Soybean Production Overview: Planting to Harvest

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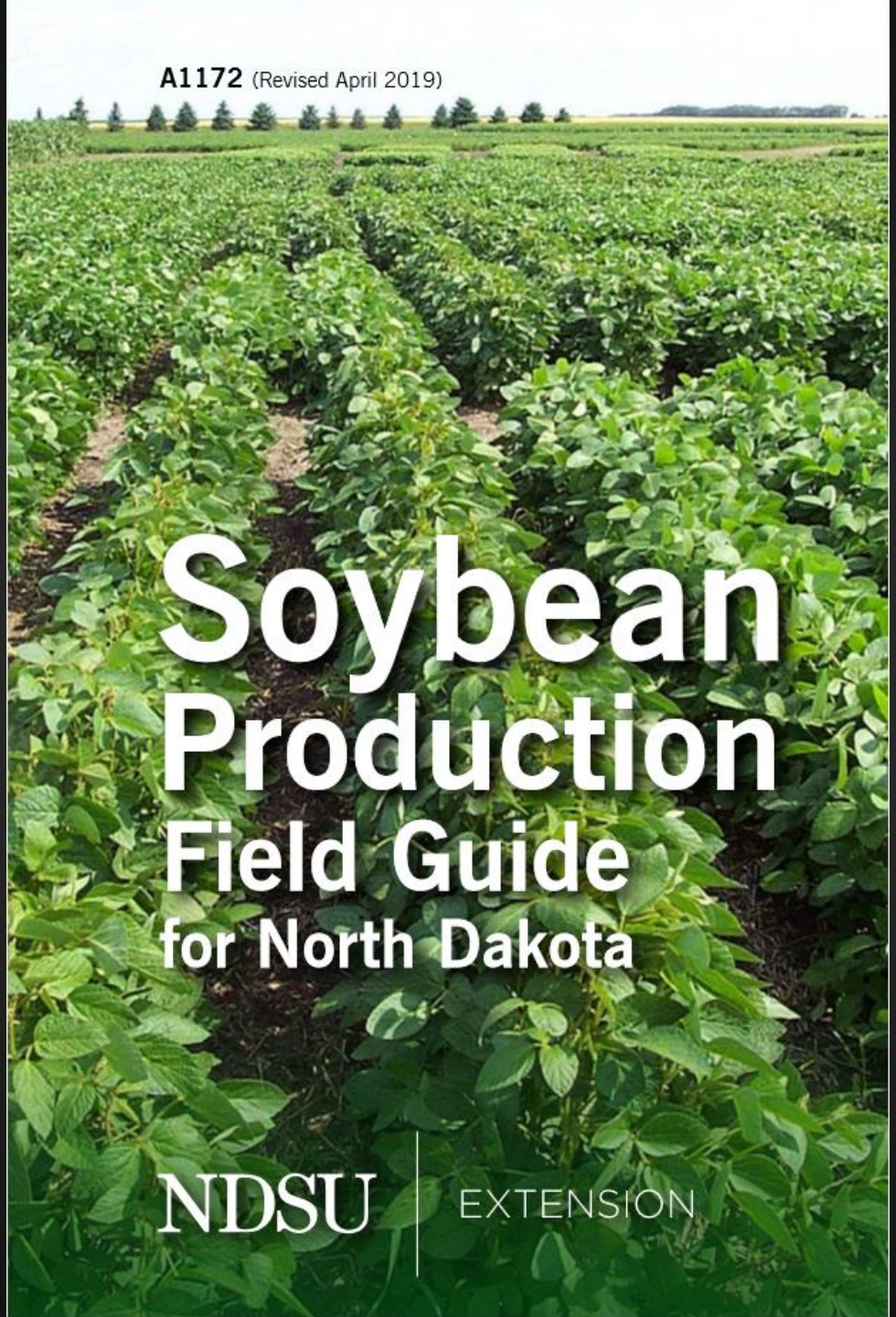
NDSU REC research agronomists

A1172 (Revised April 2019)



Soybean Production Field Guide for North Dakota

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Subjects

- Introduction
  - Variety selection; cover crops
- Plant growth stages and associated production recommendations
  - Management emphasis on plant establishment (preplant to R1 stages)
    - planting date, rows, plant population

Main Factors in Variety Selection

- **Yield**
- **Maturity**
- Disease
  - Root rot and SCN
- **Herbicide tolerance or conventional**
- Iron Chlorosis
- Specialty markets

A843-19

North Dakota Soybean

Variety Trial Results for 2019 and Selection Guide

Hans Kandel, Ted Helms, Sam Markell and Chad Deplazes (NDSU Main Station); Mike Ostlie, Blaine Schatz, Greg Endres, Ezra Aberle, Tim Indergaard and Kelly Bjerke (Carrington Research Extension Center); Kelly Cooper, Heidi Eslinger and Seth Nelson (Oakes Irrigation Site); Eric Eriksmoen, Joe Effertz and Austin Kraklau (North Central Research Extension Center, Minot); Bryan Hanson, Travis Hakanson and Lawrence Henry (Langdon Research Extension Center); John Rickertsen (Hettinger Research Extension Center); Jerry Bergman, Gautam Pradhan, Tyler Tjelde and Justin Jacobs (Williston Research Extension Center); Angie Johnson, Melissa Seykora and Brian Zimprich (NDSU Extension)

Variety trial data from all NDSU Research Extension Centers for all crops can be found at *www.ag.ndsu.edu/varietytrials.*

Several herbicide traits are represented in the tables: RR = Roundup Ready, RRXT = RR2Xtend, XT = Xtend, GT = Glyphosate Tolerant, LL = Liberty Link and LLGT27 = Liberty Link GT27.

List of Tables

NDSU | EXTENSION NDSU | NORTH DAKOTA AGRICULTURAL EXPERIMENT STATION

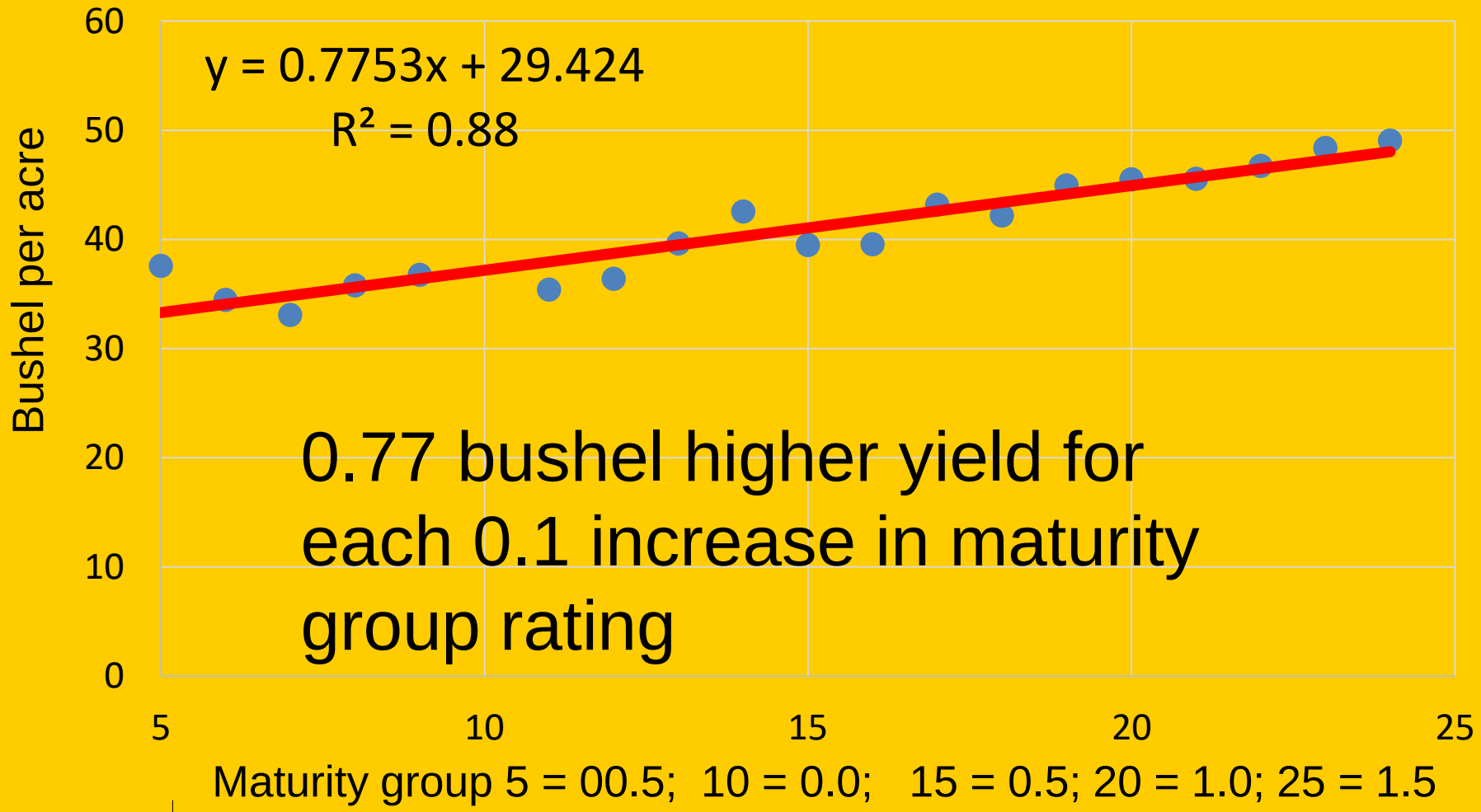
Fargo, North Dakota
December 2019

RR, GT, Xtend and Enlist soybean variety trial, Minot, 2019

Varieties	47
Companies/universities	14
Seed yield (bu/A)	
average	48.1
range	36.0-62.3
Seed yield increase (%) vs. trial average	
High (62.3 bu/A)	23
Statistically higher (LSD 0.05 = 5.5 bu/A)	**10**

E. Eriksmoen, J. Effertz and A. Kraklau

ND Survey yield in bushel per acre by maturity group, 2014-17 (1098 fields)



How do you select between 12 different soybean herbicide trait packages with resistance to various herbicides?

