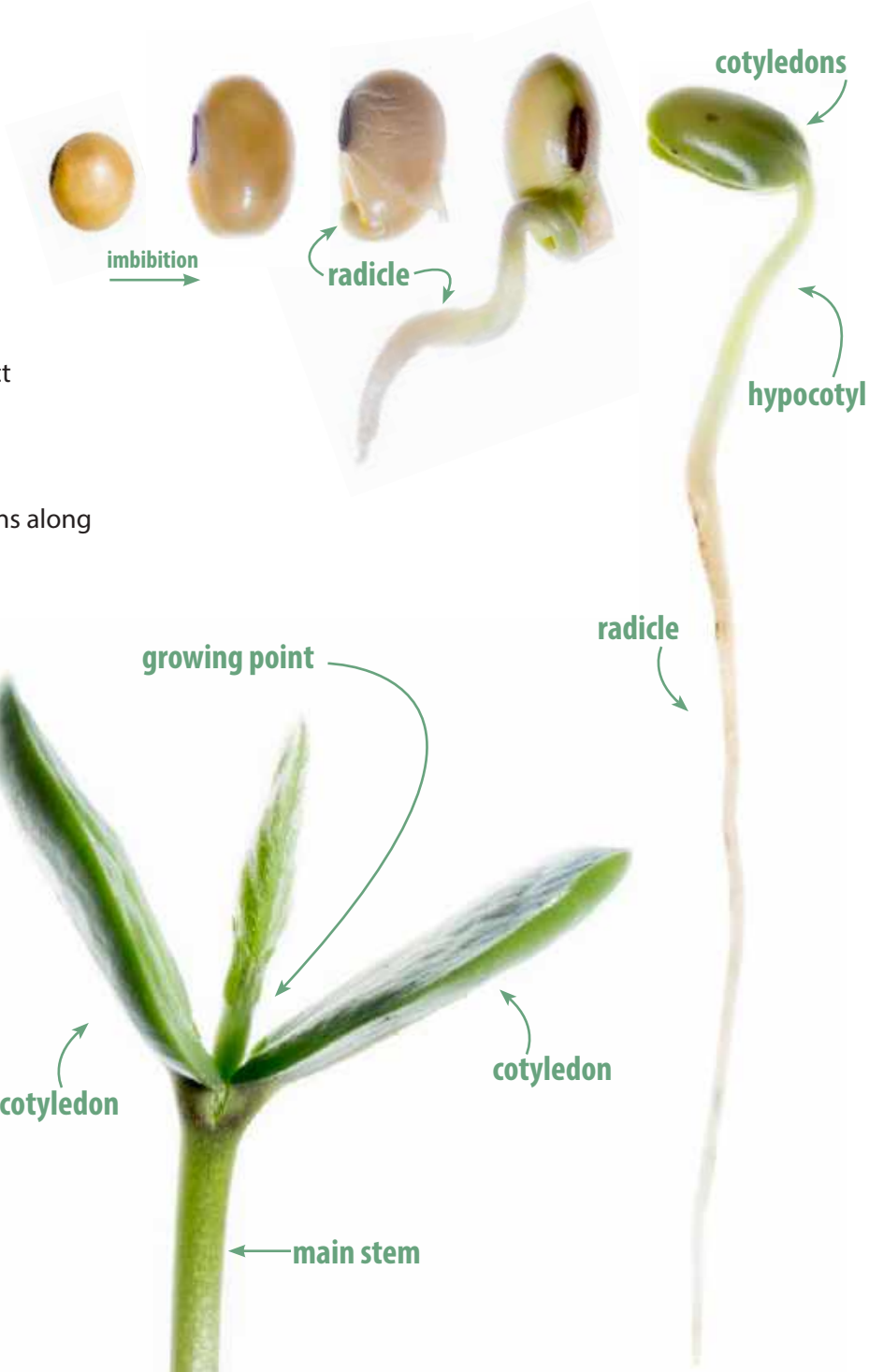
A Visual Guide to Soybean Growth Stages

Understanding and being able to correctly identify the growth stages of soybean is important for making sound agronomic management decisions. This guide describes the growth stages starting with germination, progressing through the vegetative stages (V) and concluding with the reproductive stages (R). Coolbeans!

Germination

Germination begins with the seed absorbing 50% of its weight in water, this is called imbibition

- Imbibition is dependent on soil temperature (optimum 60-70°F) and soil moisture (optimum 50%)
- Imbibition requires good seed-to-soil contact
- The radicle (or primary root) grows from the swollen seed and elongates downward
- The hypocotyl begins elongation upward toward the soil surface, pulling the cotyledons along



VE

Vegetative Stage Emergence

Cotyledons above the soil surface

VE stage occurs approximately 5-14 days after planting depending upon the soil temperature, which can be influenced by planting date

- Soil crusting and planting depth (either too deep or too shallow) can inhibit emergence
- Planting too deep can also delay emergence; planting depth should be between ¾ to 1-½ inches

Methods

There are two methods used to determine the **vegetative** growth stages of soybean. Although they use different techniques, the resulting growth stage determination is the same; it's helpful to understand how both work and be familiar with the terminology.

1. Hybrid Method (P. Pedersen)

Pedersen, Palle. 2009. *Soybean growth and development.* Iowa State University Extension, Ames, Iowa.

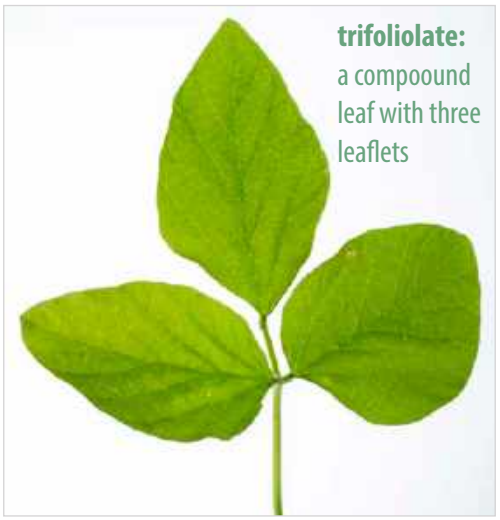
This method is commonly used in the field and grower publications; it counts the number of **open** trifoliolate leaves on the main stem.

