

Soybean Physiology: How Well Do You Know Soybeans?

Shaun Casteel, Purdue University
Soybean Extension Specialist

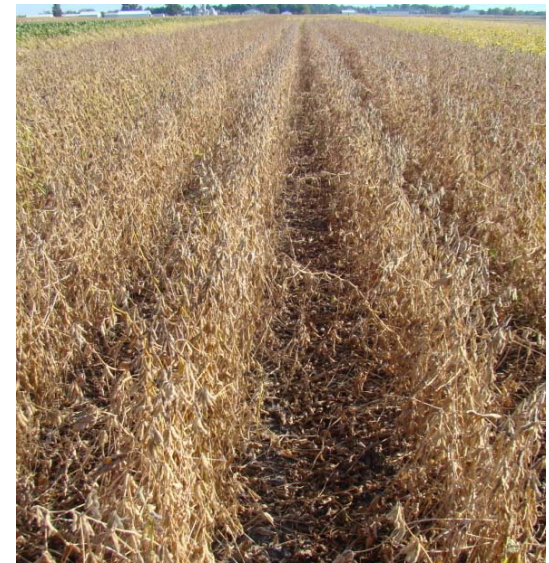
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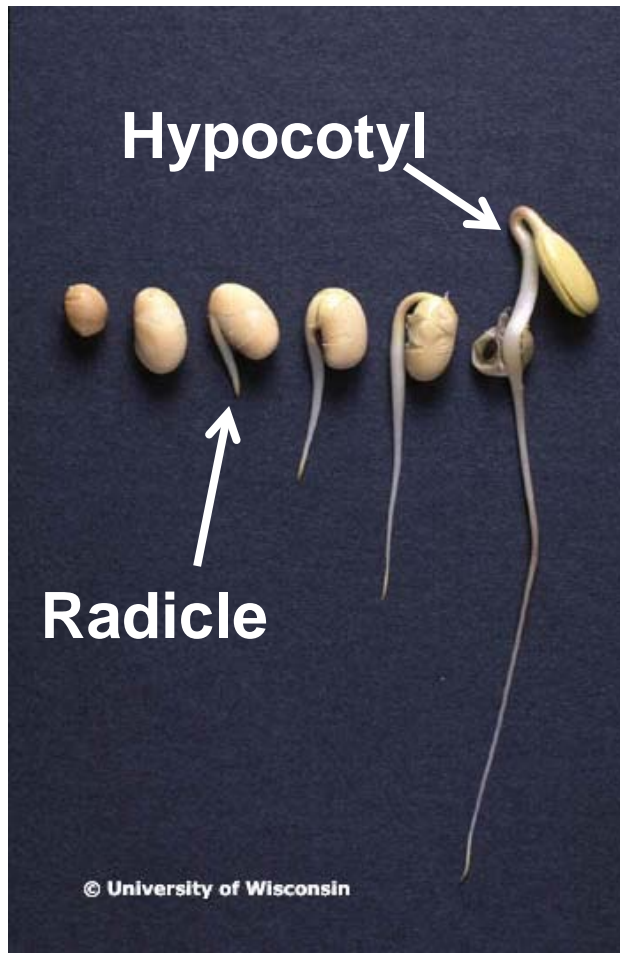


Vegetative Growth Stages



Reproductive Growth Stages

Soybean Germination



- How many nodes are present in the seed?
 - Cotyledon, Unifoliate, 1st Trifoliate
- Cell division initiates within ~36 to 48 h of imbibition
- Radicle is first to emerge
 - Water content equals ~50% of seed weight
 - Moisture & Temp dependent
- Hypocotyl pull cotyledons