Soybean Herbicide Trait	Glyphosate	Glufosinate	2,4-D Choline	Dicamba	HPPD Inhibitors
Conventional					
Glyphosate Tolerant (GT)	✔				
Roundup Ready	✔				
Roundup Ready 2 Yield	✔				
Roundup Ready 2 Yield Xtend	✔			✔	
Roundup Ready 2 Yield Xtendflex	✔	✔		✔	
LibertyLink (LL)		✔			
LLGT27	✔	✔			✔
Enlist E3	✔	✔	✔		
GT27	✔				✔
MGI		✔			✔

Source: T. Peters, NDSU Extension sugarbeet agronomist

Cover crops

Summary of rye termination timing in soybean, Carrington REC, 2013-17.

average across years and planting dates	Yield		
No rye check	35.6		
Rye terminated prior to planting	35.5		
Rye terminated @ planting	33.1	1 crop failures	
Rye terminated 2 weeks after planting	24.2	3 crop failures	
9 evaluations			

- With generally wet soil conditions across ND, opportunity to 'plant green' in 2020?

Fall-Planted Cover Crop Tolerance to Soybean Herbicides

- **Current data:**
  - **Fargo, 2016** (K. Howatt)
    - 11 corn and soybean herbicides (no crop); 10 cover crops
      - ❖ data published in 2016 ND Weed Control Research

      www.ag.ndsu.edu/weeds/nd-weed-control-research

  - **Fargo** and Carrington**, 2018;** Fargo and **Carrington, 2019** (supported by ND Soybean Council)

    Soybean herbicides:
    - Soil-applied: Sencor, Pursuit, Spartan, Valor, Zidua (and Raptor - Fargo)
    - POST: Engenia, Flexstar (and Raptor - Fargo)

    Cover crops:
    - barley, winter rye, field pea, flax, radish, turnip (and lentil - Fargo)
      - ❖ data published in 2018 and 2019 (pending) ND Weed Control Research

A1174 (Revised)

Soybean

Growth and Management

QUICK GUIDE

Reviewed by
Greg Endres, Area Agronomist
Hans Kandel, Agronomist
NDSU Extension Service

Growth, development and yield of soybeans are a result of a variety's genetic potential interacting with environmental 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.

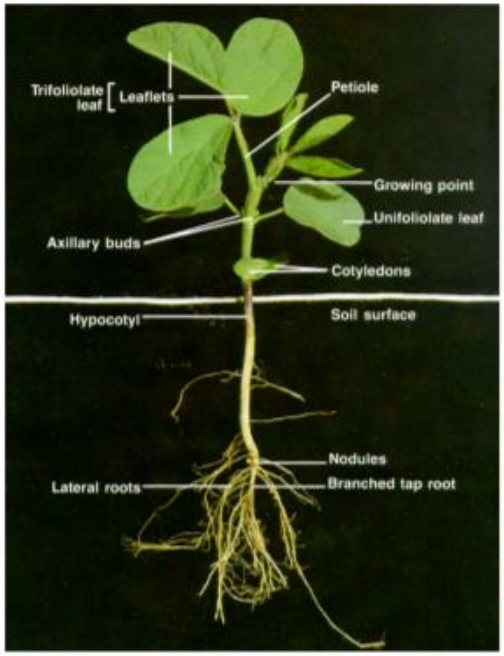


Figure 1. Soybean plant.

NDSU EXTENSION SERVICE
North Dakota State University
Fargo, North Dakota
MAY 2015

Internet search:
'NDSU soybean growth'

Soybean Growth Stages

Vegetative

- VE (plant emergence)
- VC (cotyledon stage)
- V1 (first trifoliate)
- V2 (second trifoliate)
- V3 (third trifoliate)
- V(n) (nth trifoliate)

Reproductive

- R1 (beginning bloom)
- R2 (full bloom)
- R3 (beginning pod)
- R4 (full pod)
- R5 (seed filling)
- R6 (full size seed)
- R7 (beginning maturity)
- R8 (full maturity)

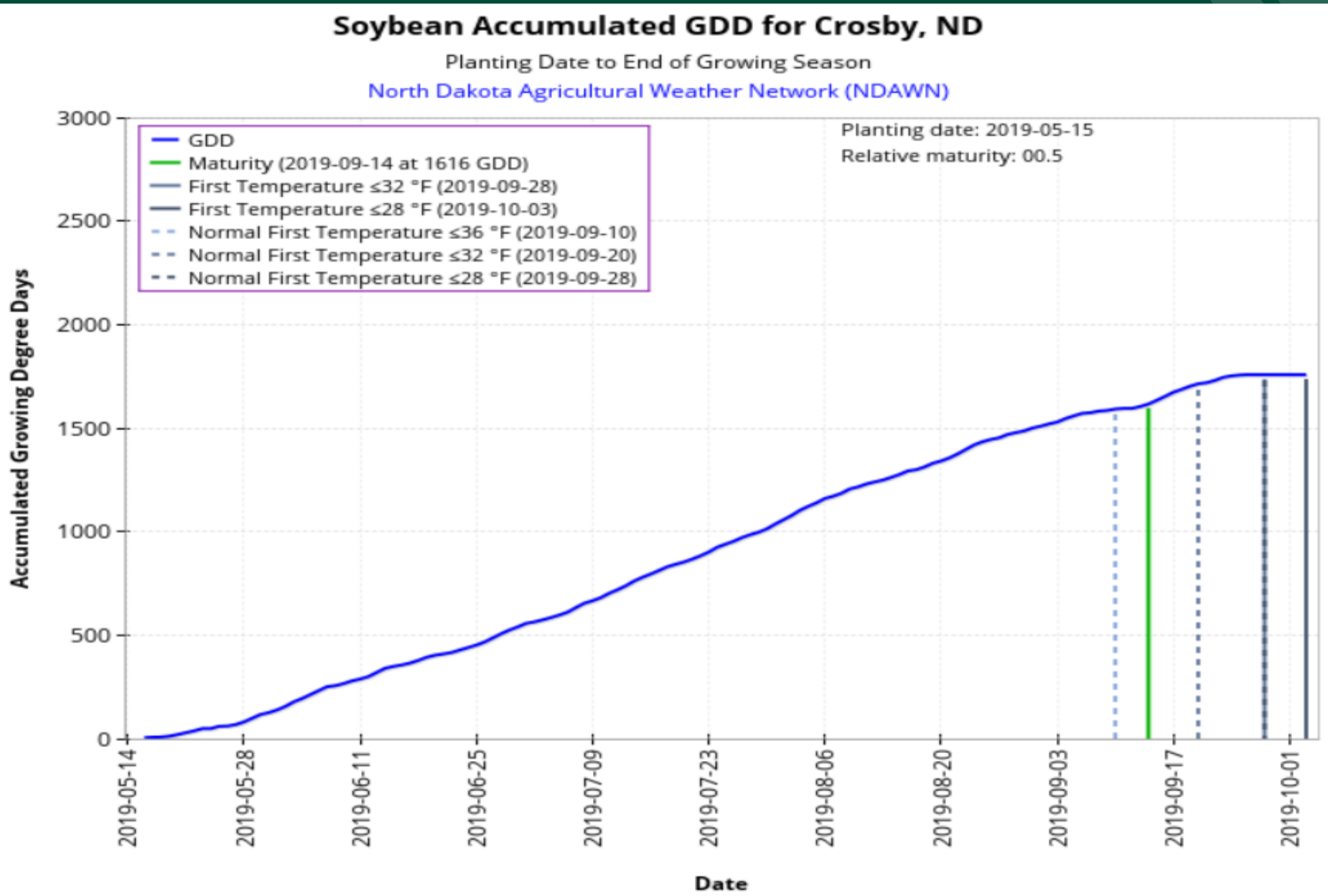
Days for soybean plant development, Carrington, 2004-07[a].

RM*	VE (emergence)	V1 (1st trif leaf)	R1 (first flower)	R3 (first pod)	R5 (first seed)	R7 (initial PM)	R8 (full PM)
	Days from planting**						
0.0	18	31	52	68	78	112	118
0.4 to 0.5	18	30	54	70	81	119	124
Average	18	31	54	70	81	117	123

*0.0 = Walsh in 2004 and RG200RR in 2005-07; 0.4 = RG604RR, O.5 = RG405RR.

