



# Nitrogen and Soybeans

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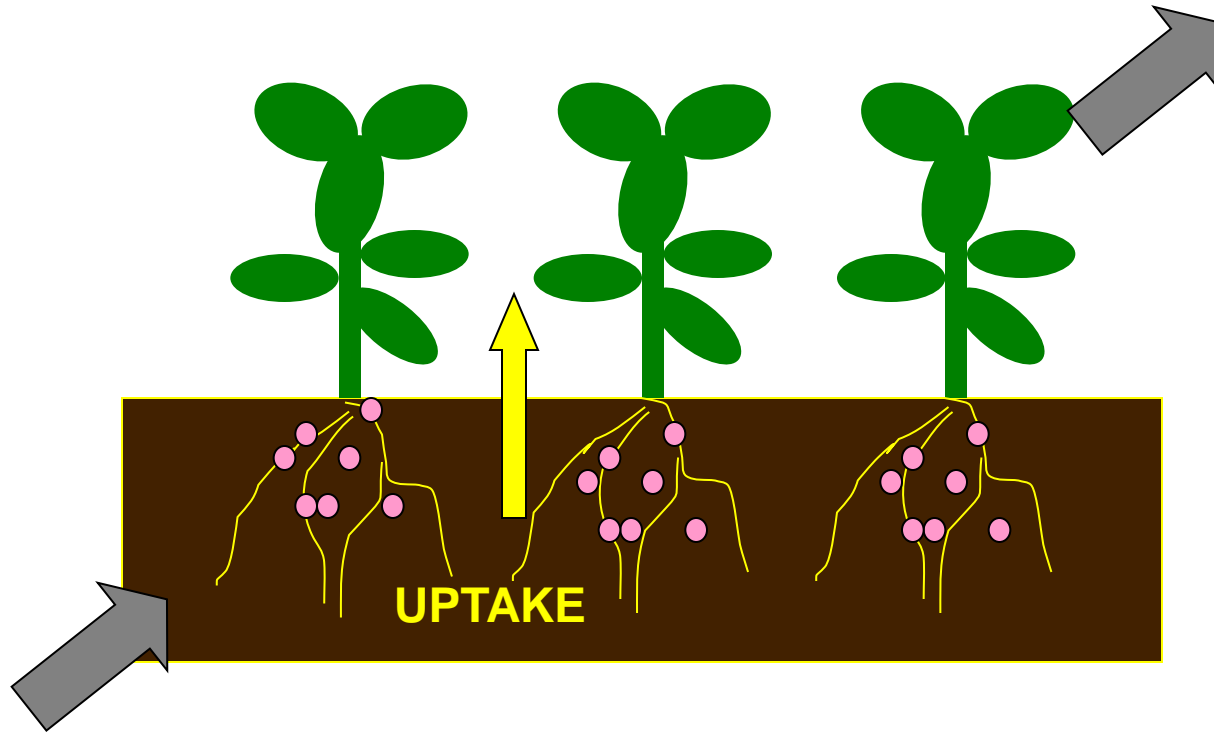
# Outline

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- Nitrogen budget of soybean field
- Review of nitrogen and soybean research
  - List of review papers on last slide
- Updates to the “soybean N credit”