Hypocotyl Pulls the Cotyledons (Seed Leaves) Out of the Soil



VE – Emergence: cotyledons and growing point are above the soil surface



cotyledons

hypocotyl

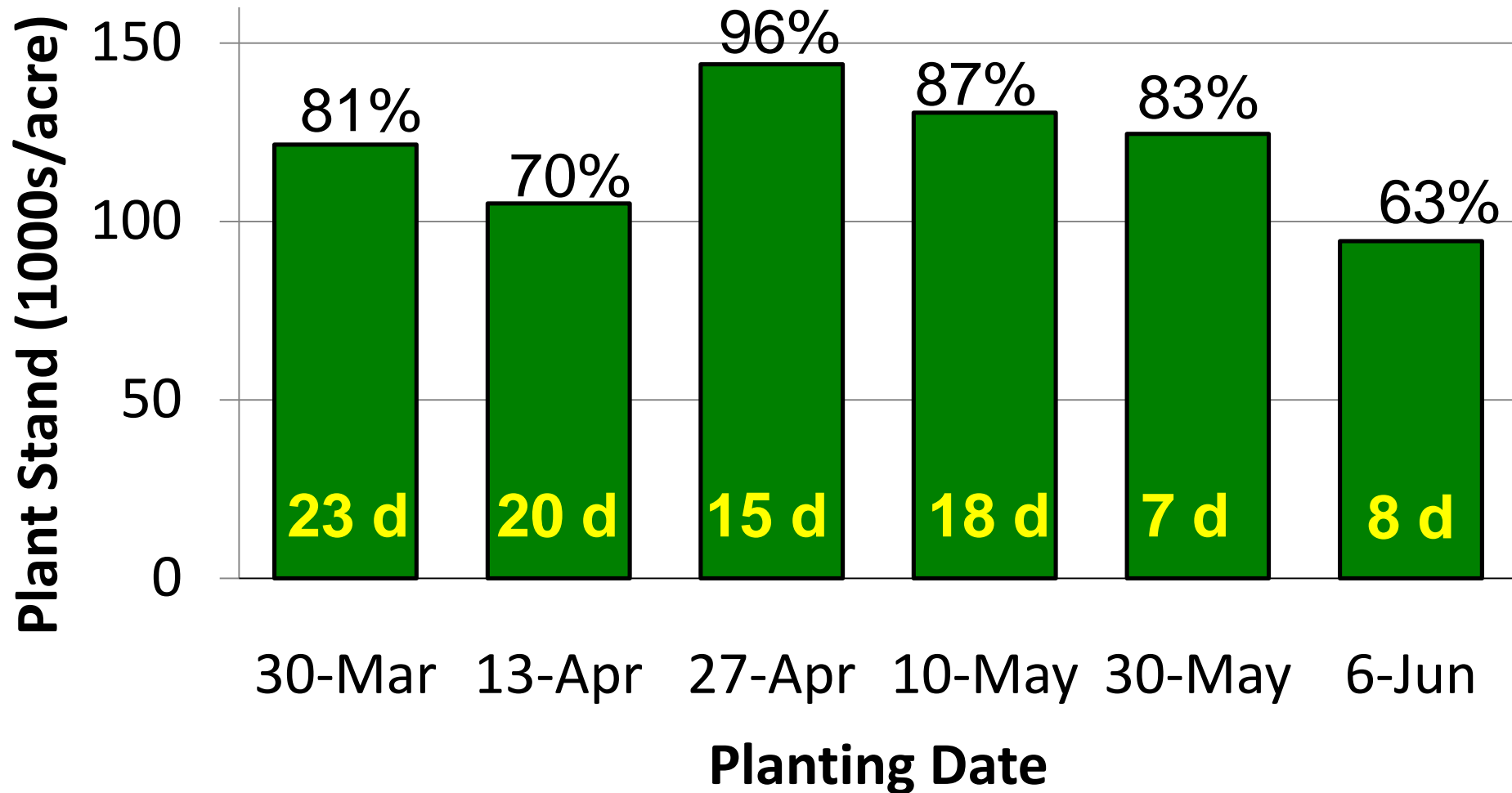
5 to 21 days
after planting

Soil Temperature & Seedling Growth

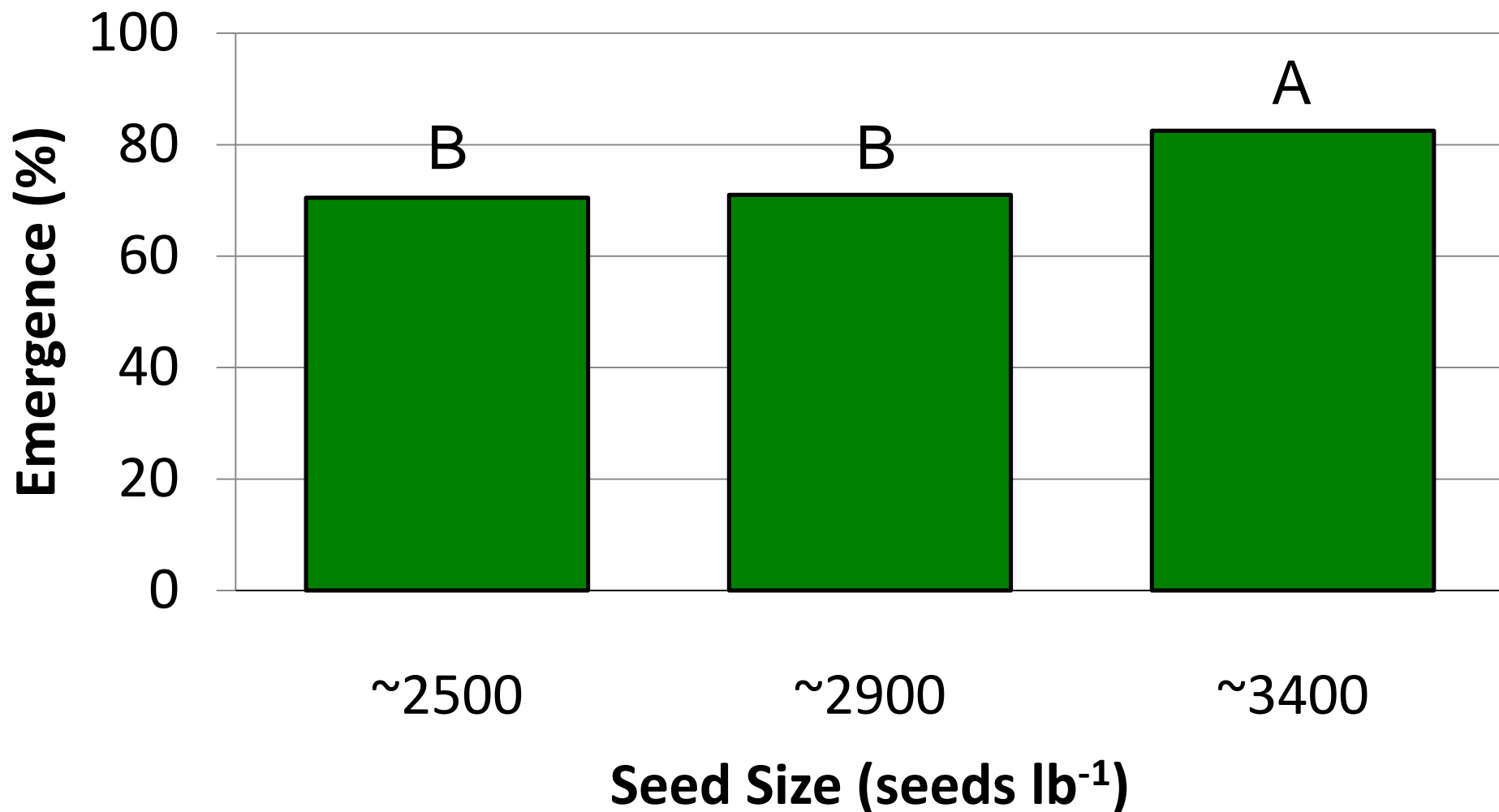
- 50 F soil is the accepted low soil temp
 - Some soybeans have germinated in 36 to 43 F
- Time to soybean germination & emergence can be related to heat unit accumulation.
 - Growing Degree Days (GDDs)



Soybean Emergence after 90 GDDs



Percent Emergence by Seed Size



VC – Cotyledons and Unifoliates Are Fully Expanded



VC – Cotyledons and Unifoliates Are Fully Expanded



- Cotyledons supply the nutrient needs of the seedling for ~7-10 days
 - Seed reserves + photosynthesis by the green cotyledons
 - Cotyledons lose ~70% of their dry weight from this nutrient allocation
- Unifoliate leaves are opposite

Soil Crusting



Swollen hypocotyl

No cotyledons

- Loss of both cotyledons can reduce yield 2 to 7%

V1 – First Trifoliolate



- Fully developed unifoliate leaves
- 1 unrolled trifoliate
 - Single, Alternating
 - Leaflets do not touch

V2 – Second Trifoliate



- 2 unrolled trifoliate
 - Single, Alternating
 - Leaflets do not touch
- 2nd trifoliate was initiated ~3 to 4 days after germination
- Active N₂ fixation

V2 – Active N₂ Fixation



- *Bradyrhizobia japonicum* penetrate root and establish N₂-fixing nodules
- Attach to epidermal cells in the actively growing region just behind the root cap.
 - Usually with immature or unformed root hairs
- Mature nodules – 28 days after infection
- Maximum size – 28 to 37 days after infection
- Degeneration – 50 to 60 days after infection