**planting dates: 2004=May 10; 2005=May 17; 2006=May 16; 2007=May 17.

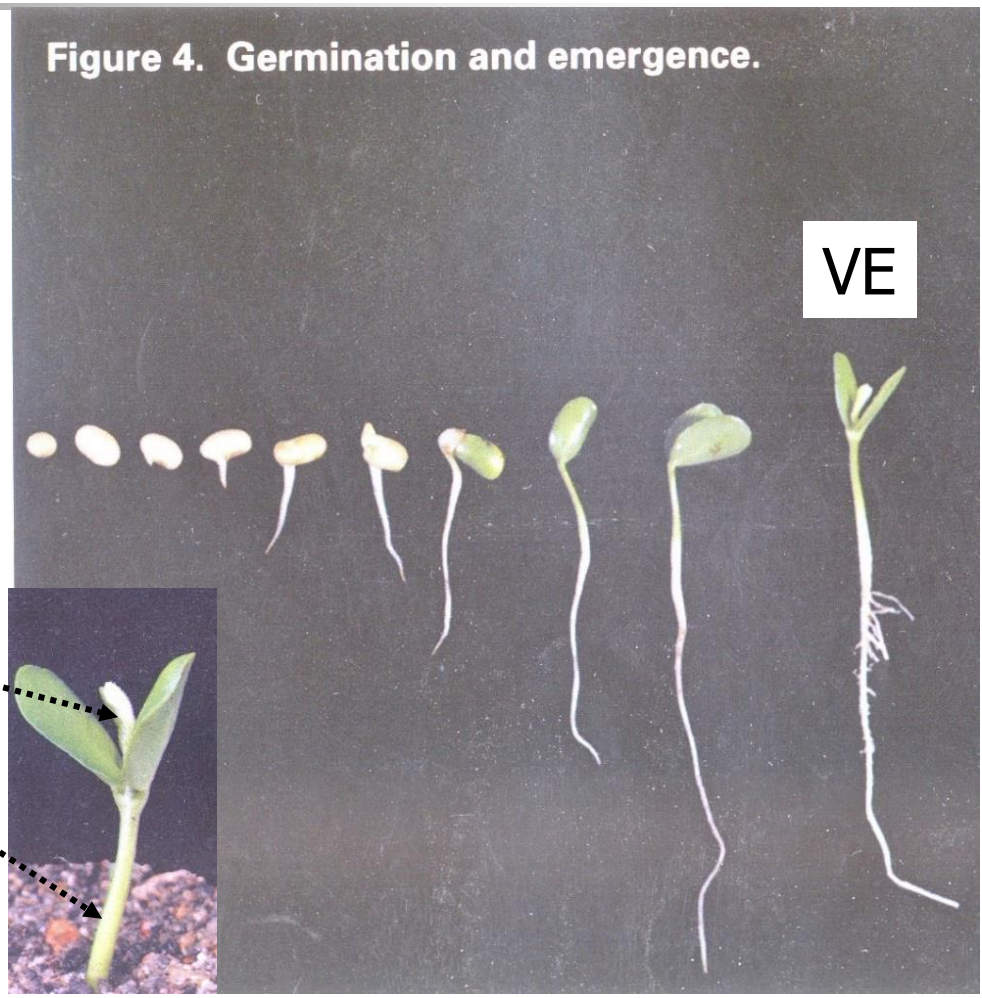
https://ndawn.ndsu.nodak.edu/


Soybean Accumulated GDD for Crosby, ND
Planting Date to End of Growing Season
North Dakota Agricultural Weather Network (NDAWN)
GDD
Maturity (2019-09-14 at 1616 GDD)
First Temperature ≤32 °F (2019-09-28)
First Temperature ≤28 °F (2019-10-03)
Normal First Temperature ≤36 °F (2019-09-10)
Normal First Temperature ≤32 °F (2019-09-20)
Normal First Temperature ≤28 °F (2019-09-28)
Planting date: 2019-05-15
Relative maturity: 00.5
Accumulated Growing Degree Days
3000
2500
2000
1500
1000
500
0
2019-05-14
2019-05-28
2019-06-11
2019-06-25
2019-07-09
2019-07-23
2019-08-06
2019-08-20
2019-09-03
2019-09-17
2019-10-01
Date

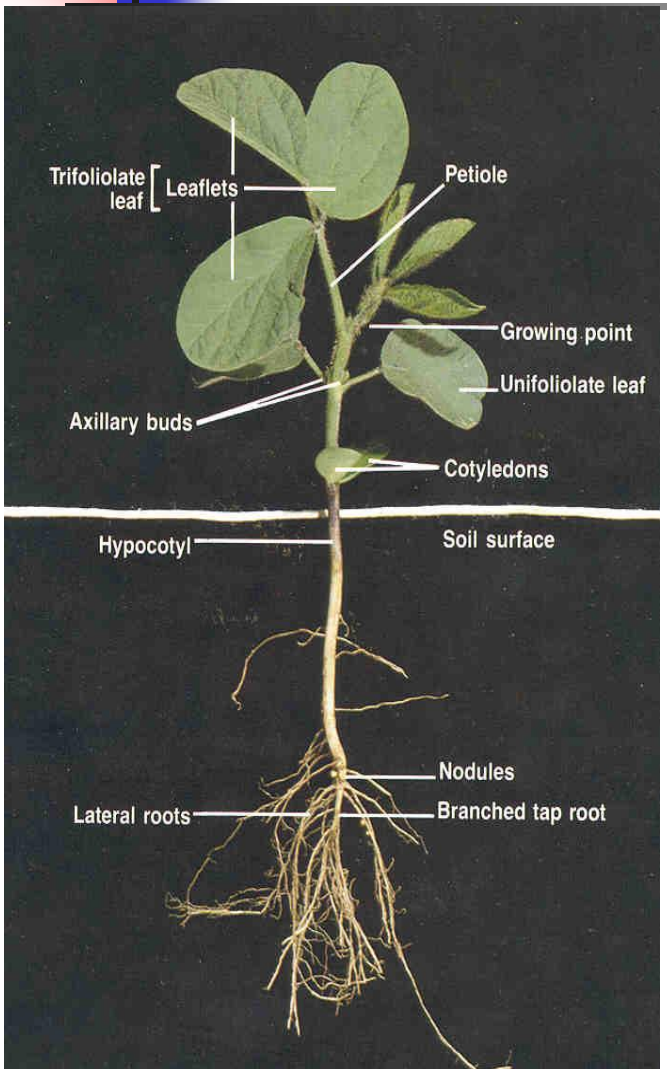
VE (plant emergence)

Begins when seed absorbs 50% moisture by weight. Germination begins at 50 degrees soil temp.

- Radical first grows from seed and anchors seedling.
- Hypocotyl elongates and pulls the cotyledons (seed leaves) out of the ground.
- Stem develops from the epicotyl (exposed when cotyledons unfold).



Soybean Plant Processes at **V1**



- Secondary (lateral) root development
- Nodules present but active N-fixation begins at V2-V3.
- Rapid plant photosynthesis and overall growth is beginning
  - V stages occur about every 4-5 days through V5 (3 days/leaf after)
  - plant stress may lengthen V period (and shorten R period)
- Growing point at top of plant
  - removal activates axillary buds

V5

Five unfolded trifoliate leaves (six nodes)

- Lateral roots may reach across a 30-inch row
- Total potential plant nodes set
- Up to six branches typically develop (during V stages)
  - develop trifoliate leaves, nodes, axillary buds, flowers, and pods similar to main stem
- R1 is nearing
  - Axillary buds in stem axils begin to develop flower clusters

NDSU Research Summary of Soybean Plant Establishment Factors

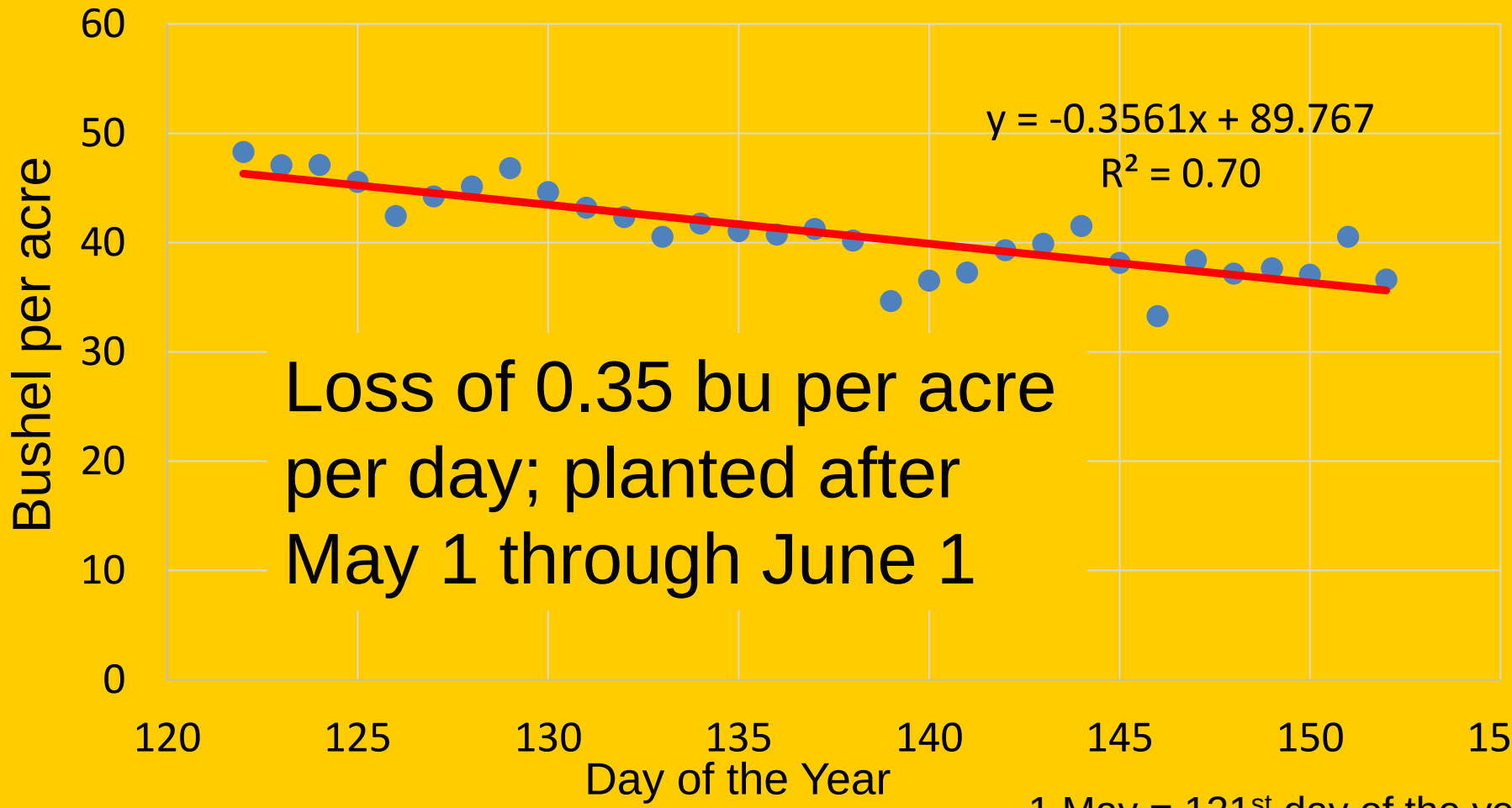
Factor	Option A	A Yield > B (%)	Option B	NDSU trials (conducted during 1999-2018)
Tillage system	reduced till	**4**	conventional till	37
Previous crop	wheat	**5**	soybean	6
Planting date	≤ early May	**6**	mid May	15
Planting rate (pls/A)	150-175,000	**6**	100-130,000	44
Row spacing (inches)	14-21	**4**	28-30	24
Seed fungicide	yes	**6**	no	29
Seed inoculation with soybean history	yes	**2**	no	16
P app at planting time	broadcast	**0.5**	band (away from seed)	7
Timing of initial weed control	at planting	**5**	early POST (2- to 4-inch weeds)	8

Compiled by Greg Endres, Extension agronomist

What potential yield advantage exists with **early planted** soybean?

- NDSU research in south central/east ND (11 site-years; 2011-17) indicates **10%** yield increase with first week of May (or earlier) planting vs. 3rd week of May planting (two week delay).
  - When soil tilth is adequate and soil temperature one to two days following planting is near 50 degrees.
- Limited research in western ND (4 site-years; 2015-17) has indicated reduced yield with early May planting.

