Nitrogen and Soybeans

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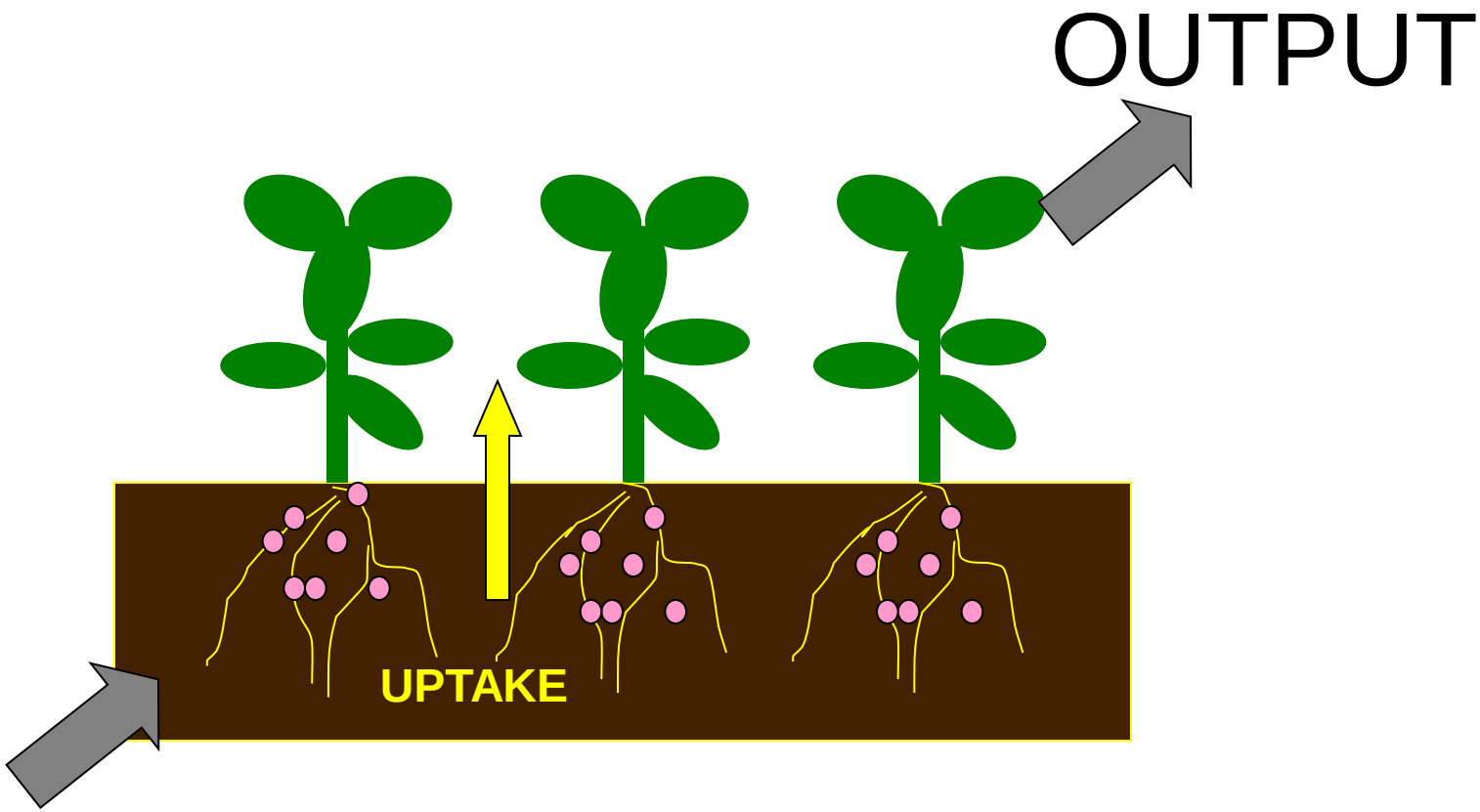
2009 Area Soil, Water, and Nutrient Management Meetings