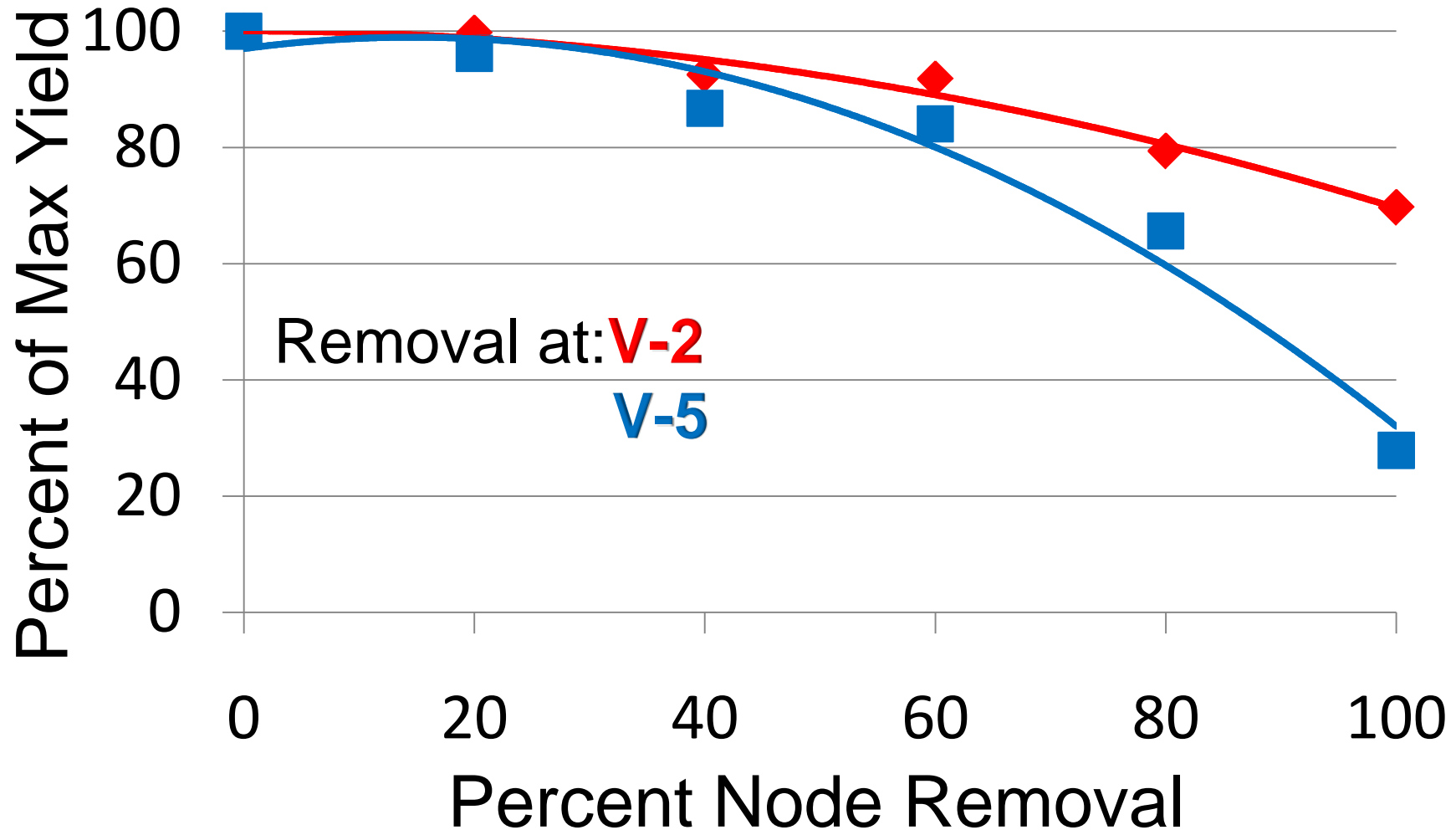
Nutrient **UPTAKE**: Soybean vs. Corn

| | | N | P ₂ O ₅ | K ₂ O |
|---------|--------|--------------------------------|-------------------------------|------------------|
| | | -----lb bu ⁻¹ ----- | | |
| Soybean | Grain | 3.8 | 0.84 | 1.3 |
| | Stover | 1.1 | 0.24 | 1.0 |
| | Total | 4.9 | 1.08 | 2.3 |
| Corn | Grain | 0.9 | 0.38 | 0.27 |
| | Stover | 0.45 | 0.16 | 1.1 |
| | Total | 1.35 | 0.54 | 1.37 |

Nutrient **REMOVAL**: Soybean vs. Corn

| | | N | P ₂ O ₅ | K ₂ O |
|-----------------|--------|----------------------------------|-------------------------------|------------------|
| | | -----lb acre ⁻¹ ----- | | |
| Soybean – 60 bu | Grain | 228 | 50.4 | 78 |
| | Stover | 66 | 14.4 | 60 |
| | Total | 294 | 64.8 | 138 |
| Corn – 180 bu | Grain | 162 | 68.4 | 48.6 |
| | Stover | 81 | 28.8 | 198 |
| | Total | 243 | 97.2 | 246.6 |