2. Fehr and Caviness Method

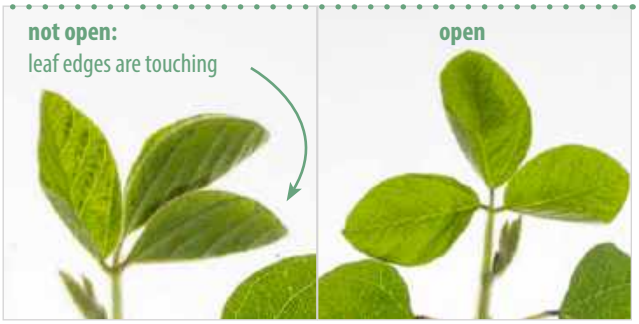
Fehr, W.R., Caviness, C.E., 1977. *Stages of soybean development.* Cooperative Extension Service, Agriculture and Home Economics Experiment Station, Iowa State University, Ames, Iowa.

This method is used in academic settings and journal articles; it counts the number of nodes on the main stem, beginning with the unifoliolate nodes, that have or have had a **fully developed** leaf. A leaf is considered fully developed and the node is counted when the leaf at the node immediately above it is open.

Quick tips!

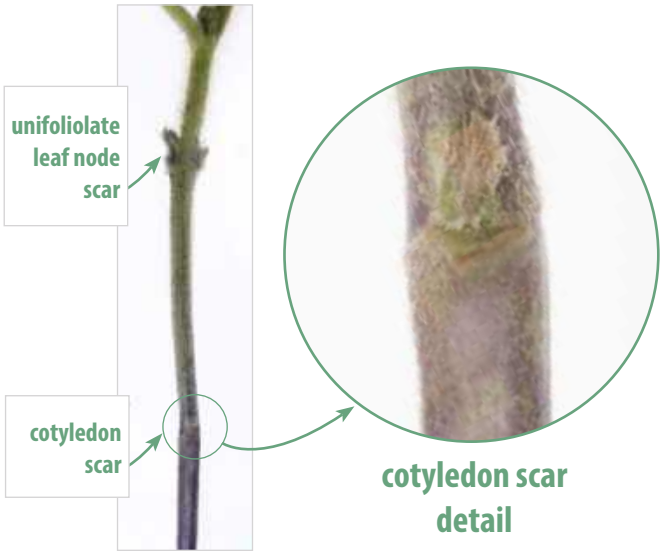


A leaf is considered **open** when the individual leaves are unrolled, and the leaf edges are no longer touching.



A leaf is considered **fully developed** when the leaf at the node immediately above it is open.

A node is the part of the stem where the leaf petiole develops.



Leaf scars can be useful for locating nodes even if the leaves are lost or damaged.

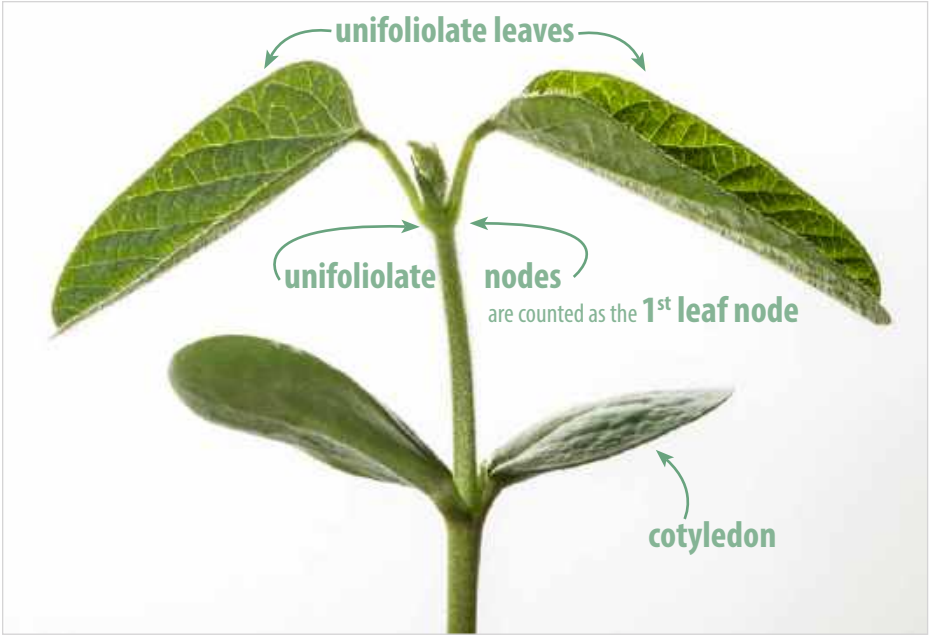
1. Begin at the lowest portion of the stem above the soil surface. Feel for the first set of scars from the cotyledons. The scars will be opposite on the stem.
2. Above these are a second set of opposite scars that mark the unifoliolate leaf nodes.
3. All of the scars above the unifoliolate leaf nodes are singular and opposite on the stem.

VC

Vegetative Stage Cotyledon

Unifoliolate leaves unrolled sufficiently so the leaf edges are not touching

- Unifoliolate leaves are simple, consisting of a single leaf blade
- Unifoliolate leaf nodes are opposite on the stem and are counted as the 1st leaf node
- The cotyledons are the first source of nutrients and energy prior to photosynthesis
- Plants will not recover if damaged below cotyledons



V1

Vegetative Stage 1

Hybrid method:

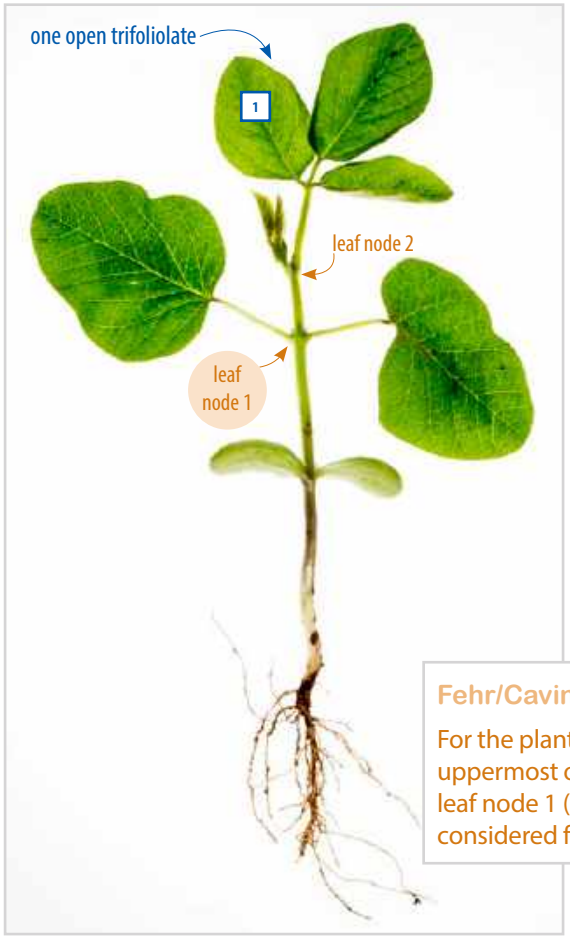
One open trifoliolate

Fehr/Caviness method:

Fully developed leaves at unifoliolate nodes

- The 2nd leaf node and all nodes to follow are singular and alternate on the stem
- Nitrogen fixing root nodules begin to form on the roots through infection by *Bradyrhizobium japonicum* bacteria (introduced via inoculation or native in the soil)
- Nitrogen fixation is necessary for high yields
- Assess stand count during this stage to determine if replanting is necessary

see *Think Twice Before Replanting Soybeans* at http://www.coolbean.info/library/documents/SoybeanReplant_2014_FINAL.pdf or download the BeanCam app, links available at http://ipcm.wisc.edu/apps/beancam/



3 easy steps — Fehr/Caviness method

1. Starting at the top of the plant, find the uppermost **open** trifoliolate on the main stem and locate the corresponding node.
2. Move down the stem to the next node.
3. Count that node and all nodes below it on the main stem including the 1st leaf node (unifoliolates nodes).

   The number of nodes counted is the vegetative growth stage.

Fehr/Caviness method:

For the plant pictured, leaf node 2 has the uppermost open trifoliolate, so the leaves at leaf node 1 (the unifoliolate nodes) would be considered fully developed; the plant is at V1.

Good to know!

Each method uses a similar notation for the vegetative stages:

Hybrid method: **Vn** .....where **n** represents the number of open trifoliolates

Fehr/Caviness: **Vn nth node**..where **n** represents the number of nodes on the main stem (beginning with the unifoliolate leaf nodes) that have or had a fully developed leaf

V2

Vegetative Stage 2

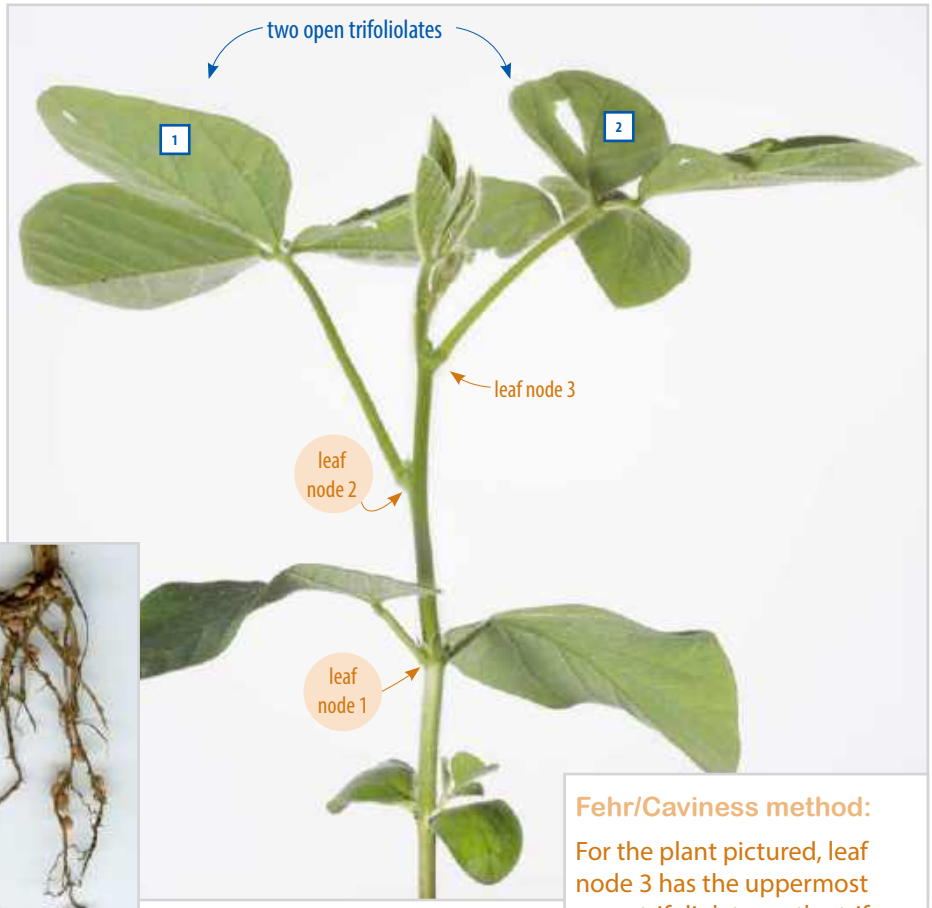
Hybrid method:

Two open trifoliolates

Fehr/Caviness method:

Fully developed trifoliolate leaf at node above the unifoliolate nodes

- Lateral roots are growing rapidly
- Active nitrogen fixation of the root nodules has most likely begun



Fehr/Caviness method:

For the plant pictured, leaf node 3 has the uppermost open trifoliolate, so the trifoliolate at leaf node 2 (the node above the unifoliolate nodes) would be considered fully developed; the plant is at V2.

If weeds are present during these stages, consider herbicide application to minimize yield loss