# Nitrogen Budget

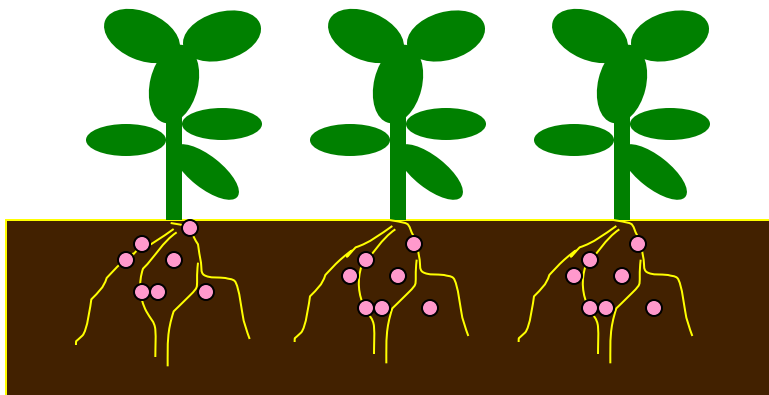
OUTPUT



INPUT

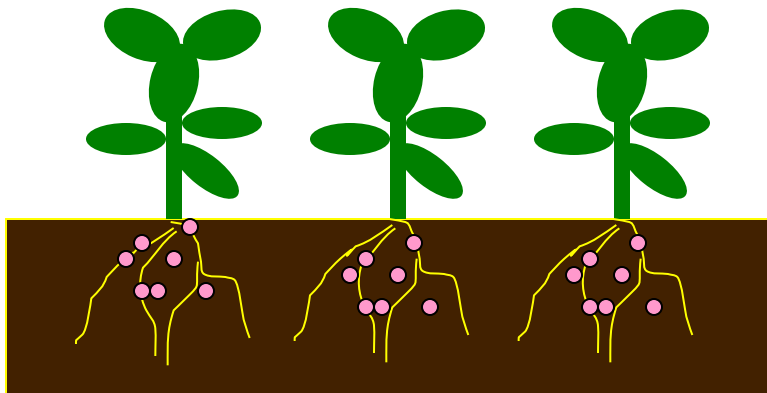
# Nitrogen budget of soybean field

- Output = N content of grain
- Review of 57 studies (Salvagotti et al., 2008):
  - Average yield = 40 bu/ac
  - N concentration of grain = 6.34%
  - 3.8 lb of N is removed with 1 bu of yield



# Nitrogen budget of soybean field

- Input = Biological N fixation
- Symbiotic relationship between bacteria (*Bradyrhizobium*) and plant



Nodules house  
the bacteria

# Nodulation process

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- Bacteria infect root hairs
- First nodules form 1 week after planting
- Active N<sub>2</sub> fixation begins @V2-V3
- Highest N<sub>2</sub> fixation occurs R5/R6
- Soybeans can regulate this process – lack of available nitrogen triggers the nodulation process

# N<sub>2</sub> fixation is not a free lunch!

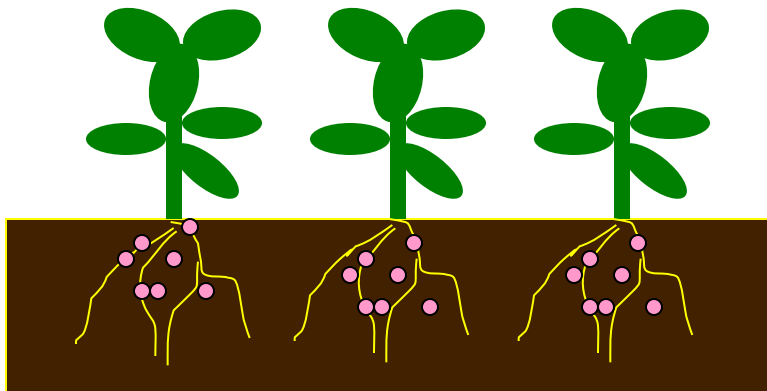
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- Requires energy
- $\text{N}_2 + 3\text{H}_2 + \text{energy} = 2\text{NH}_3$
- Microbes obtain this energy from carbohydrates
- Photosynthetically-derived carbohydrates from plant
- Thus, it is more energy efficient to take up available soil nitrogen from organic matter, manure, or fertilizer application

# Nitrogen budget of soybean field

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- Uptake = Plant available nitrogen in the soil + biological N fixation
- 58% of total N uptake comes from N<sub>2</sub> fixation (36 to 74%; Salvagotti et al., 2008)
- 5 lb of uptake per 1 bu yield