Effect of Node Removal at V2 and V5 on Grain Yield in 2004

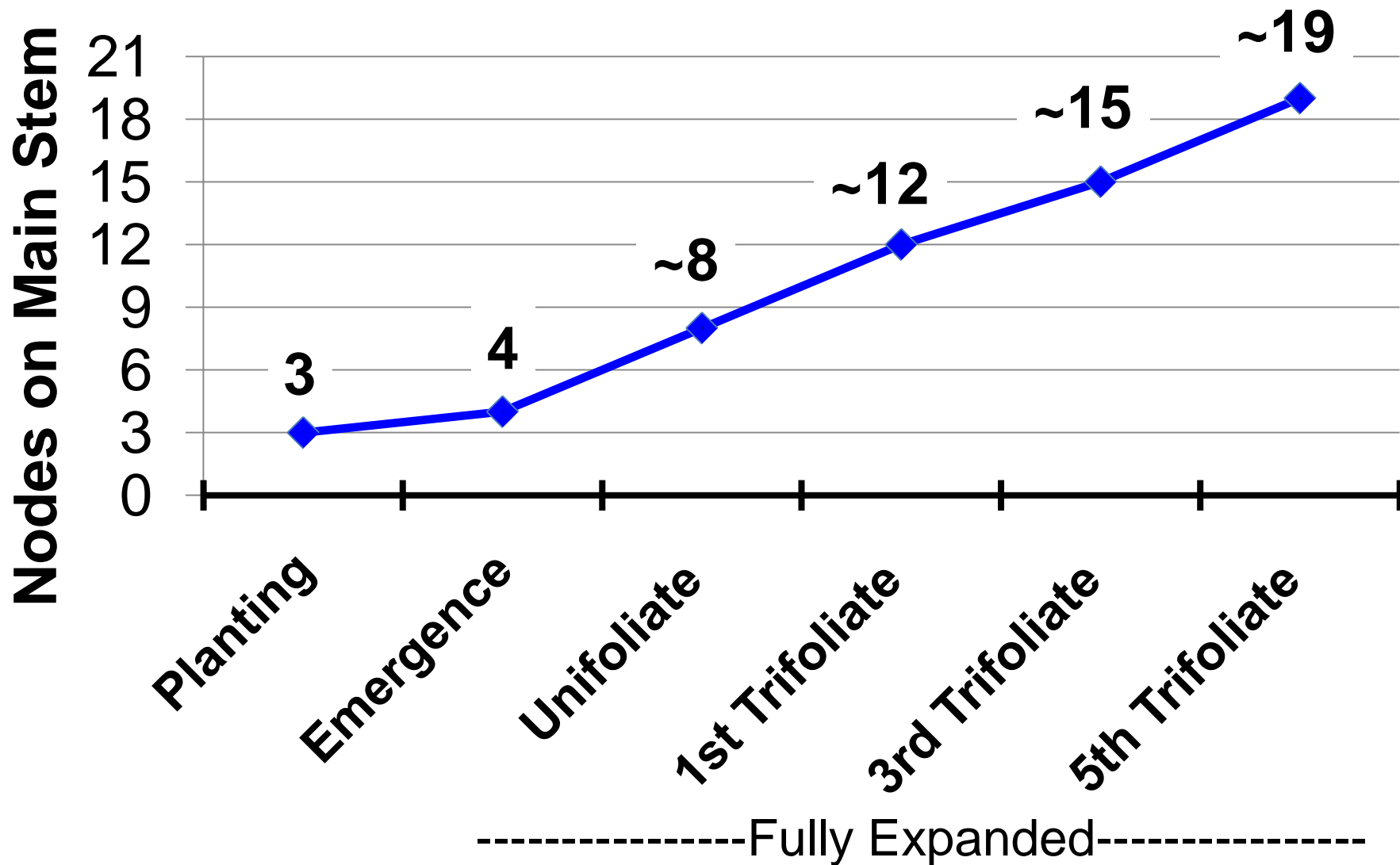


V5 – Fifth Trifoliate



- 5 unrolled trifoliates
 - Single, Alternating
 - Leaflets do not touch
- VC to V5: new V stage every ~5 to 7 days
 - Root growth as much as ~0.5 to 0.75 inch per day (Kasper et al., 1976)
- V5 to R5: new V stage every ~3 to 5 days