Outline

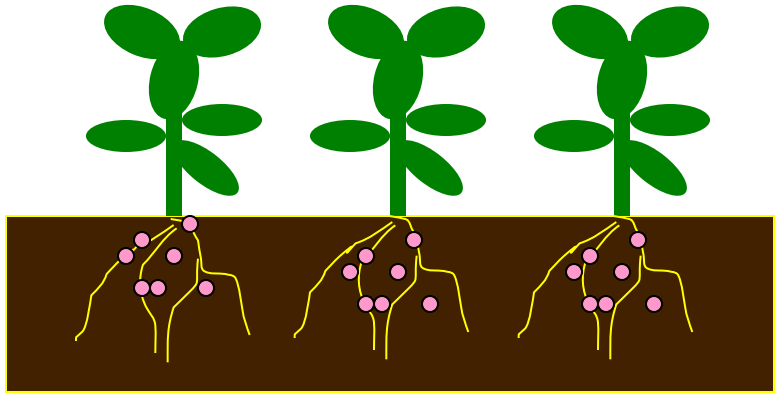
- Nitrogen budget of soybean field
- Review of nitrogen and soybean research
  - List of review papers on last slide
- Updates to the “soybean N credit”

Nitrogen Budget



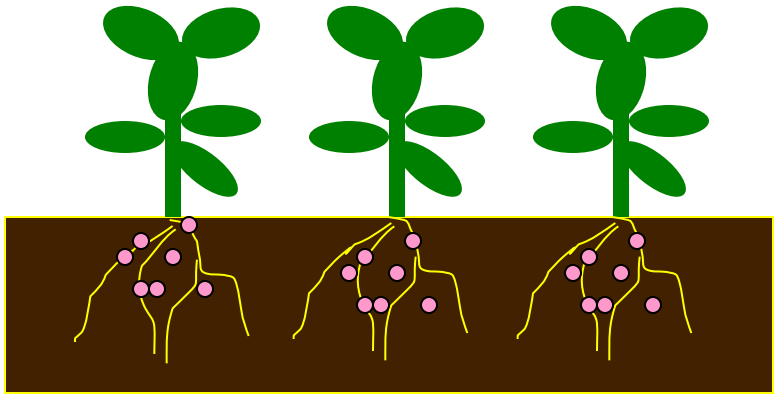
Nitrogen budget of soybean field

- 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



Nodulation process

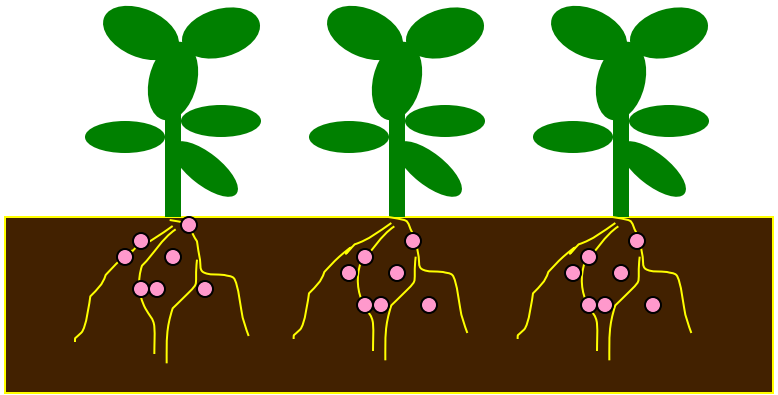
- Bacteria infect root hairs
- First nodules form 1 week after planting
- Active N_2 fixation begins @V2-V3
- Highest N_2 fixation occurs R5/R6
- Soybeans can regulate this process – lack of available nitrogen triggers the nodulation process

N2 fixation is not a free lunch!