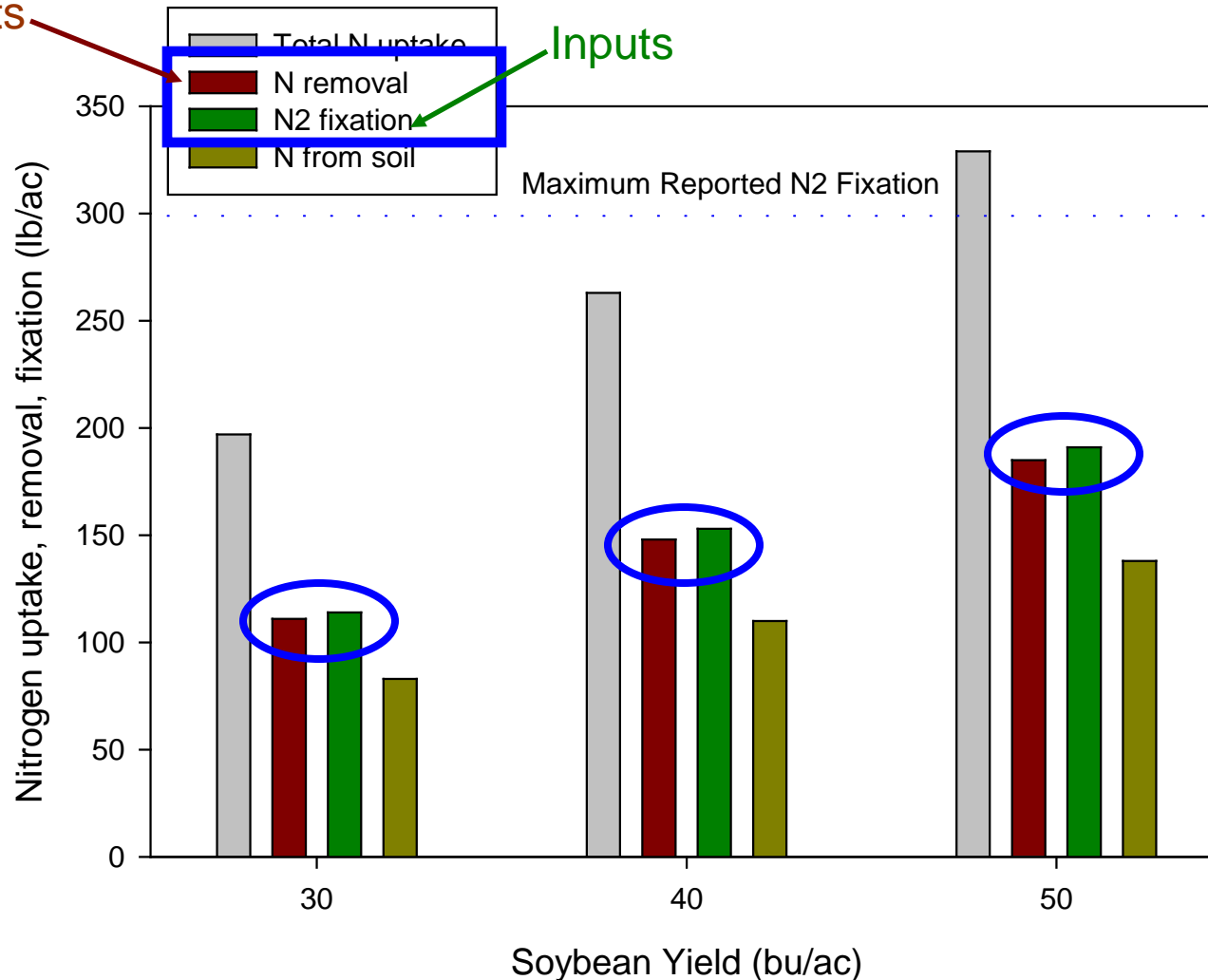




# N Budget in Soybean Field

Outputs

Inputs

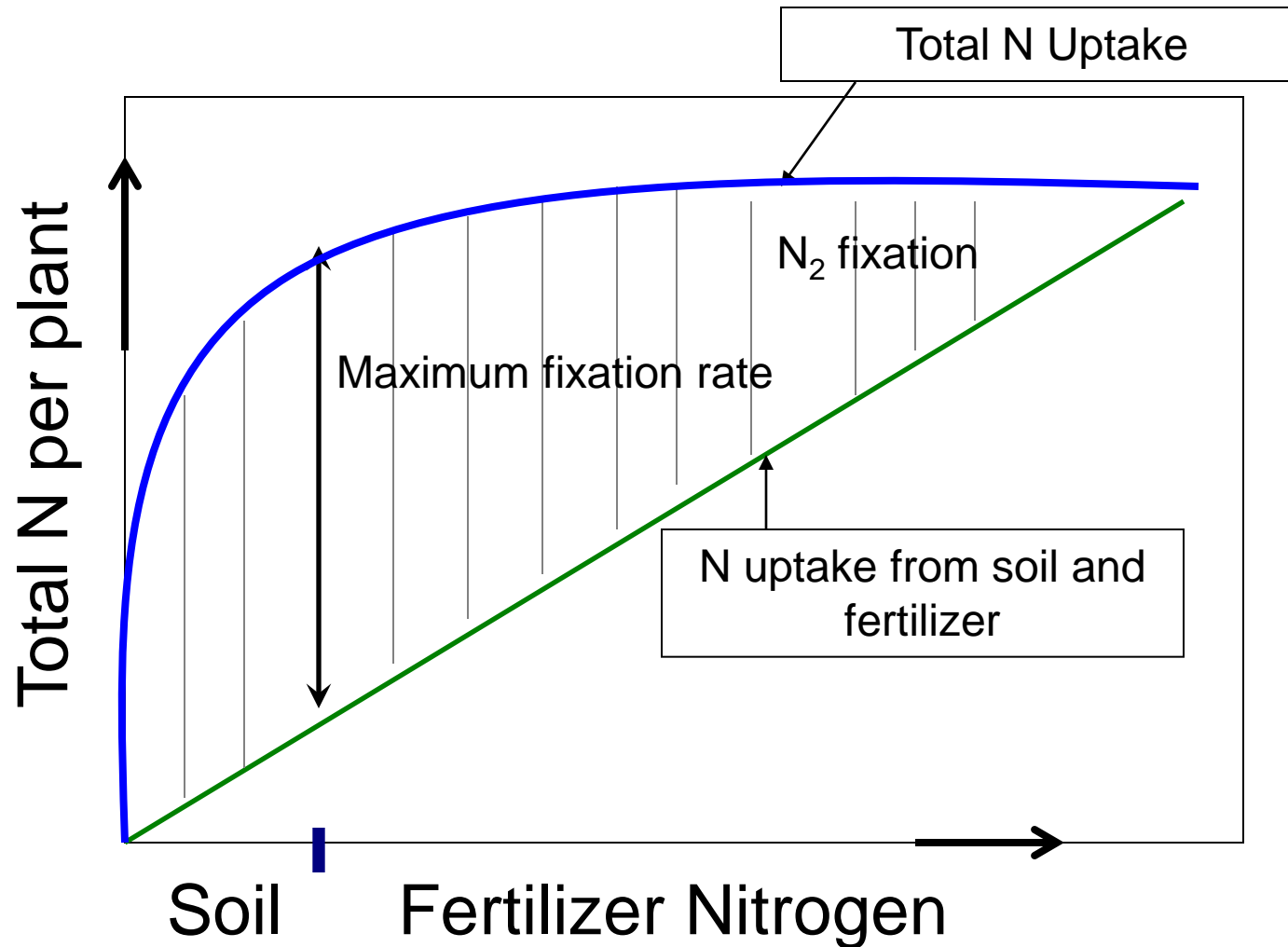


# Nitrogen budget of soybean field

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- Soybean phase of rotation is N neutral (inputs=outputs)
- Are there any benefits to N fertilizer application?

# Fertilizer N vs. N fixation



# Fertilizing soybean with N

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Overall consensus:



- Applying N can delay nodulation, reduce the amount of  $N_2$  fixation, or both
- Has been shown to be beneficial in very specific circumstances

# Fertilizing soybean with N

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Potential options:

- Preplant
- Early season “yellowing”
- During high N demand stage
- Manure applications

# Preplant N application

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- This is an attempt to boost early season soybean growth before nodulation develops



# Preplant N application

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- **No clear benefit on most soils**
- Research conducted in MN, IA, and WI does not suggest this is a beneficial strategy
- Potential benefit: when soil has low ability to provide N in early season (low residual N, low soil organic matter)
- No such scenarios have been identified in WI





# Early season yellowing

The Soy Report: <http://thesoyreport.blogspot.com/2009/06/yellow-soybeans-and-nitrogen-fixation.html>

**N application would only further delay  
nodulation –  
Some level of N stress is required for  
symbiotic relationship to fully develop**



# In-season application

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- Results in MN, SD, IA, and IL do not suggest that this is a recommended practice for this region
- Small percentage of studies show yield increase
- This yield increase is rarely economic



# In season application

- Potential benefit seen in irrigated soybeans (Kansas, Nebraska)
- High yield potential ( $> 65$  bu/ac)
- Extra N supplements during high N demand periods