of Nodes Initiated on Main Stem



Reproductive Stages

R1: Beginning Bloom

R2: Full Bloom

R3: Beginning Pod

R4: Full Pod

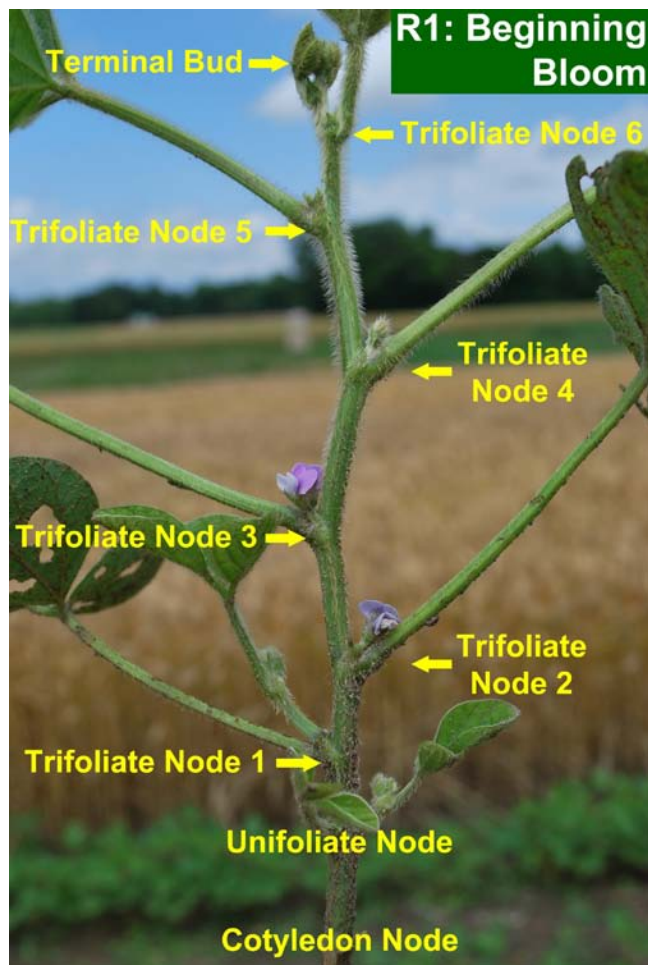
R5: Beginning Seed

R6: Full Seed

R7: Beginning Maturity

R8: Full Maturity

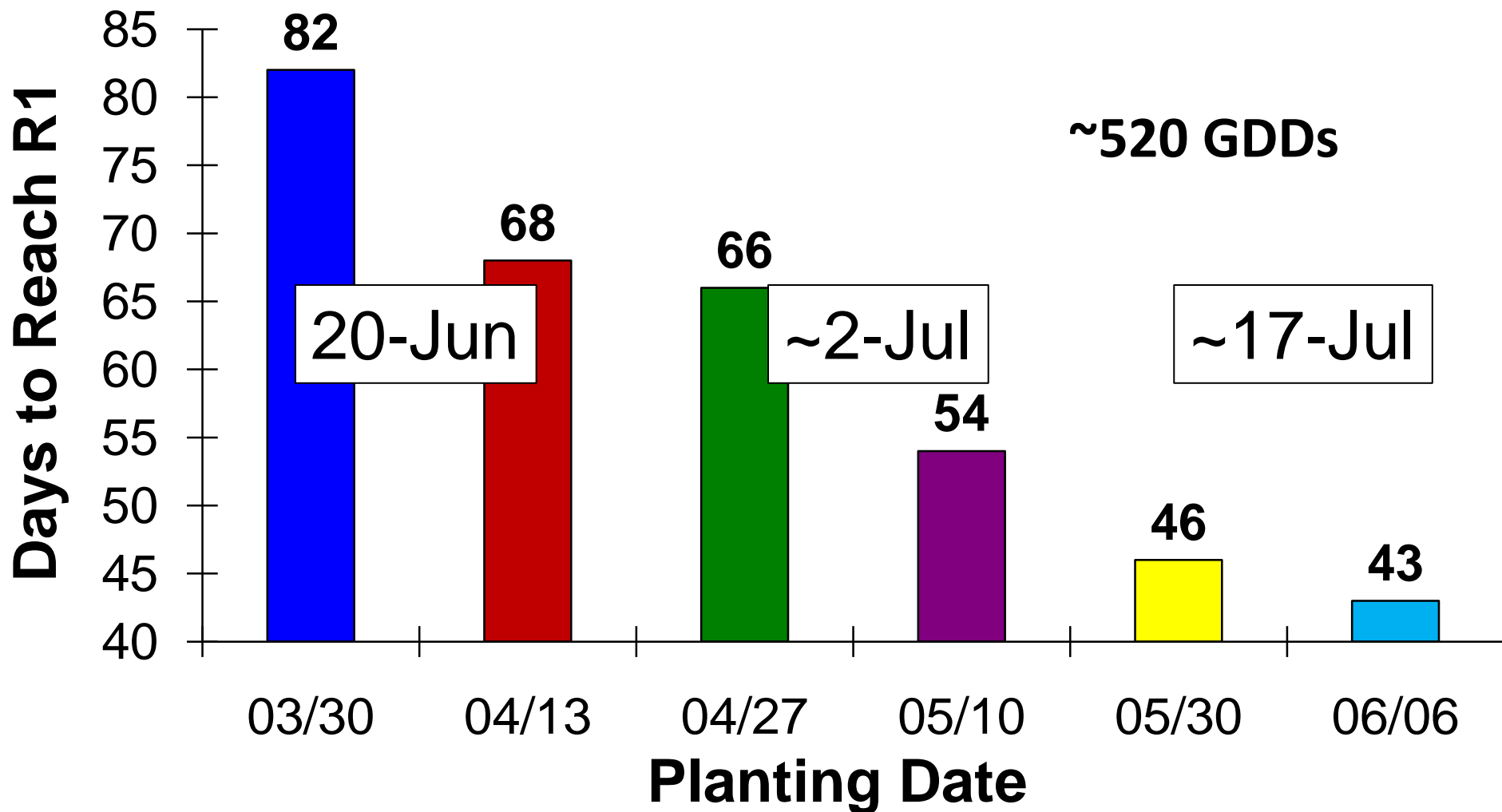
R1: Beginning Bloom



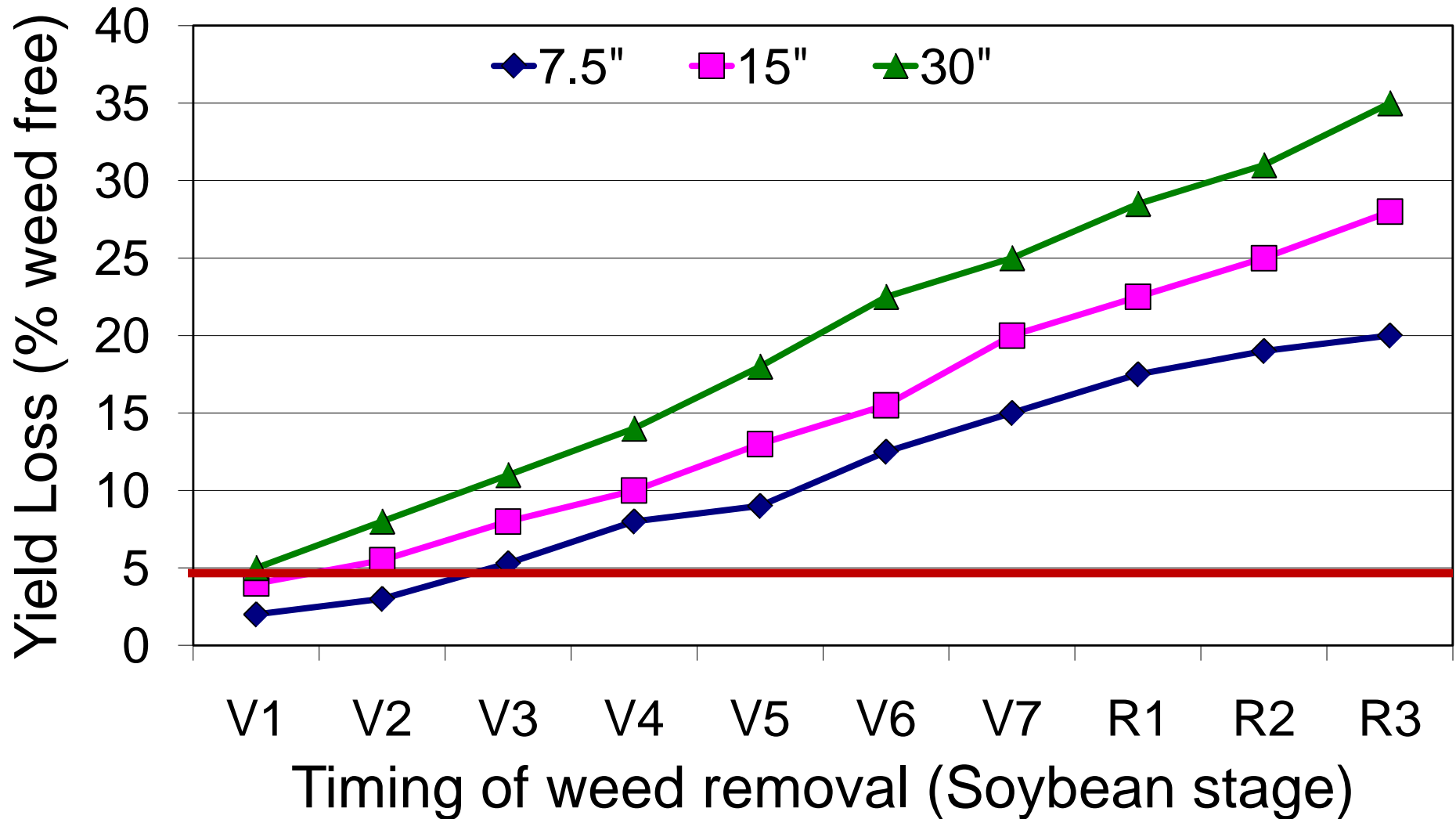
- Open flower at **any node on the main stem**
- Flowering begins at 3rd to 6th node (V6 to V10 stage)
- Flowering period is 3 to 4 wk
 - Begins ~6 to 8 wk after emergence
 - Peaks R2 to R3; ends ~R5
- **Vertical root growth rates increase rapidly**
 - As much as 1.3 to 3.2 in/day (Kasper et al., 1976)

~Days to R7 - 70

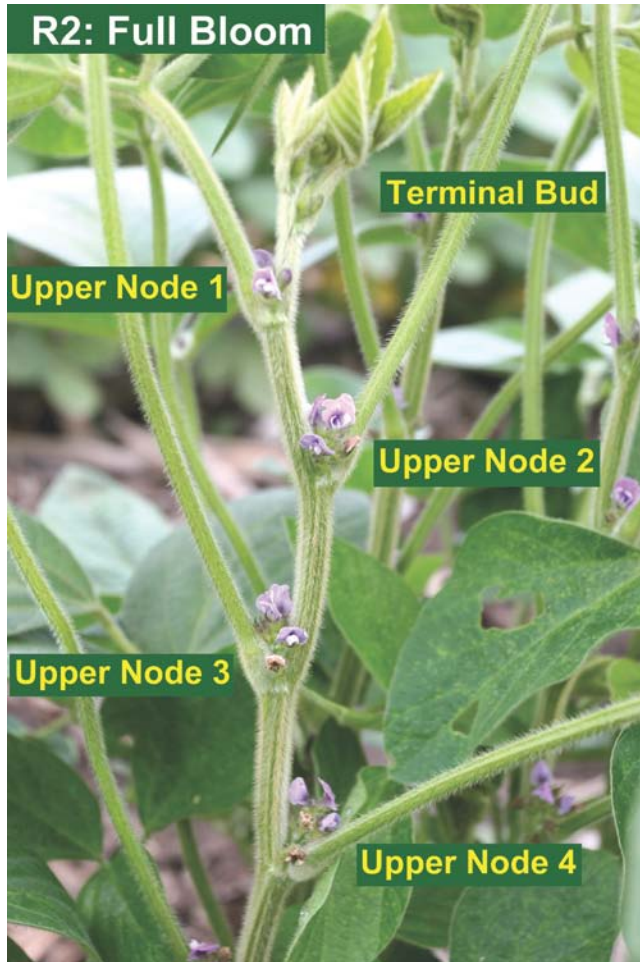
of Days from Planting to R1



Yield Effects of Weed Removal by Row Width



R2: Full Bloom



- Open flower at one of **two** uppermost main-stem nodes
- Accumulated **25%** of total **dry wt** & **50%** of total **node #**
- Rapid dry wt and nutrient accumulation from R2 until R7 initiation
- **N-fixation rate** ↑
- 50% defoliation ↓ yield 60%

~Days to R7 - 65

R3: Beginning Pod

Any pod that is **~3/16 inch long** and is on one of the four uppermost nodes of the main stem.