Planting day of the year vs yield in bushel per acre 2014-2017 (1023 fields)



1 May = 121st day of the year.
4 June = 155th day of the year.

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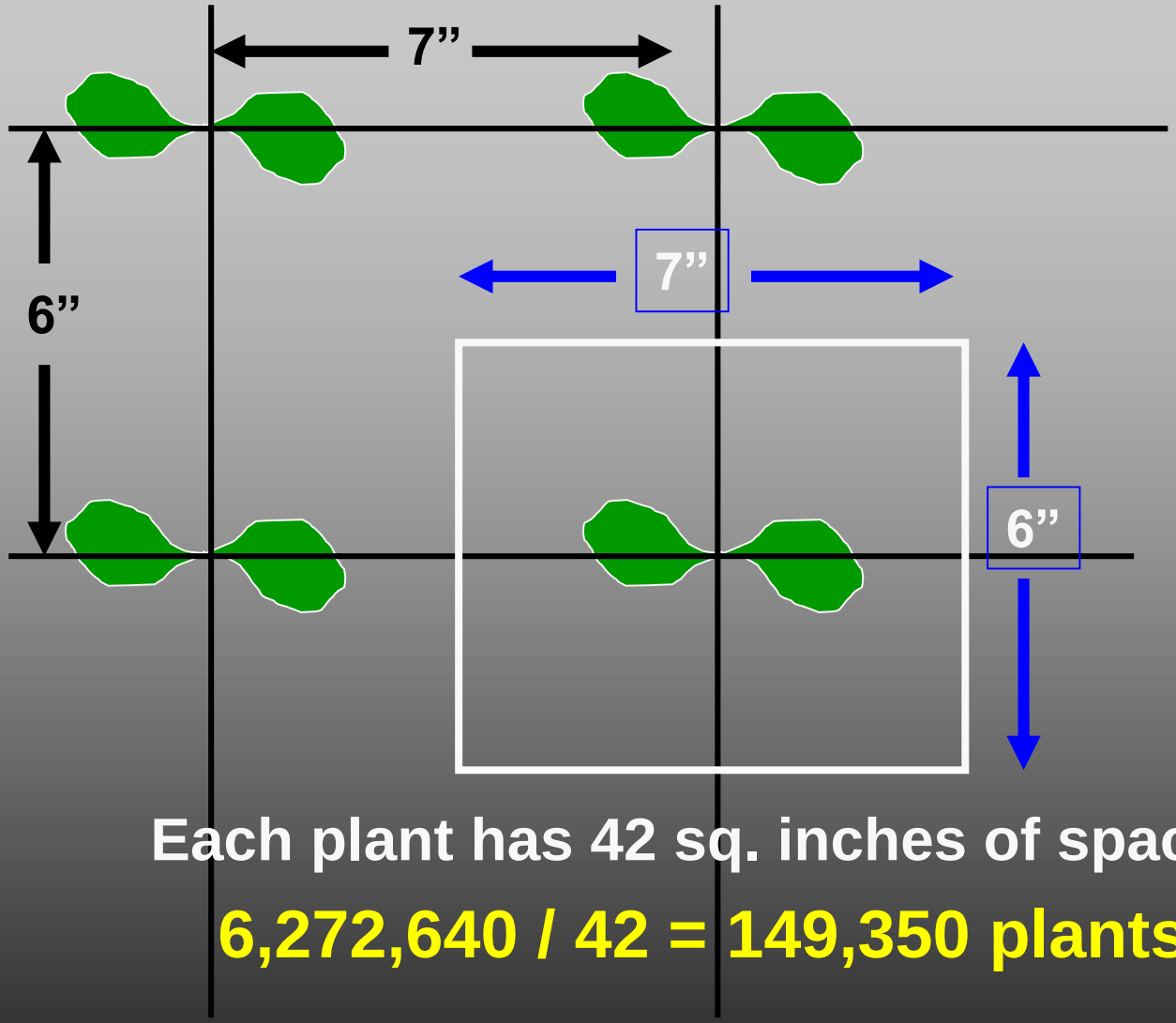
NDSU recommends an established soybean stand of 150,000 plants/acre for any row spacing.

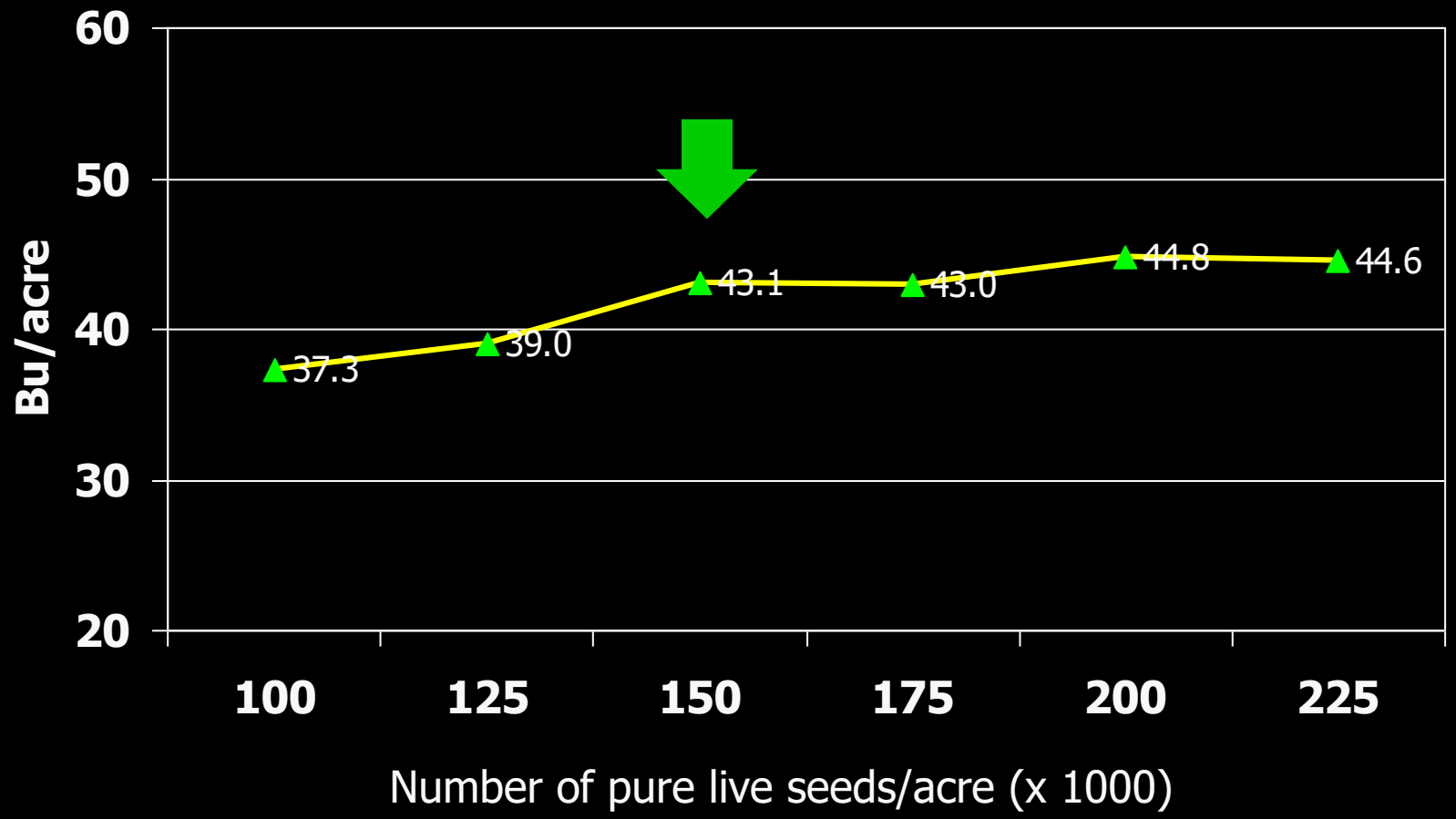
- Unlikely yield impact with variance of -10 to -12%



Each plant has 42 sq. inches of space:

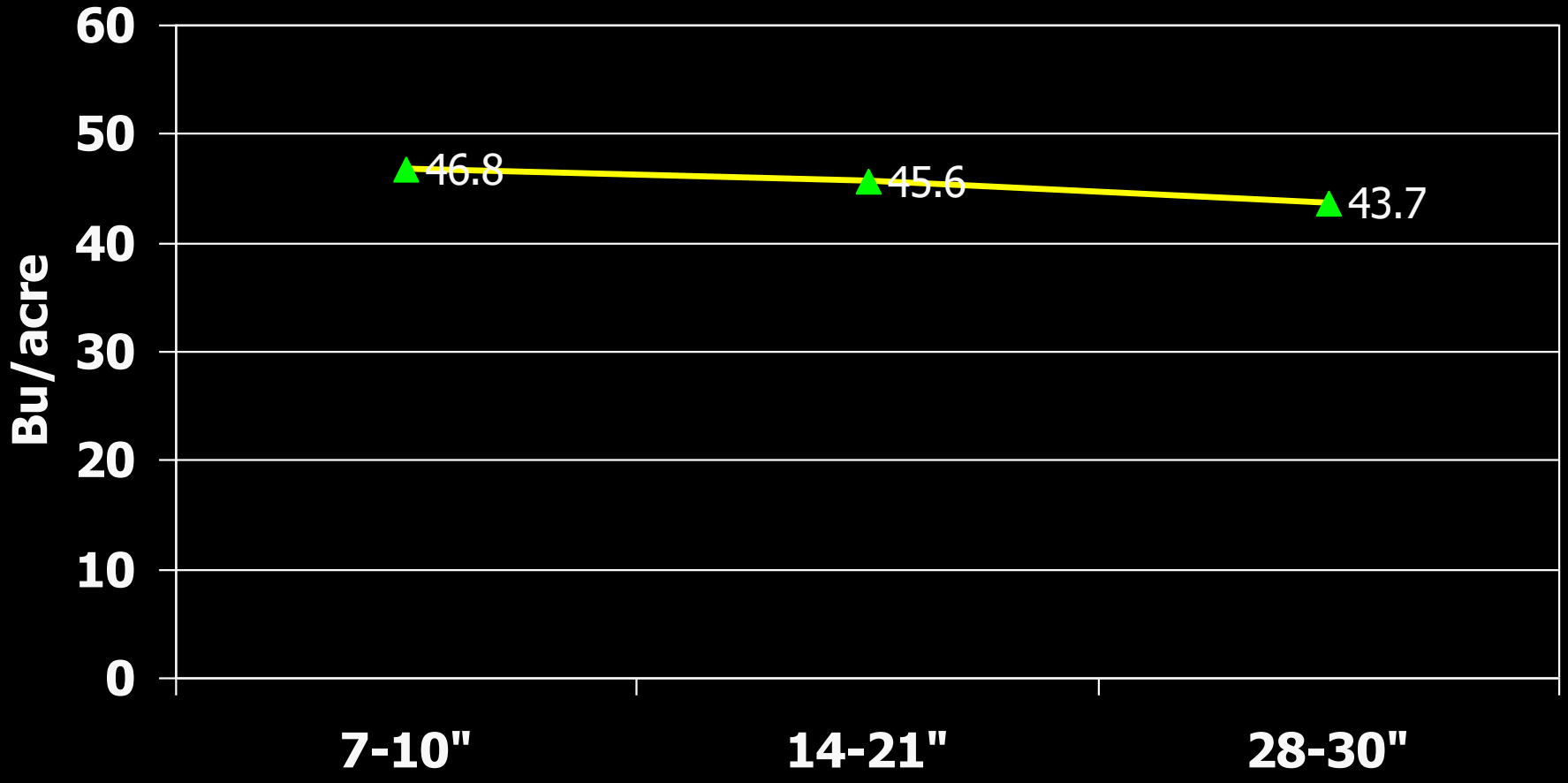
6,272,640 / 42 = 149,350 plants/A

Planting rate influence on soybean yield, five north-central ND trials*, 2015



*Garrison, Minot, Mohall, Rugby and Wilton; Eric Eriksmoen, North Central REC (Minot)

Row spacing influence on soybean yield, Minot, Carrington and Oakes, 1999-2016 (8 site-years)



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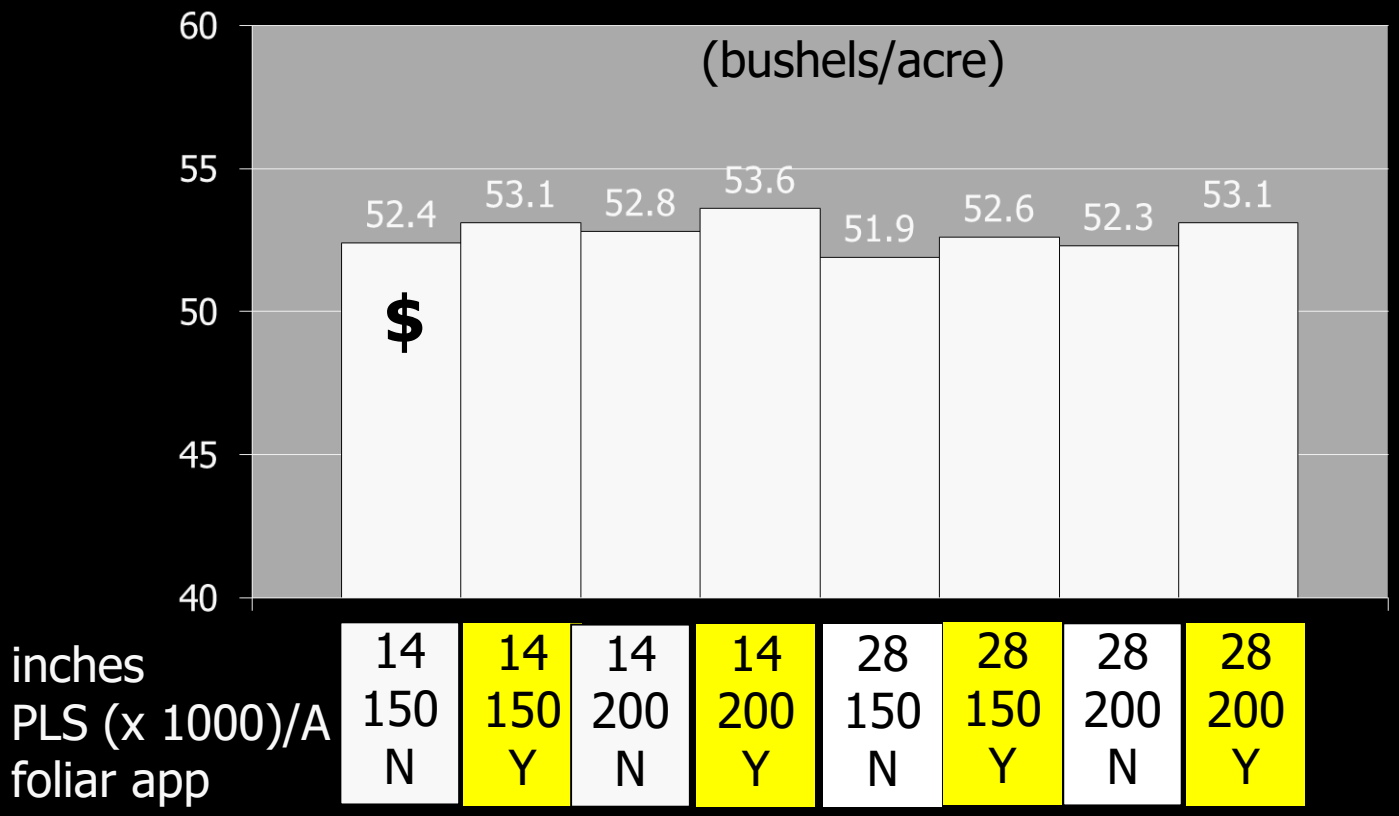
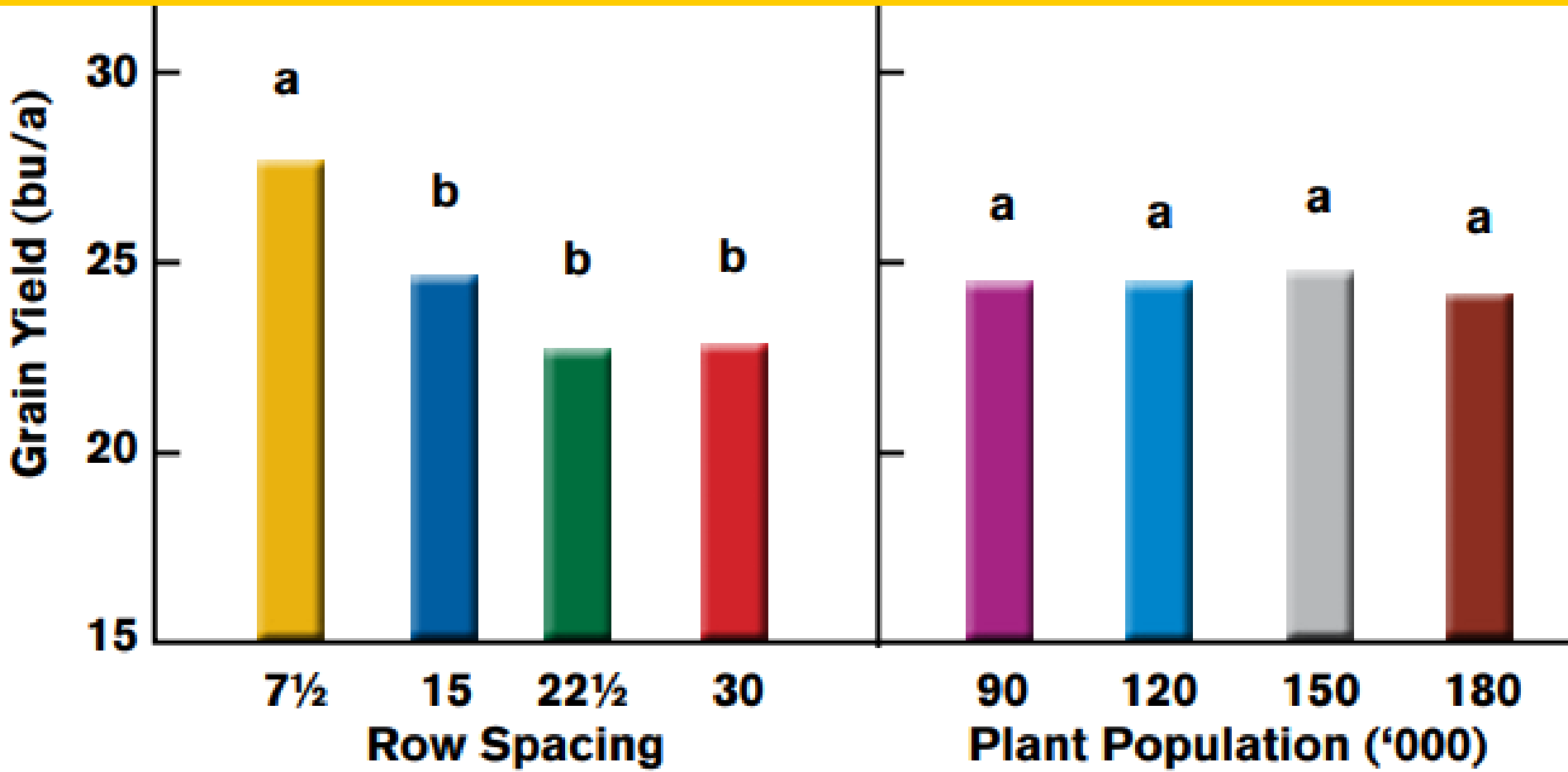
Soybean intensive mgmt study, Carrington and Cass County, 2008-11 (8 site-yr):
SEED YIELD and HIGHEST NET RETURN with row spacing, planting rate and foliar inputs.