V3

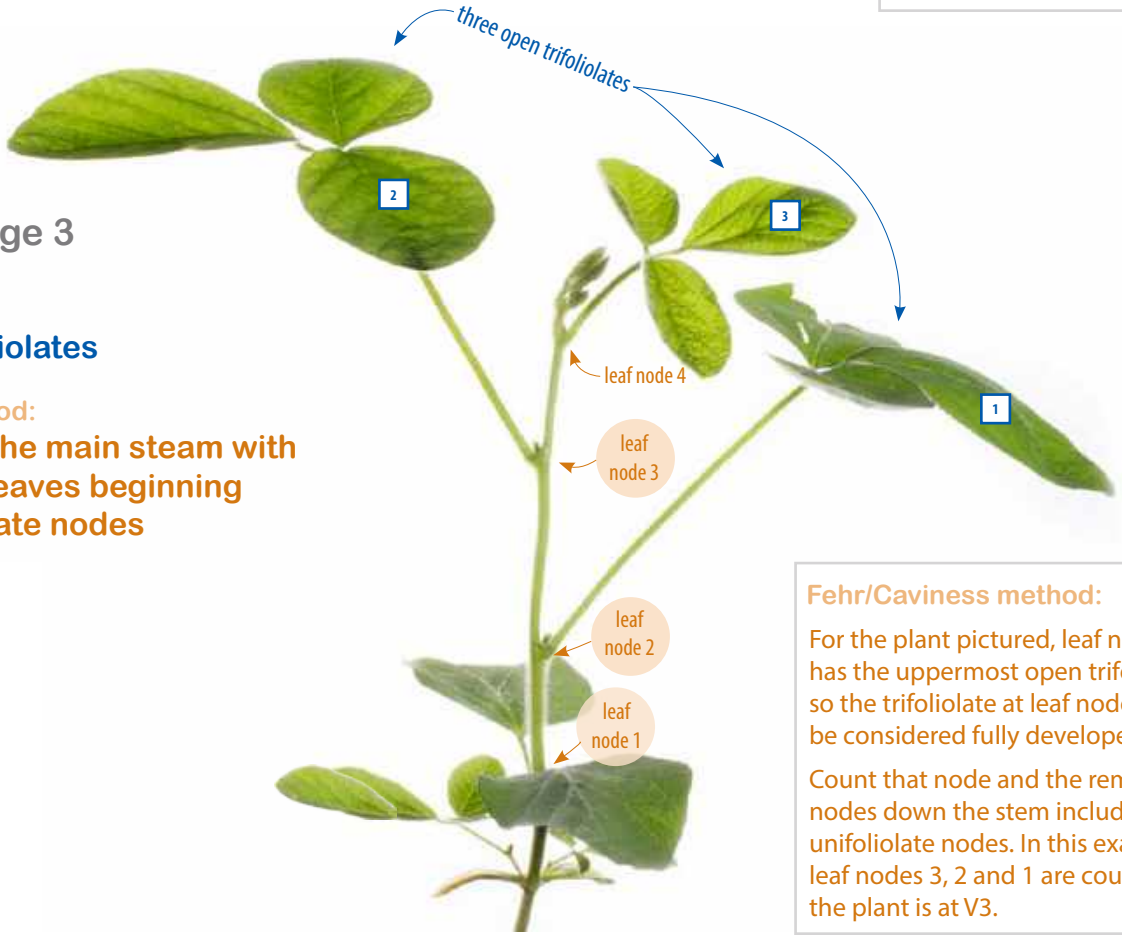
Vegetative Stage 3

Hybrid method:

Three open trifoliolates

Fehr/Caviness method:

Three nodes on the main steam with fully developed leaves beginning with the unifoliolate nodes



Fehr/Caviness method:

For the plant pictured, leaf node 4 has the uppermost open trifoliolate, so the trifoliolate at leaf node 3 would be considered fully developed.

Count that node and the remaining nodes down the stem including the unifoliolate nodes. In this example, leaf nodes 3, 2 and 1 are counted; the plant is at V3.

V4

Vegetative Stage 4

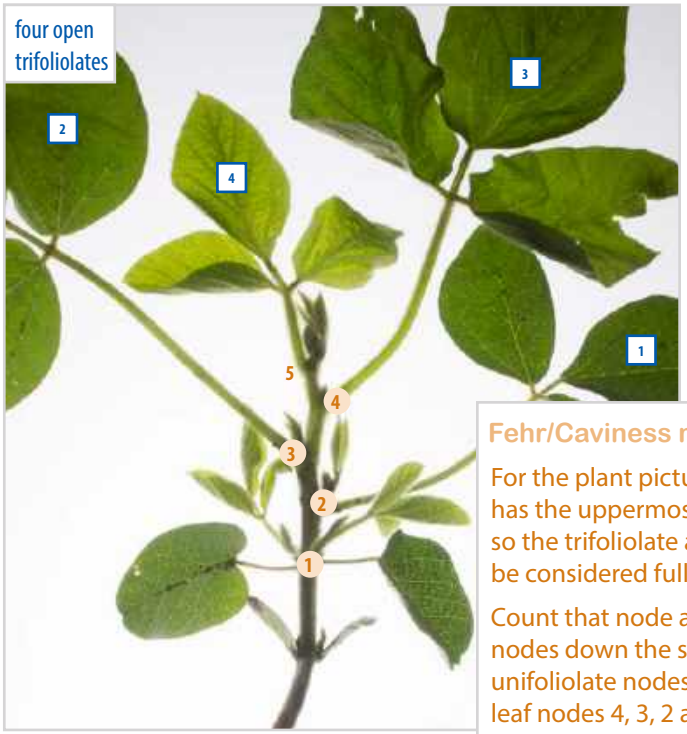
Hybrid method:

Four open trifoliolates

Fehr/Caviness method:

Four nodes on the main stem with fully developed leaves beginning with the unifoliolate nodes

- For May planting dates in Wisconsin, flower buds start to develop between V4-V6
- Plants can recover from 100% defoliation at this stage with minimal risk of yield loss



Fehr/Caviness method:

For the plant pictured, leaf node 5 has the uppermost open trifoliolate, so the trifoliolate at leaf node 4 would be considered fully developed.

Count that node and the remaining nodes down the stem including the unifoliolate nodes. In this example, leaf nodes 4, 3, 2 and 1 are counted; the plant is at V4.

V5

Vegetative Stage 5

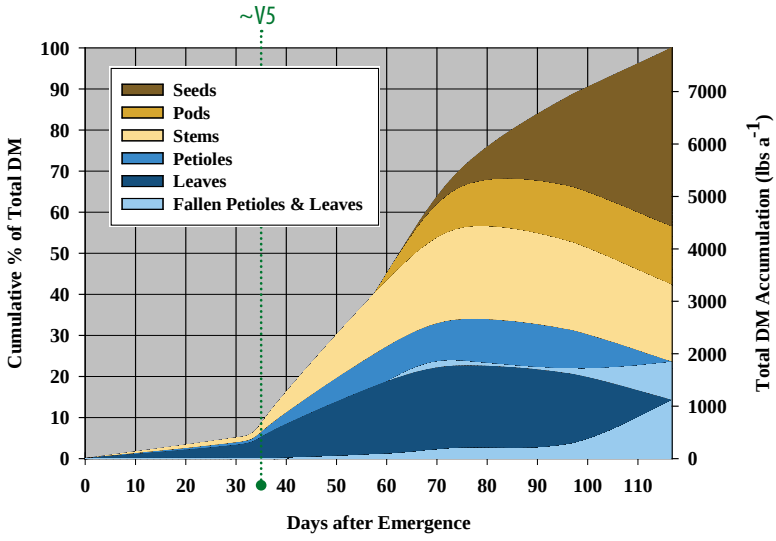
Hybrid method:

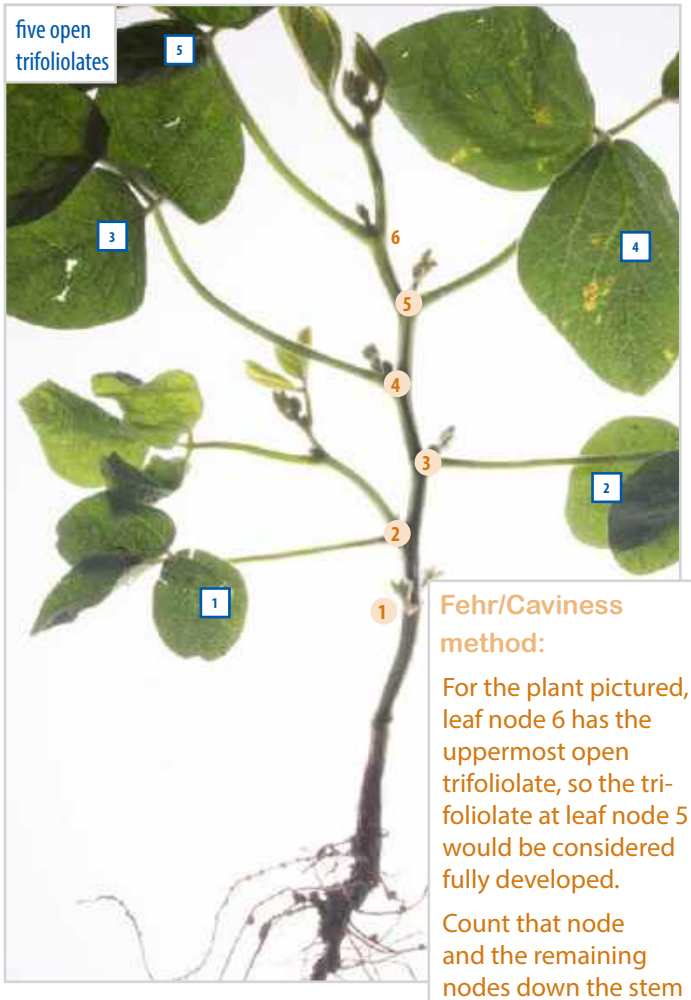
Five open trifoliolates

Fehr/Caviness method:

Five nodes on the main stem with fully developed leaves beginning with the unifoliolate nodes

- Rapid dry weight accumulation begins





Fehr/Caviness method:

For the plant pictured, leaf node 6 has the uppermost open trifoliolate, so the trifoliolate at leaf node 5 would be considered fully developed.

Count that node and the remaining nodes down the stem including the unifoliolate nodes. In this example, leaf nodes 5, 4, 3, 2 and 1 are counted; the plant is at V5.

Keep going!

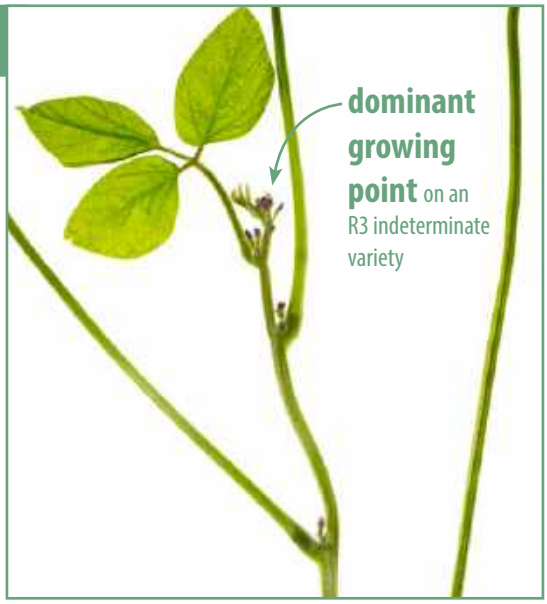
V6, V7, etc., you get the picture. After V6, stages progress rapidly, usually every 3-5 days. Soybean growth habit (whether a variety is determinate or indeterminate) will influence how many more V stages occur and if the V stages cease or continue after the R stages begin.

Soybean growth habits

The dominant growing point's behavior differs with the two types of soybean growth habits.

Indeterminate

Continues new vegetative growth even after flowering begins



The dominant growing point on the main stem is also called the apical meristem or the stem apex.

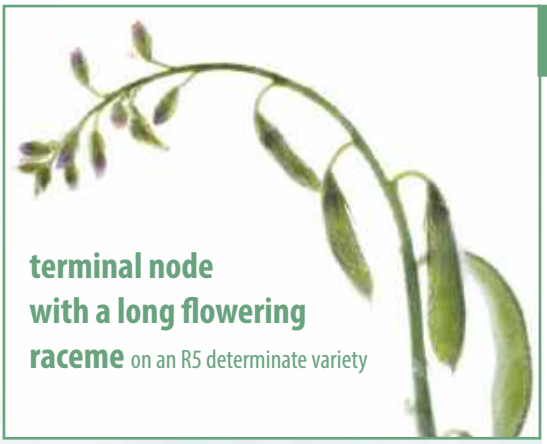
IMPORTANT NOTE!

*The images in this guide generally represent **indeterminate** varieties grown in Wisconsin, keep in mind:*

- *Rate of development can vary based on temperature, maturity group, soil conditions, planting date and planting patterns*
- *Differences may occur in time between stages, internode length, plant height and number of leaves*

Indeterminate varieties are typically grown in the Central and Northern U.S. **(maturity groups 0.0~4.5)**