**~3/16-in
pod length**

Developing pods, withering flowers, open flowers, & flower buds can all be found during this stage.

R3: Beginning Pod

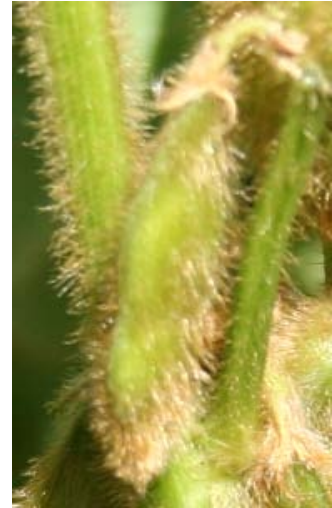
- A **3/16 inch long pod** at **one of the four uppermost** nodes on the main stem
- Yield is a function of:
 - Base population
 - Pod number
 - Seeds per pod
 - Seed weight
- Ability to compensate for stress by modifying these factors decreases from R1 to R5



~Days to R7 - 55

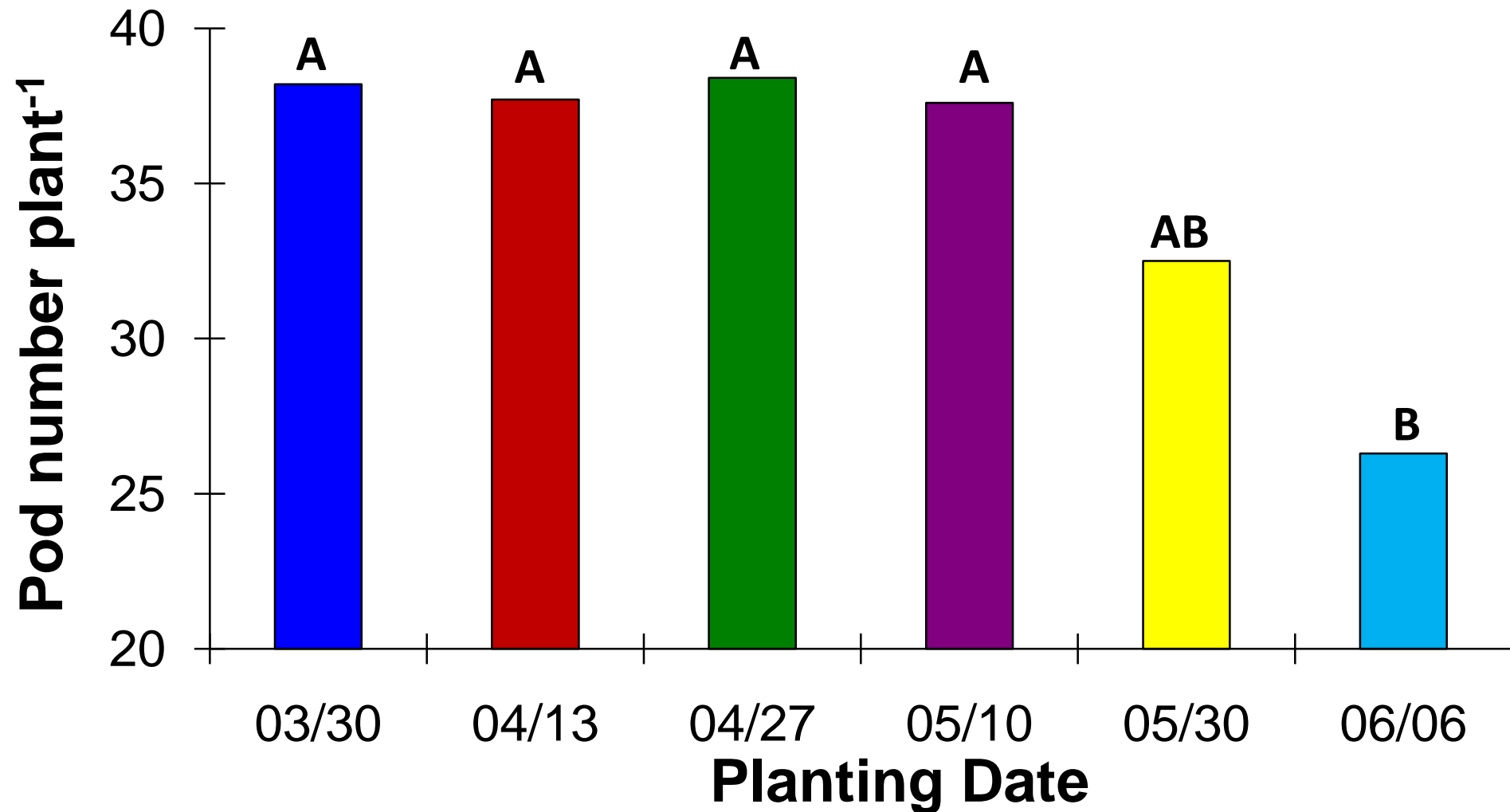
R4: Full Pod

- A **3/4 inch pod at one of the four uppermost nodes** on the main stem
- Rapid pod growth & beginning seed development
- From R4 to middle R5 critical for yield
 - Rapid and steady dry matter accumulation
 - Flowering is complete
 - Young seeds & pods are most prone to abortion
- **Yield reduction based on total pod #** is the main yield limiting factor
 - ↓ Seed # per pod and seed size may also occur



~Days to R7 - 45

Planting Date Effect on Pod Number Plant⁻¹



R5: Beginning Seed

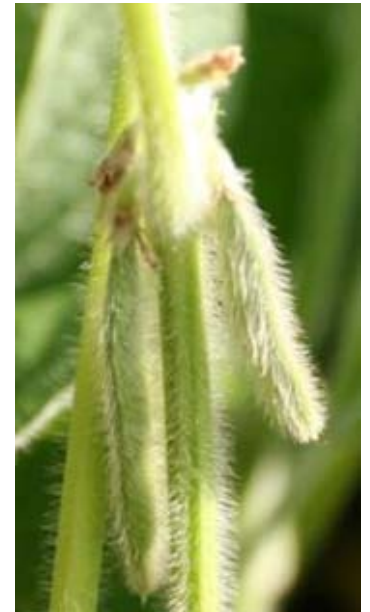
Seed is 1/8th inch long in a pod at one of four uppermost nodes on main stem