Replaces some of this

Supplements some of this

Yield	Total N uptake	N <sub>2</sub> fixation	N from soil
bu/ac		lb/ac	
70	460	267	193

# Manure application

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- Studies in IA – yield increase of 0 to 7 bu/ac
- Studies in MN – yield decrease of -3 to increase of 9 bu/ac

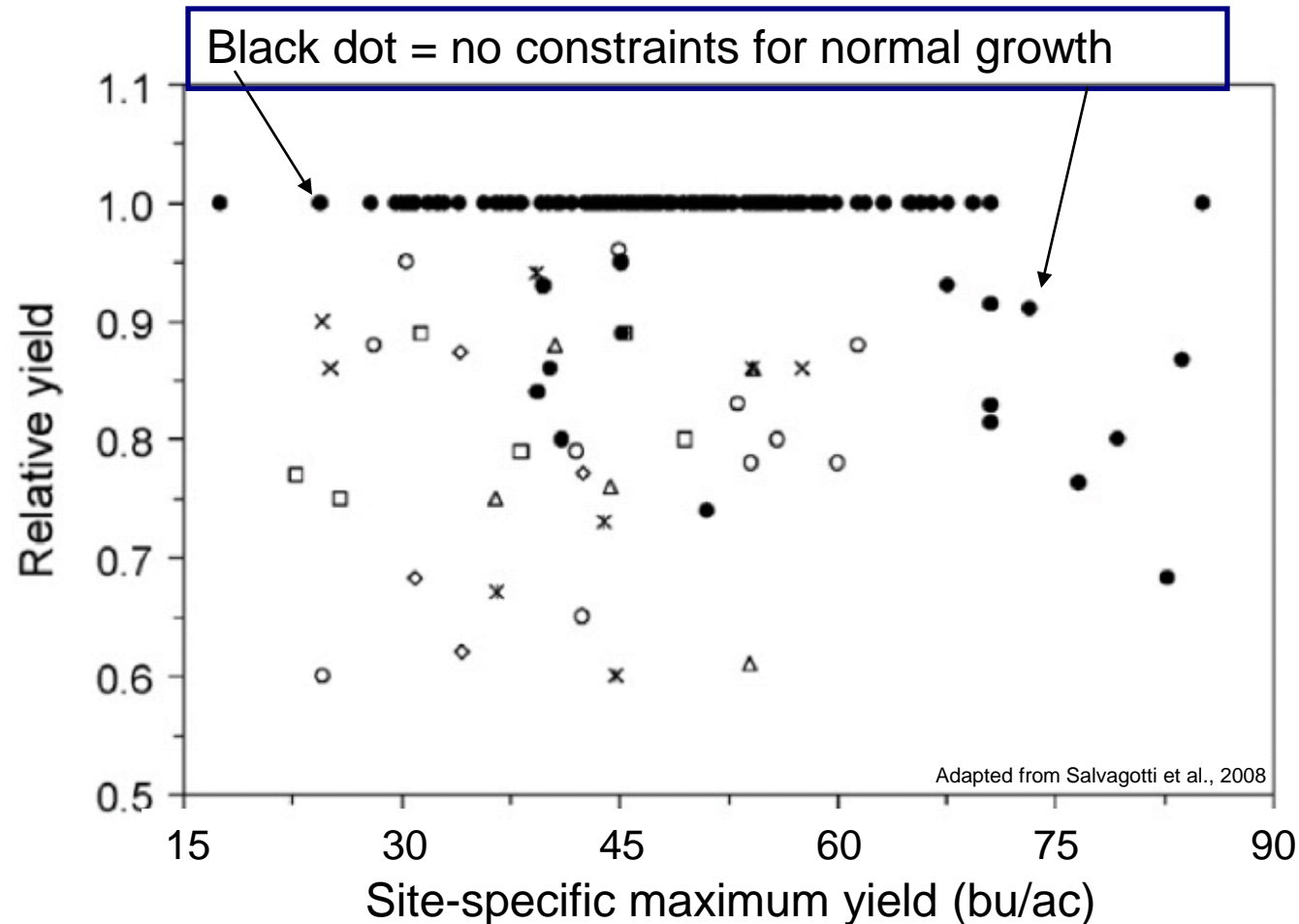


# Manure application

- Unclear what causes yield increase
  - ? Slow-release of ammonium from manure from mineralization
  - ? Lower negative impact on  $N_2$  fixation reduction
- N application as manure does not appear to decrease yields
- Yield decrease attributed to incidence of white mold
- Other precautions:
  - salt injury to seed if manure applied near seed
  - enhancement of soybean disease – should be avoided in fields with history of white mold or damping off diseases