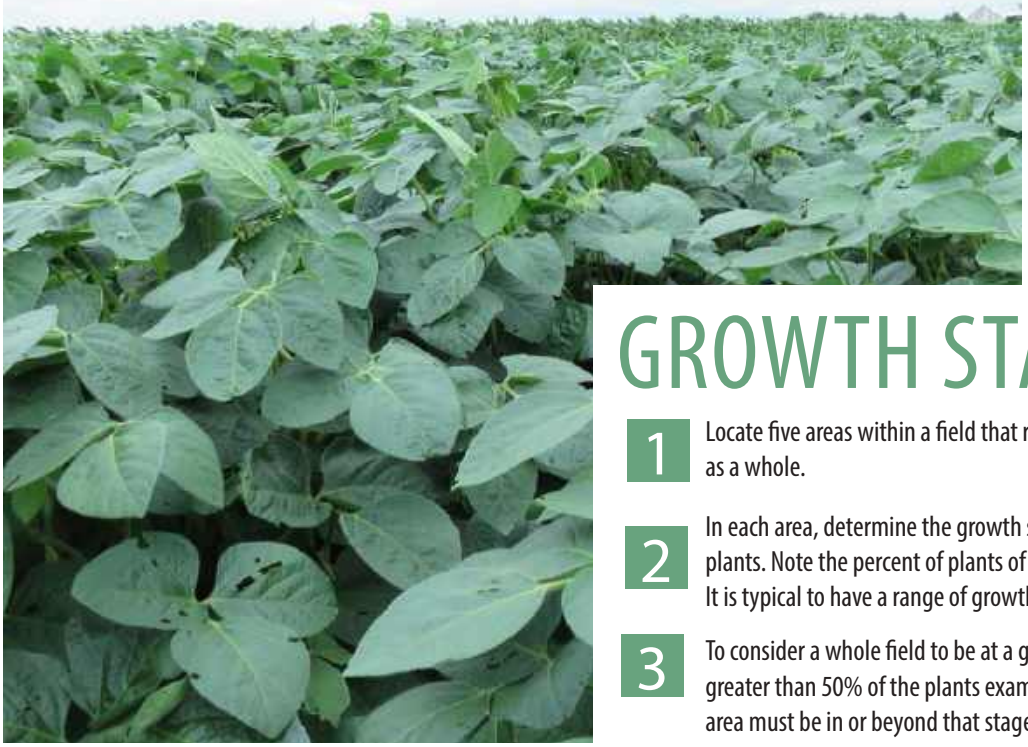
Determinate varieties are typically grown in the Southern U.S. **(maturity groups 4.5~6.0)** and in South America



Determinate

Ceases new vegetative growth soon after flowering begins

- Determinate plants have a terminal node with a long flowering raceme on the main stem, indicating the end of vegetative growth
- Flowers develop around the same time on determinate varieties; therefore pod and seed development are more uniform when compared to an indeterminate variety



It is critical to accurately identify the correct growth stage for the entire field in order to make sound management decisions!

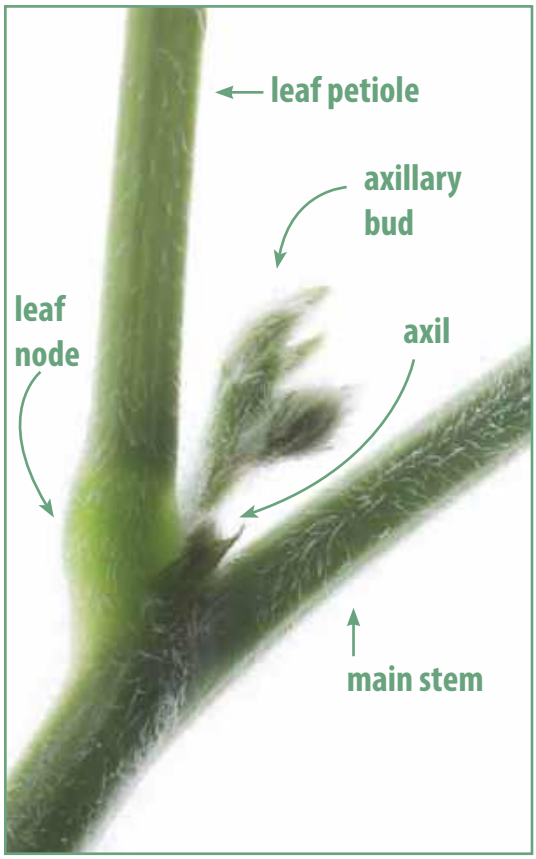
GROWTH STAGING A FIELD

1. Locate five areas within a field that represent the field as a whole.
2. In each area, determine the growth stage of at least ten plants. Note the percent of plants of each growth stage. It is typical to have a range of growth stages.
3. To consider a whole field to be at a growth stage, greater than 50% of the plants examined within each area must be in or beyond that stage.

	Growth Stage	
Area	V3	V4
1	50%✓	50%
2	40%	60%✓
3	70%✓	30%
4	60%✓	40%
5	60%✓	40%

The field in this example would be at V3.

Axillary buds



Soybean plants have multiple growing points on the main stem called axillary buds. They are located in the axil, which is located at the upper-angle junction between the main stem and leaf petiole. Each axillary bud is capable of branching or can remain dormant.

If the dominant growing point is damaged, the plant responds by directing the axillary buds to branch and further develop.

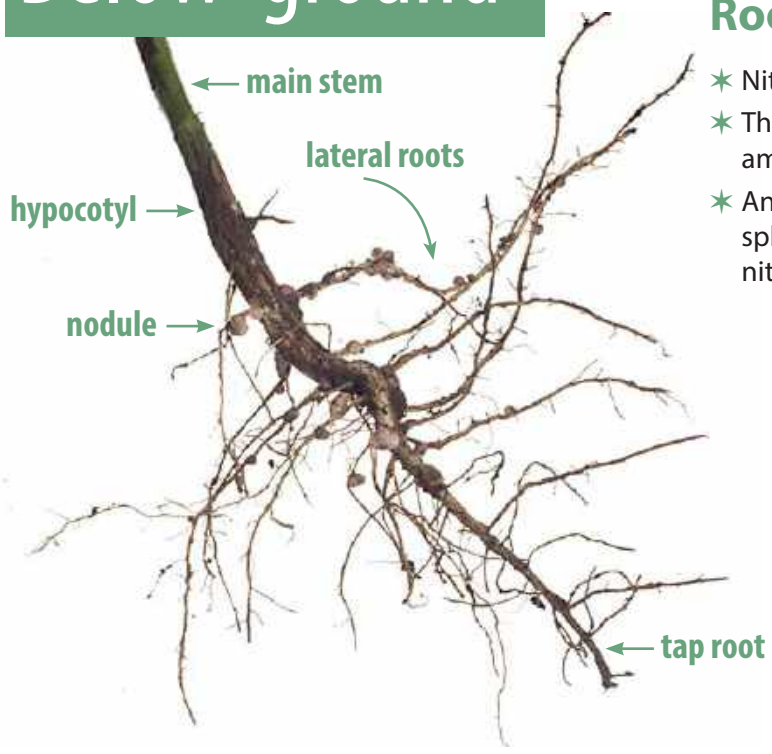
This is important! If a plant's growing point is damaged (by hail, for example), the plant has the capacity to recover via the axillary buds. Pretty cool....

Compare these V5 plants: The growing point (apical meristem) of the plant on the right has been clipped; the plant has more branching and consequently more development of leaves, nodes, axils, axillary buds, flowers and pods.