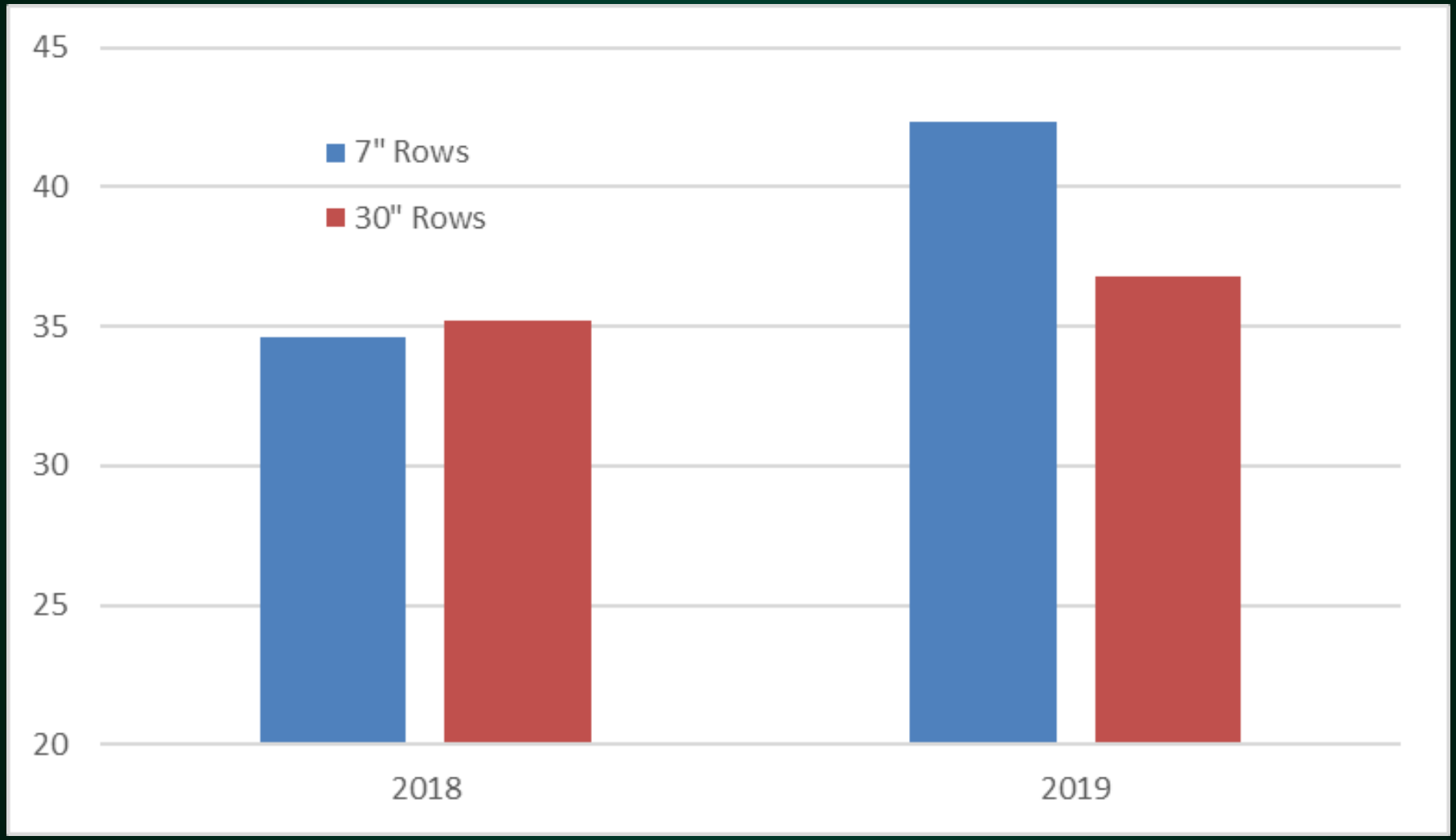
Endres, Kandel et al.

Soybean row spacing X planting rate, Williston, 2017



Drs. G. Pradhan, J, Bergman and J. Staricka

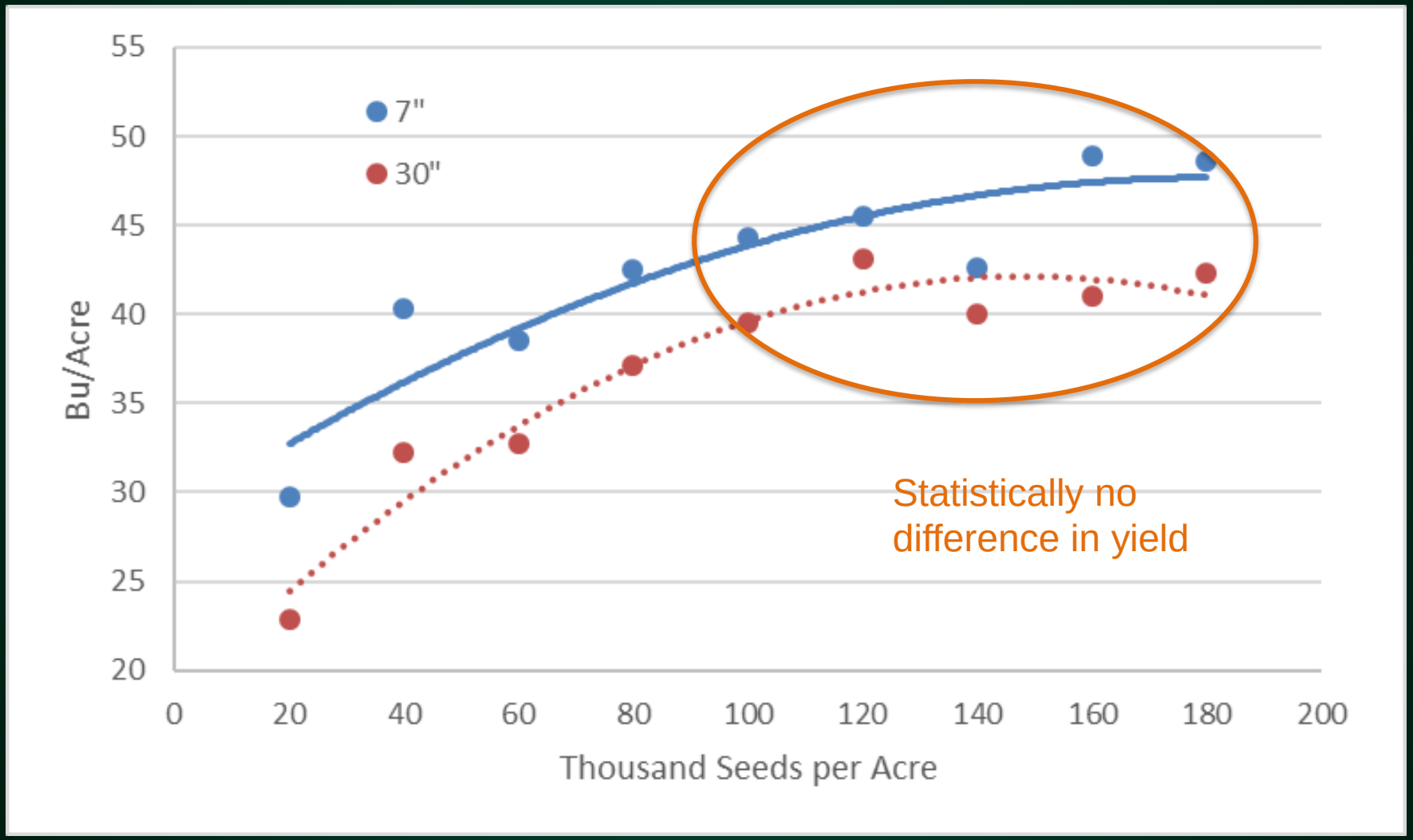
Soybean row spacing X planting rate study, Hettinger, 2018-19



NDSU NORTH DAKOTA STATE UNIVERSITY

J. Rickertsen et al.

Soybean row spacing X planting rate study, Hettinger, 2019



NDSU NORTH DAKOTA STATE UNIVERSITY

J. Rickertsen et al.

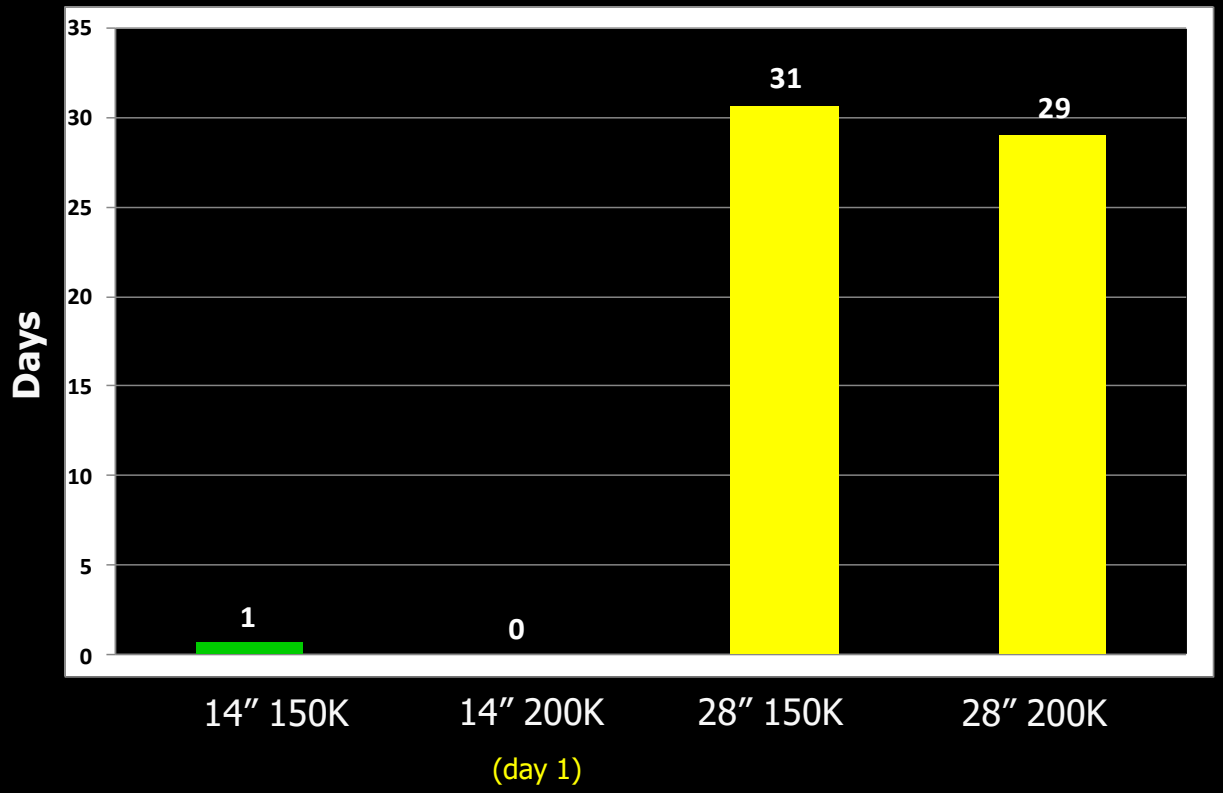
What are free farming inputs?