~Days to R7 - 35

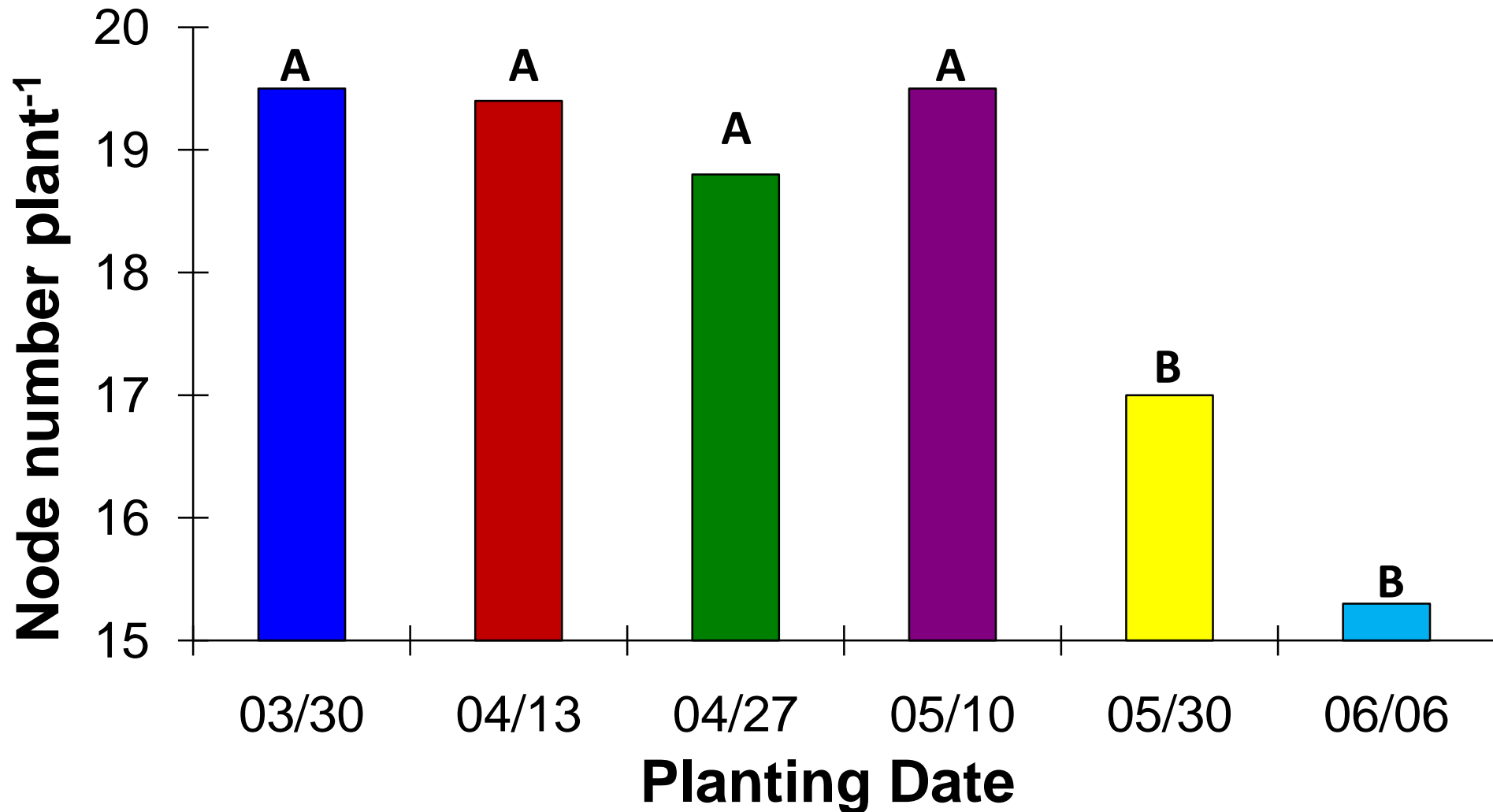
R5: Beginning Seed

- **Seed is 1/8th inch long in a pod at one of four uppermost nodes on main stem**
- **Rapid seed filling and redistribution of dry matter/nutrients occur**
- **Root growth slows as seed growth begins**
- **Midway between R5 and R6**
 - **Maximum height**
 - **Maximum node number**
 - **Maximum leaf area**
 - **N-fixation rate peaks then rapidly ↓**



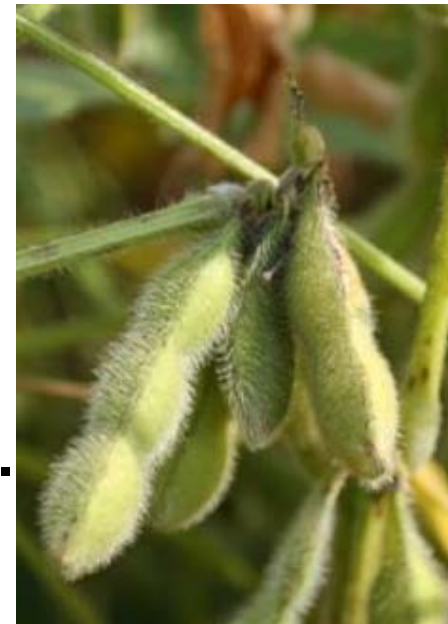
~Days to R7 - 35

Planting Date Effect on Node Number Plant⁻¹



R6: Full Seed

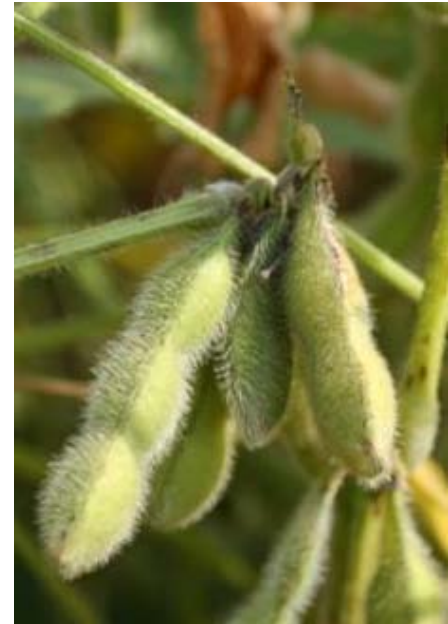
A pod containing a **green seed that fills the pod capacity** is located at one of the four uppermost main stem nodes.