V5 soybean with intact apical meristem

V5 soybean with clipped apical meristem

Below-ground



Root nodules

- Nitrogen fixation continues through R6
- The number of nodules is not strongly correlated to the amount of nitrogen fixed; nodule efficiency is more important
- An actively nitrogen fixing nodule is pink in the middle when split open (green, brown or white internal coloration mean no nitrogen fixation is occurring)

detail of active nitrogen fixing nodule

R1

Reproductive Stage 1

One open flower at any node on the main stem

- Flowering begins on the 3rd to 6th nodes of the main stem
- Flowering on the branches begins after those on the main stem
- Flowers can be purple or white
- If a field has a history of white mold, this is the earliest growth stage to apply an effective fungicide

R2

Reproductive Stage 2

Open flower at one of the two uppermost nodes on the main stem with a fully developed leaf

- Flowering will continue for 3-5 weeks
- 20-80% of flowers produced will be aborted
- 50% defoliation can reduce yield by 6%
- 100% defoliation can reduce yield between 23-40%

R3

Reproductive Stage 3

Pod is 3/16 inch long at one of the four uppermost nodes on the main stem with a fully developed leaf

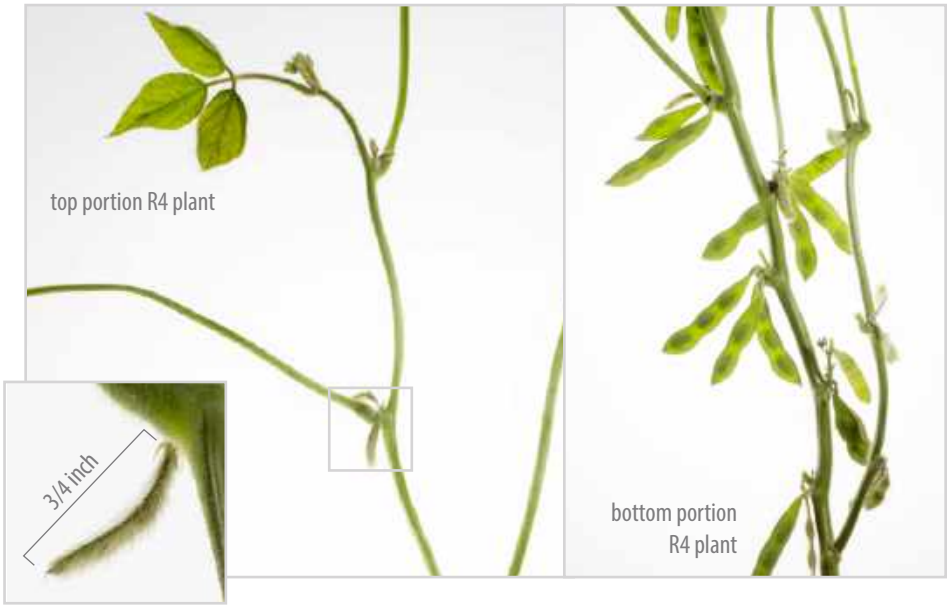
- A plant can have all of the following: developing pods, withering flowers, new open flowers and flower buds
- Potassium uptake rates peak shortly after R2, ranging between 3.5-5.2 lb K_2O /acre/day
- Last growth stage to treat for white mold

R4

Reproductive Stage 4

Pod is 3/4 inch long at one of the four uppermost nodes on the main stem with a fully developed leaf

- At this stage, rapid pod growth is occurring and seeds are starting to develop
- Flowering continues on the upper branch nodes
- Peak nitrogen uptake rates occur between R4-R5, ranging between 3.0-4.0 lb N /acre/day



Pod and seed development

IMPORTANT NOTE!

The size of the developing pods and seeds at one of the four uppermost nodes on the main stem with a fully developed leaf determines the R stage from R3 thorough R6. When staging plants, ***it is important to examine only these nodes*** *as plants will simultaneously have a range of pods and seed sizes above and below these nodes.*

Soybean plant at R6, note the range of pod sizes throughout the plant.

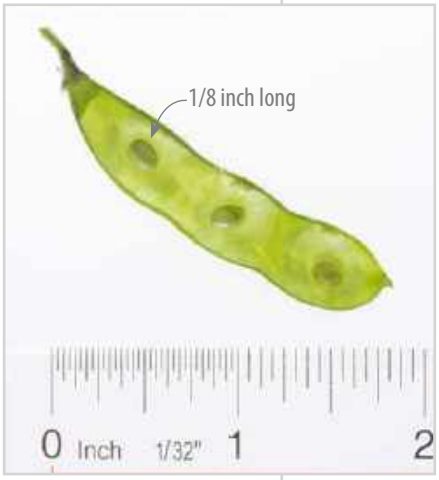
R5

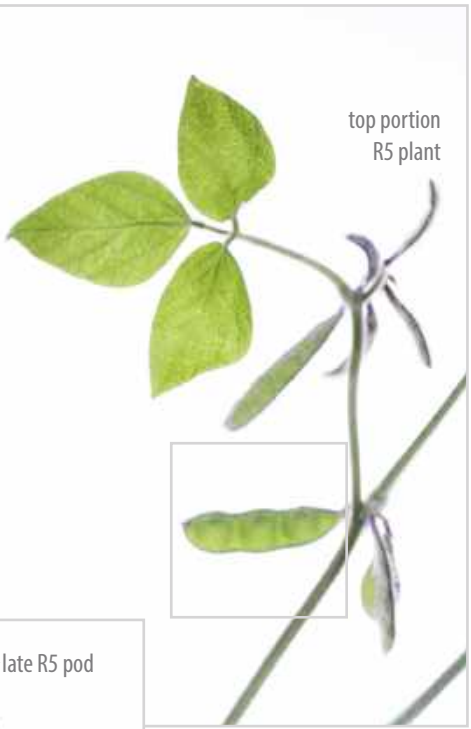
Reproductive Stage 5

Symptoms of many diseases, including white mold and SDS begin to show up at this growth stage. This is a good growth stage to determine the severity of disease. **Treating most diseases with fungicides is not recommended at this time.**

Seed is 1/8 inches long in the pod at one of the four uppermost nodes on the main stem with a fully developed leaf

- Rapid seed filling begins, while root growth slows
- Dry weight and nutrients begin redistributing through the plant to the developing seed
- 50% defoliation can decrease yield by 15-17%
- After R5.5, nitrogen uptake by the roots and existing nitrogen in vegetative tissue begins rapid remobilization to the seed





R6

Reproductive Stage 6

Pod containing a green seed that fills the pod cavity at one of the four uppermost nodes on the main stem with a fully developed leaf