"Farmers and ranchers…take sunlight, water, and carbon dioxide and make into products they sell."

Dwayne Beck, South Dakota State University

Challenge:
Field canopy closure by first flower (R1 stage)

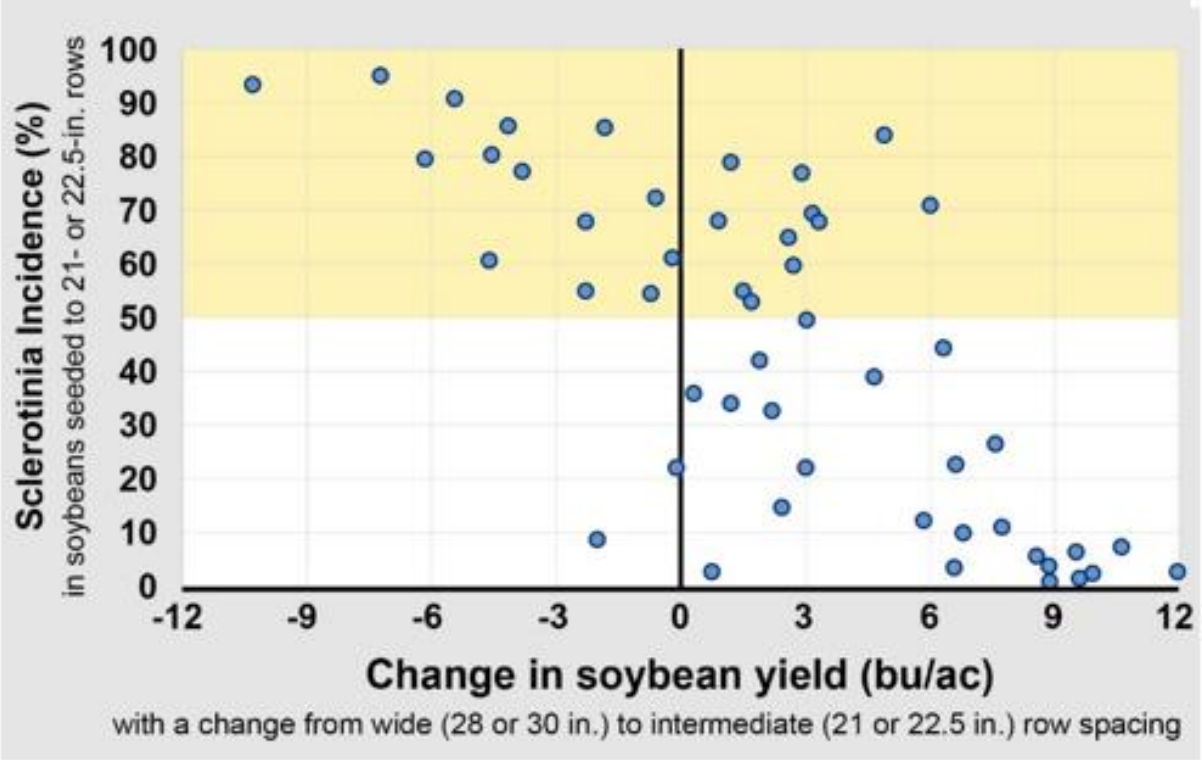
Soybean intensive mgmt study, Carrington and Cass County, 2008-10 (3 site-yr):
CANOPY CLOSURE with row spacing and planting rate.



Endres, Kandel et al.

How much white mold needs to be present for wide rows to have a yield advantage over narrow rows?

Figure 2. Impact of row spacing on soybean yield in soybeans grown under Sclerotinia disease pressure. *Each dot represents a soybean variety tested at one location in one year.*



M. Wunsch, CREC plant pathologist

Soybean Growth Stages

Vegetative

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- VC (cotyledon stage)
- V1 (first trifoliate)
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- R2 (full bloom)
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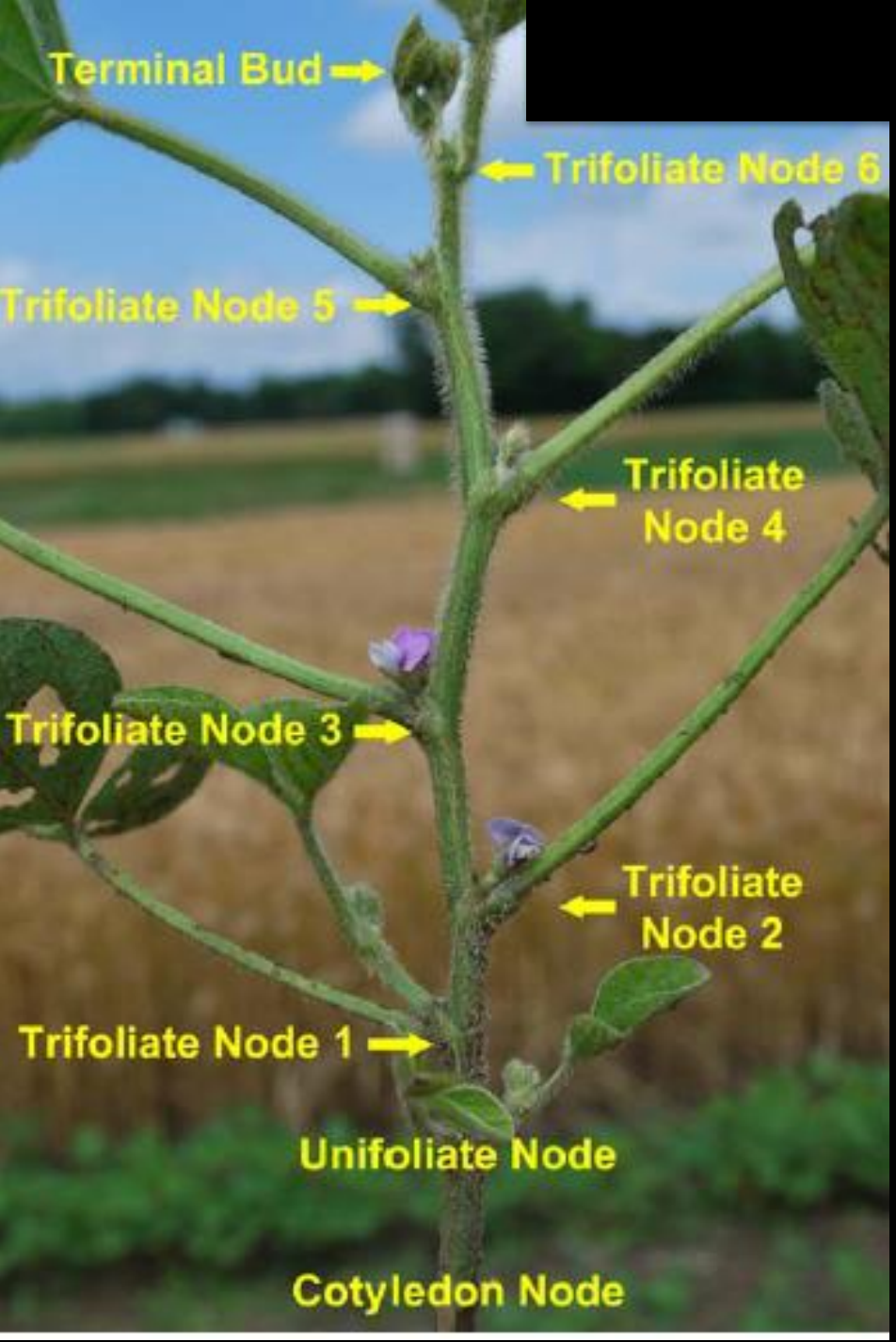
- R4 (full pod)
- R5 (seed filling)
- R6 (full size seed)
- R7 (beginning maturity)
- R8 (full maturity)



1. Beginning Bloom (R1)

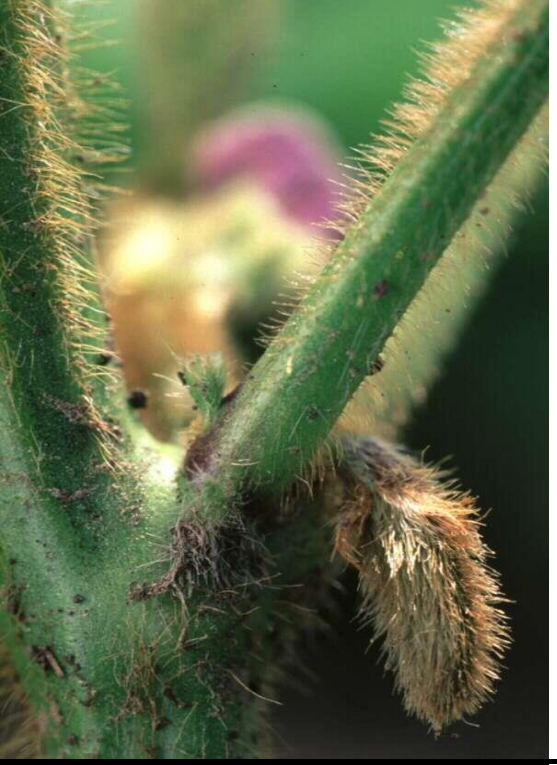
At least one flower is on the plant at any node on the main stem. Soybean **flowering always initiates on the third to sixth node** on the main stem, depending on vegetative stage when flowering begins. This flower initiation will progress up and down the plant. Branches eventually also flower. Within 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 to R5, as are secondary roots and root hairs nearer the soil surface.

2. Full Bloom (R2)

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 percent of its total dry weight and nutrients** and has obtained about **50 percent of its mature height**. About 50 percent of the total mature node number has been established. Very rapid nitrogen (N), phosphorus (P), potassium (K) and dry-matter accumulation is occurring and will continue through R6.