~Days to R7 - 20

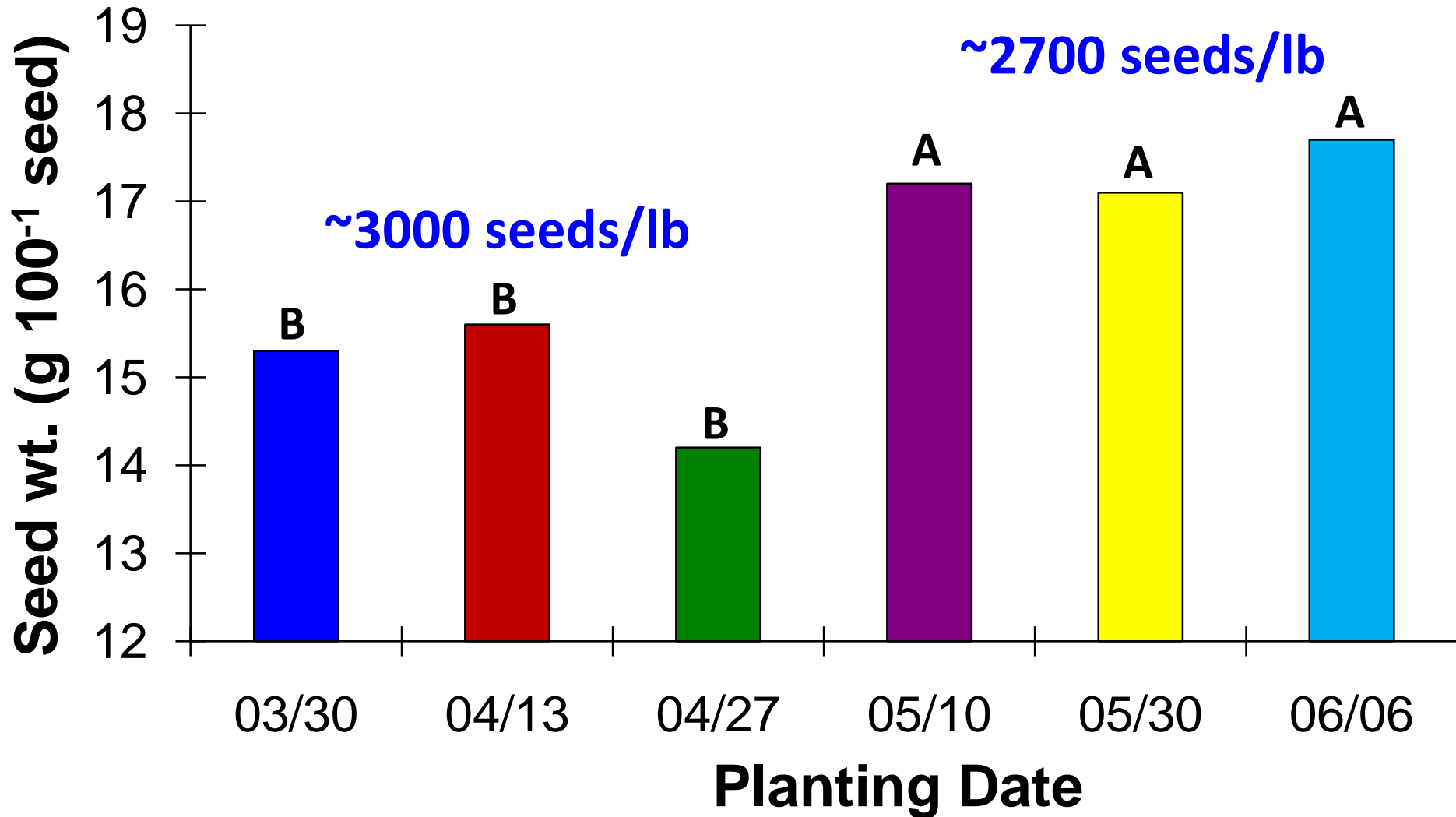
R6: Full Seed

- A pod containing a **green seed that fills the pod capacity** is located at one of the four uppermost main stem nodes.
- **Total plant pod weight is maximized**
- **Rate of dry weight and nutrient accumulation slows**
- Root growth is complete between R6 and R7



~Days to R7 - 20

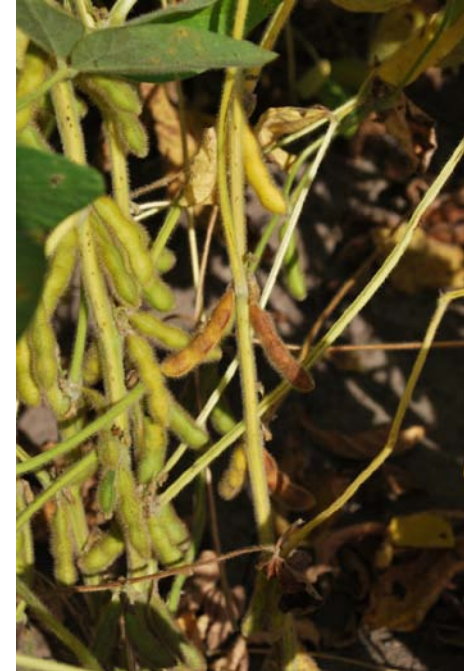
Planting Date Effect on Seed Size



R7: Beginning Maturity



Plants shedding leaves
just prior to R7



One pod anywhere
with mature color

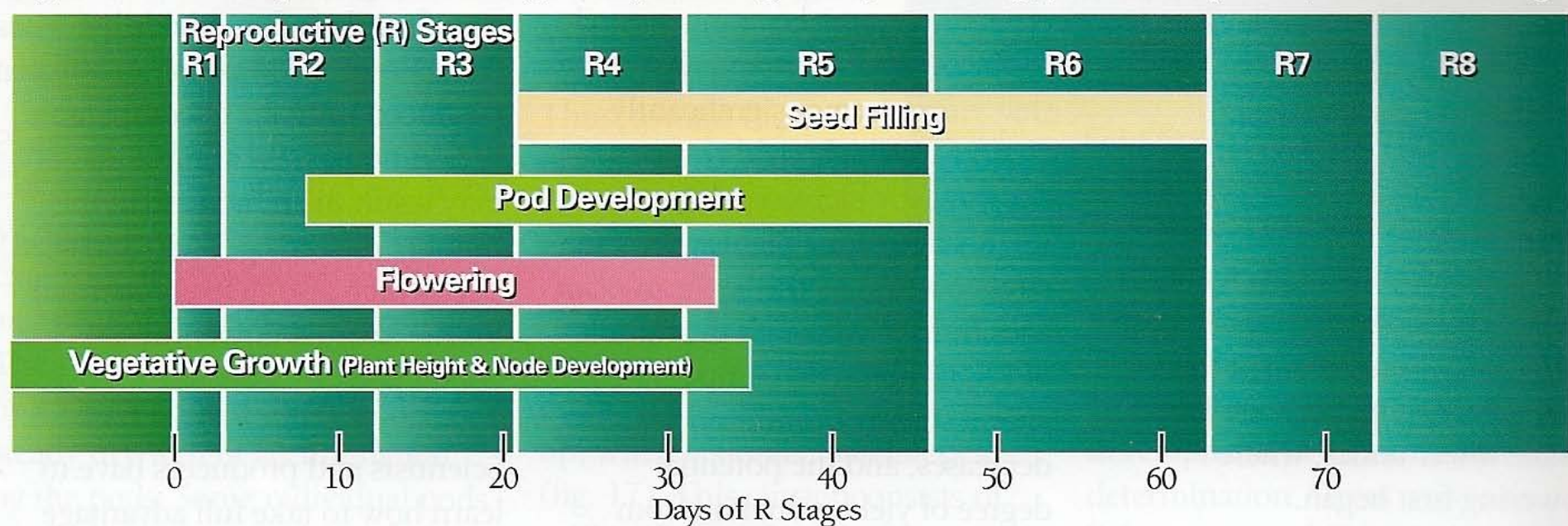
R8: Full Maturity



- 95% of pods reached mature color
- ~35% grain moisture in freshly matured pod
- ~15% within another 5 to 10 days
- Below-optimum plant stands cause more branching, low pod heights & can delay maturity
- Above-optimum plant stands increase lodging

Duration of Soybean Development

Figure 11. Development and timing of vegetative growth, flowering, pod development, and seed filling.



Any Questions?

Shaun Casteel

765-494-0895

scasteel@purdue.edu

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