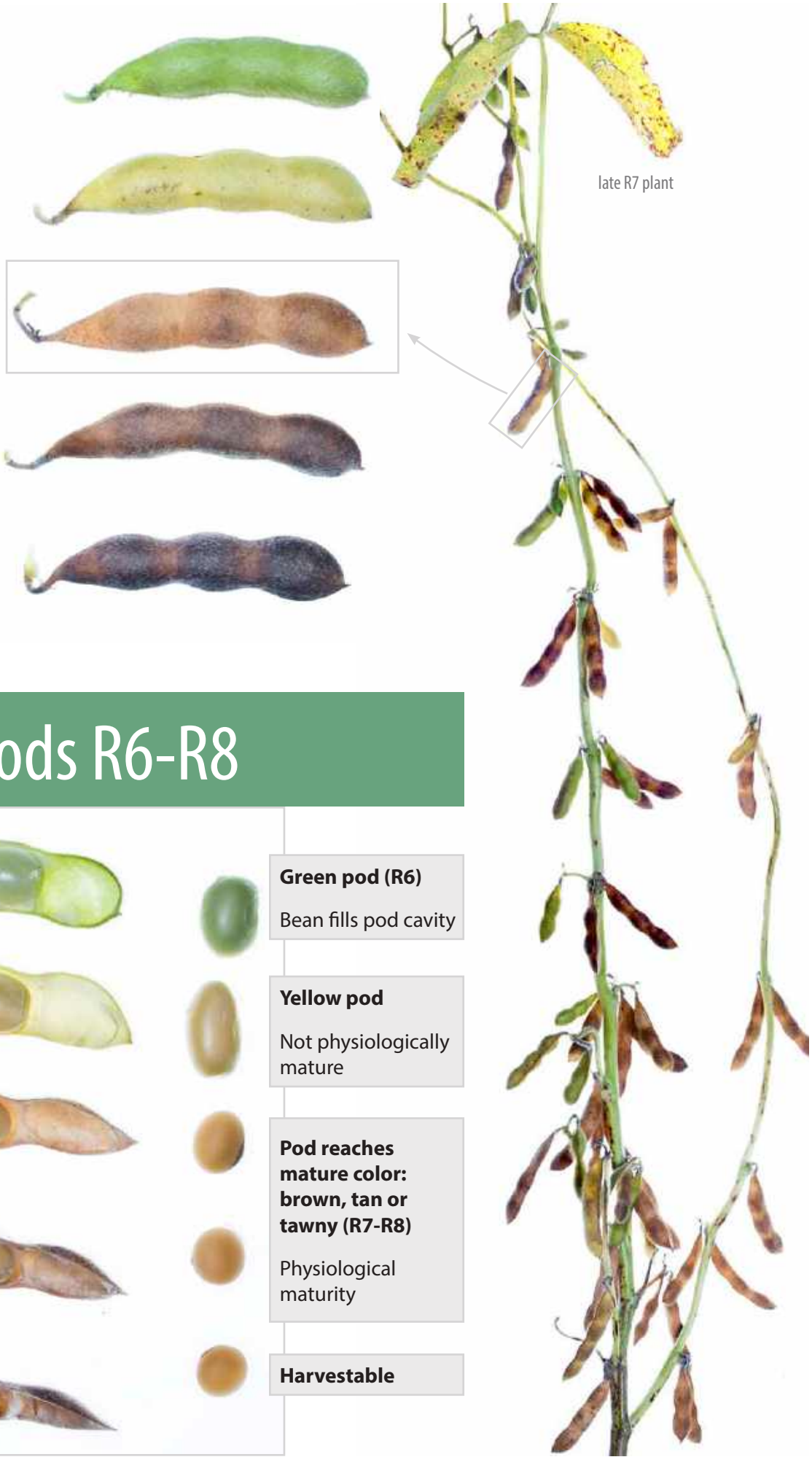
- Beans of many sizes can be found on the plant
- Large amounts of nitrogen are still being accumulated from the soil and remobilized to the seed

R7

Reproductive Stage 7

One mature-colored pod anywhere on the main stem

- Yellow pods are moving toward maturity
- Tan, brown or tawny pods (depending on variety) signal physiological maturity
- Seeds at the R7 growth stage are at approximately 60% moisture
- Continue irrigation until R7



late R7 plant

Maturing pods R6-R8

Green pod (R6)

Bean fills pod cavity

Yellow pod

Not physiologically mature

Pod reaches mature color: brown, tan or tawny (R7-R8)

Physiological maturity

Harvestable

R8

Reproductive Stage 8

95% of pods have reached mature pod color

- Mature pod color does not necessarily indicate that beans are ready to harvest
- 5-10 days of drying weather are typically required after R8 for soybean moisture to be less than 15%
- Harvesting at 13% moisture is optimal for storage
- Delaying harvest after optimal moisture is reached can result in yield loss due to shattering and shrinkage

Pod reaches mature color: brown, tan or tawny

Physiological maturity

Harvestable

late R8 plant

TOTAL NUTRIENT UPTAKE AND REMOVAL PER BUSHEL OF SOYBEAN AND NUTRIENT REMOVAL PER TON OF HARVESTED STOVER

Nutrient	Total uptake (lb/bu)	Removal in grain[1] (lb/bu)	Removal in stover[2] (lb/ton DM)
Nitrogen (N)	**3.75**	**3.30**	**19.0**
Phosphorus (P_2O_5)*	**0.90**	**0.74**	**5.2**
Potassium (K_2O)*	**2.30**	**1.17**	**39.0**
Sulfur (S)	**0.21**	**0.16**	**2.2**
Magnesium (Mg)	**0.51**	**0.16**	**9.3**
Calcium (Ca)	**0.96**	**0.12**	**27.5**

Note: These are not nutrient application recommendations, refer to UWEX A2809 ***Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin*** for more information.

[1] Removal in the grain was calculated at 13% grain moisture.

[2] Stover nutrient content can vary considerably due to the year and yield level. For more accurate estimate of harvested stover, submit samples for nutrient analysis.

* Phosphorus and potassium are displayed in terms of their fertilizer equivalents.

Use this equation to calculate lb/acre uptake or removal for a specific nutrient or use the **Soybean Uptake and Removal Calculator** available at http://badgerbean.com/calculator

expected or actual soybean yield **x** total uptake or removal value of nutrient **=** lb/acre uptake or removal

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This publication is available from the **Nutrient and Pest Management Program** web (ipcm.wisc.edu); phone (608) 265-2660; email (npm@hort.wisc.edu)

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