The appearance of new flowers on the plant begins to slow between R2.5 and 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 percent at this stage will reduce yield by 6 percent.**



3. Beginning Pod (R3)

A pod on the upper four nodes is 3/16 inch long. Temperature or drought **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 numbers per plant at this time. Because **60 to 75 percent of most flowers typically abort** on soybeans, any stress that increases this abortion will influence yield greatly. Half of most flowers are lost before pods begin developing and loss of the other half is due to pod abortion. However, the long flowering period of soybeans is one reason the 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. The dry weight of pods is increased greatly from R4 to R5. The plant has a pod at this stage that is at least 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 to 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 percent at this stage will reduce yields by 80 percent; the plant is less able to compensate from stress and vegetative damage. Stress can lower yields by reducing pod numbers and the number of beans per pod, and to a lesser extent, by reducing seed size.

This stage has seed at least 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.

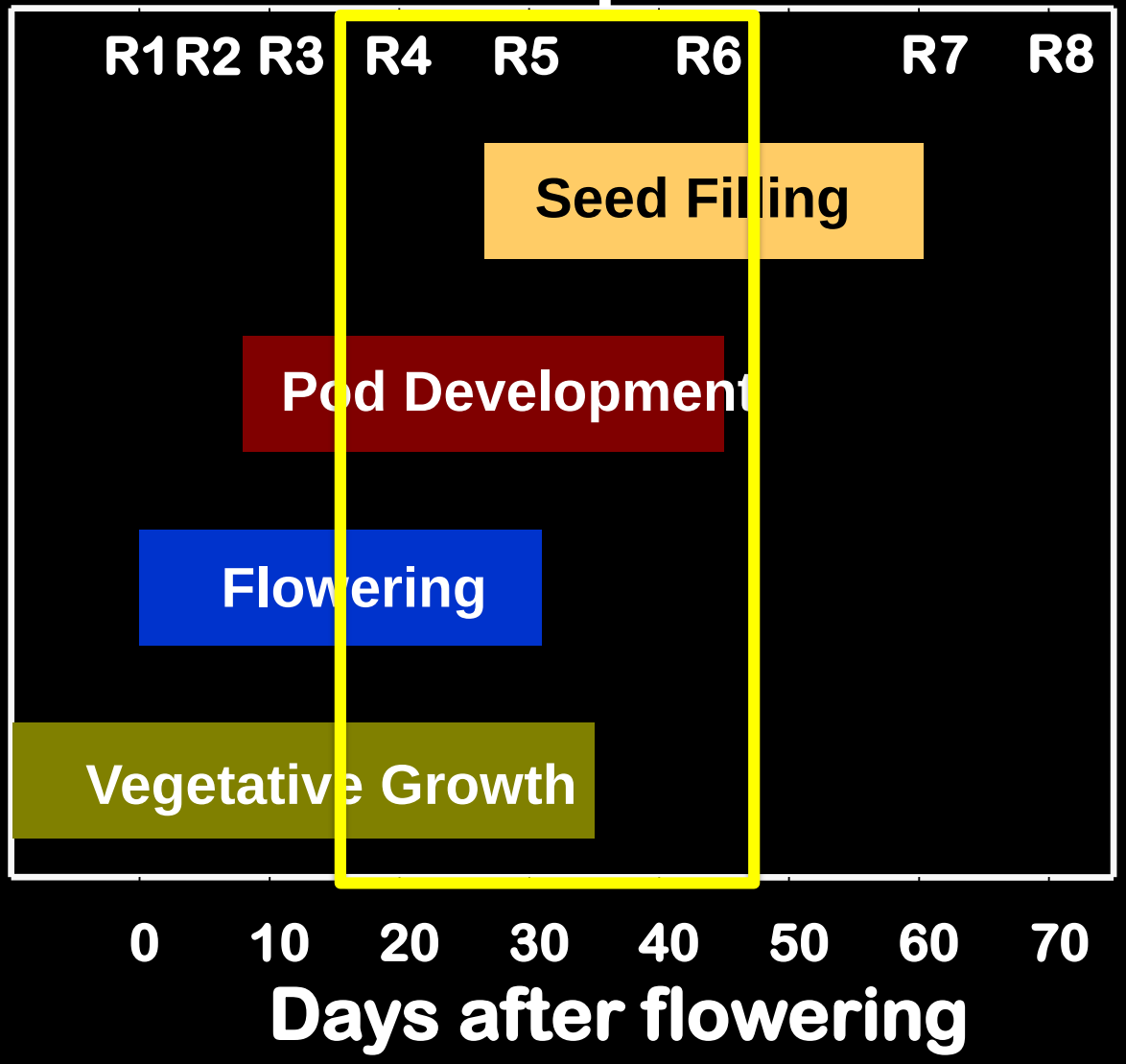
Seed accumulation will continue until shortly after R6.5, with about 80 percent of total seed dry weight being accomplished.

6. Full Seed (R6)

This stage also is known as the "green bean" stage or beginning full-seed stage, and total pod weight will peak during this stage. The 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 about R6.5.**

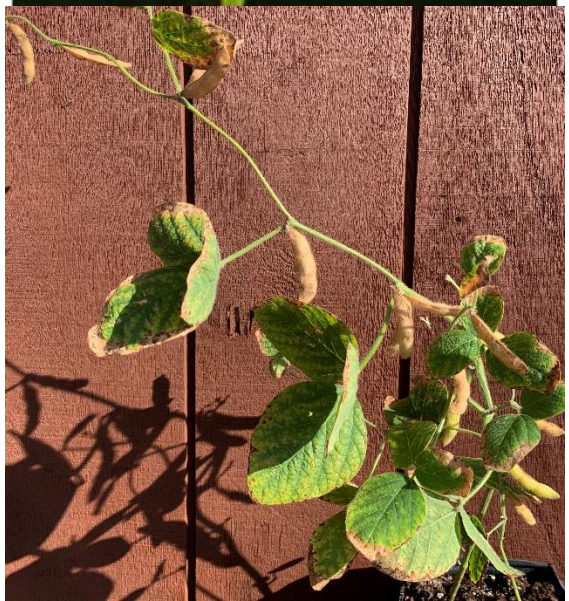
Soybean Reproductive Development



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 visible when all the green is lost from the seeds and pods (they appear yellow).

Seeds contain about 35 percent 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 percent 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 percent 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 percent or less moisture. When harvesting, leave short stubble to ensure a full harvest. **A 3½-inch stubble still leaves 5 percent or more of the crop and a 6½-inch stubble, 12 percent or more.**

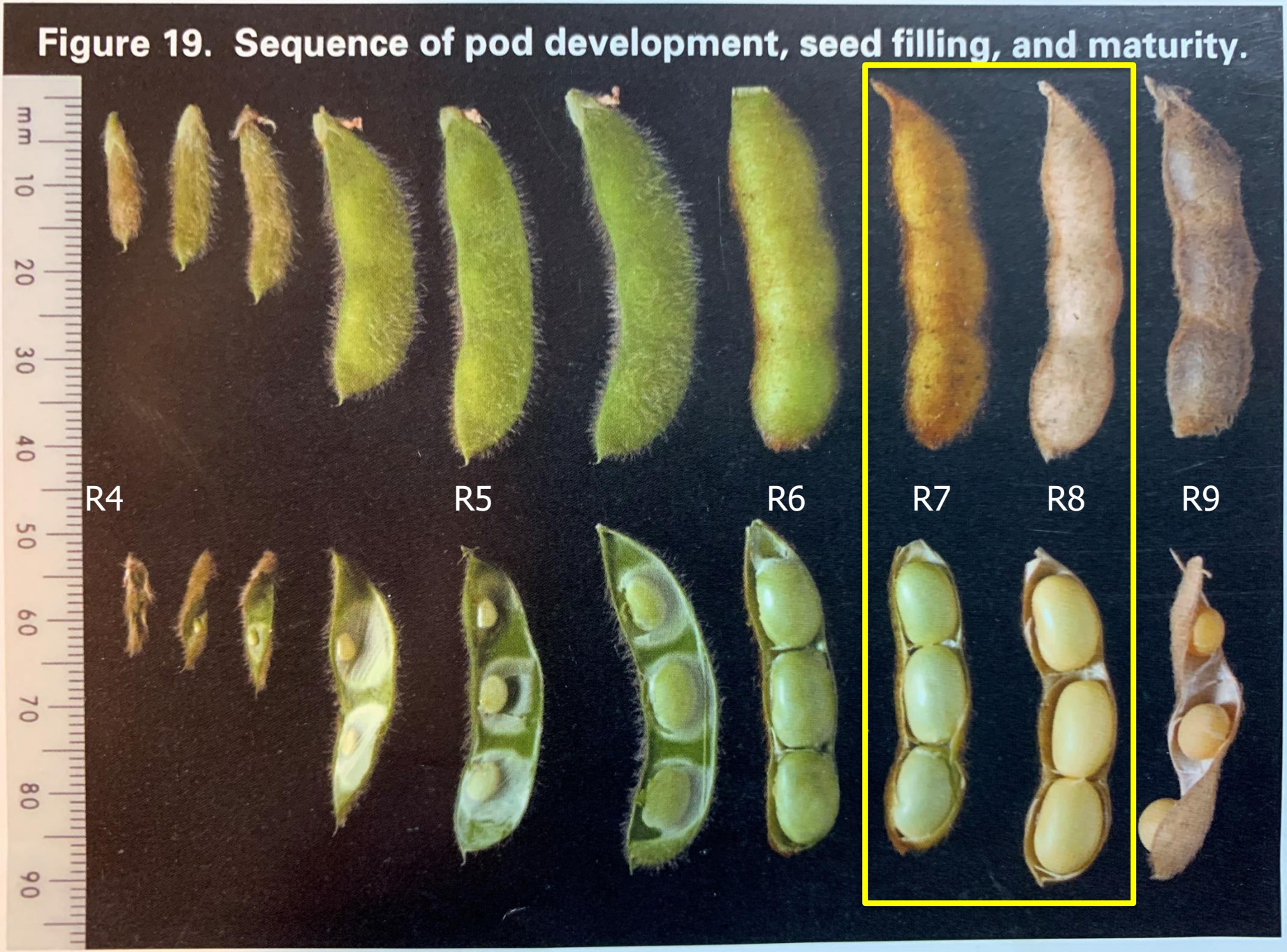


Figure 19. Sequence of pod development, seed filling, and maturity.
mm
10
20
30
40
50
60
70
80
90
R4
R5
R6
R7
R8
R9

Soybean summary

- Do your homework on variety selection
- Cover crop options available
- Timely plant in narrow rows targeting the establishment of 150,000 plants/acre
- Know growth stages and associated plant biology = opportunities for intensive management