# Constraints for soybean production



All other responsive sites had limitations of: environmental stress (low temp, drought) or mismanagement (no inoculation, low pH)

# N fertilization

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- Response to N fertilization is often a result of something else suppressing yields
  - Stress conditions
    - Which you can't control or predict
  - Inoculation and pH
- Proper inoculation and soil testing/lime application are better soybean management practices than N application

# The bottom line...

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- Is it possible to increase yields with fertilizer N additions in WI – yes
- Is it possible to increase net profits with fertilizer N additions in WI – not really
- **No nitrogen source, rate, timing, or application method consistently improves productivity in soybeans**

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# Soybean N “credit”

If the soybean crop is N neutral (inputs=outputs), how can there be a credit?



# No longer a credit



## University of Wisconsin Nitrogen Guidelines for Corn

N:Corn Price Ratio (see table on other side)

Soil <sup>1</sup>	Previous Crop	lbs N/acre (total to apply) <sup>2</sup>			
		0.05	0.10	0.15	0.20
high/very high yield potential soils	Corn, Forage legumes, Legume vegetables, Green manures <sup>5</sup>	165 <sup>3</sup> 135-----190 <sup>4</sup>	135 120-----155	120 100-----135	105 90-----120
	Soybean, Small grains <sup>6</sup>	140 110-----160	115 100-----130	100 85-----115	90 70-----100
medium/low yield potential soils	Corn, Forage legumes, Legume vegetables, Green manures <sup>5</sup>	120 100-----140	105 90-----120	95 85-----110	90 80-----100
	Soybean, Small grains <sup>6</sup>	90 75-----110	60 45-----70	50 40-----60	45 35-----55
sands/ loamy sands	Irrigated—All crops <sup>5</sup>	215 200-----230	205 190-----220	195 180-----210	190 175-----200
	Non-irrigated—All crops <sup>5</sup>	120 100-----140	105 90-----120	95 85-----110	90 80-----100

Corn following soybeans has its own N recommendation, established independently of corn following corn N recommendations

# It is a rotation effect

# Soybean rotation effect

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- Research from Bundy and Schoessow determined that the rotation effect is not based on above ground biomass
- Soybean stubble was removed and had no impact on optimal N fertilizer rate for subsequent corn crop
- Forage legume credits are still based on above ground biomass

# Soybean rotation effect

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## Possible causes:

- Change in N mineralization rate (below ground biomass?)
- Reduction in pest pressure through interruption of pest cycles.
- Enhanced corn root functioning in the year after soybean
- Changes in physical soil properties and moisture availability

# Conclusions

- N application to soybean not recommended
- Manure application to soybean does not negatively impact yield
- New N recommendations for corn were designed specifically for corn-soybean rotations





**Questions?**

**[www.soils.wisc.edu/extension](http://www.soils.wisc.edu/extension)**

**[www.soils.wisc.edu/~ruark](http://www.soils.wisc.edu/~ruark)**

# References

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- Salvagiotti et al. 2008. Nitrogen uptake, fixation and response to fertilizer N in soybean: A review. *Field Crops Res.* 108:1-13 (<http://tiny.cc/soybeanNreview>)
- Kelling, K.E. 2003. Foliar feeding of soybeans. *New Horizons in Soil Science.* Issue #5-2003
- Sawyer, J.E. 2001. Nitrogen fertilizer and swine manure application to soybean. ICMC, Iowa State Univ. [www.agronext.iastate.edu/immag/info/nfertsymanure01.pdf](http://www.agronext.iastate.edu/immag/info/nfertsymanure01.pdf)
- Oplinger and Bundy. 1998. Nitrogen fertilization of soybean – Wisconsin results. WI Fertilizer, Agrilime & Pest Management Conference, Madison, WI
- Bundy, L.G. 1993. Soybean nitrogen needs and credits. *New Horizons in Soil Science.* Issue #4-1993