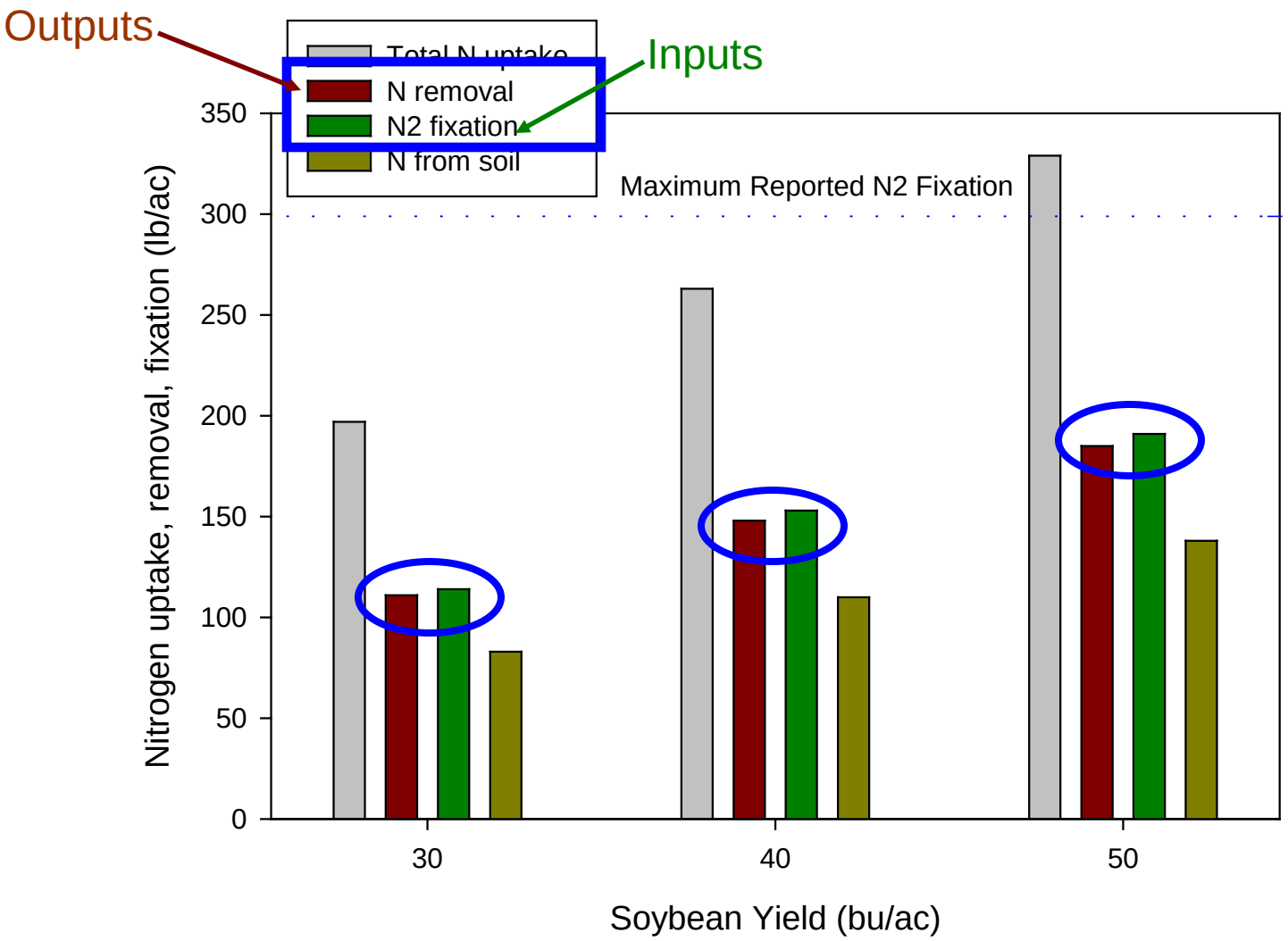
- Requires energy
- $N_2 + 3H_2 + \text{energy} = 2NH_3$
- Microbes obtain this energy from carbohydrates
- Photosynthetically-derived carbohydrates from plant
- Thus, it is more energy efficient to take up available soil nitrogen from organic matter, manure, or fertilizer application

Nitrogen budget of soybean field

- Uptake = Plant available nitrogen in the soil + biological N fixation
- 58% of total N uptake comes from N2 fixation (36 to 74%; Salvagotti et al., 2008)
- 5 lb of uptake per 1 bu yield



N Budget in Soybean Field

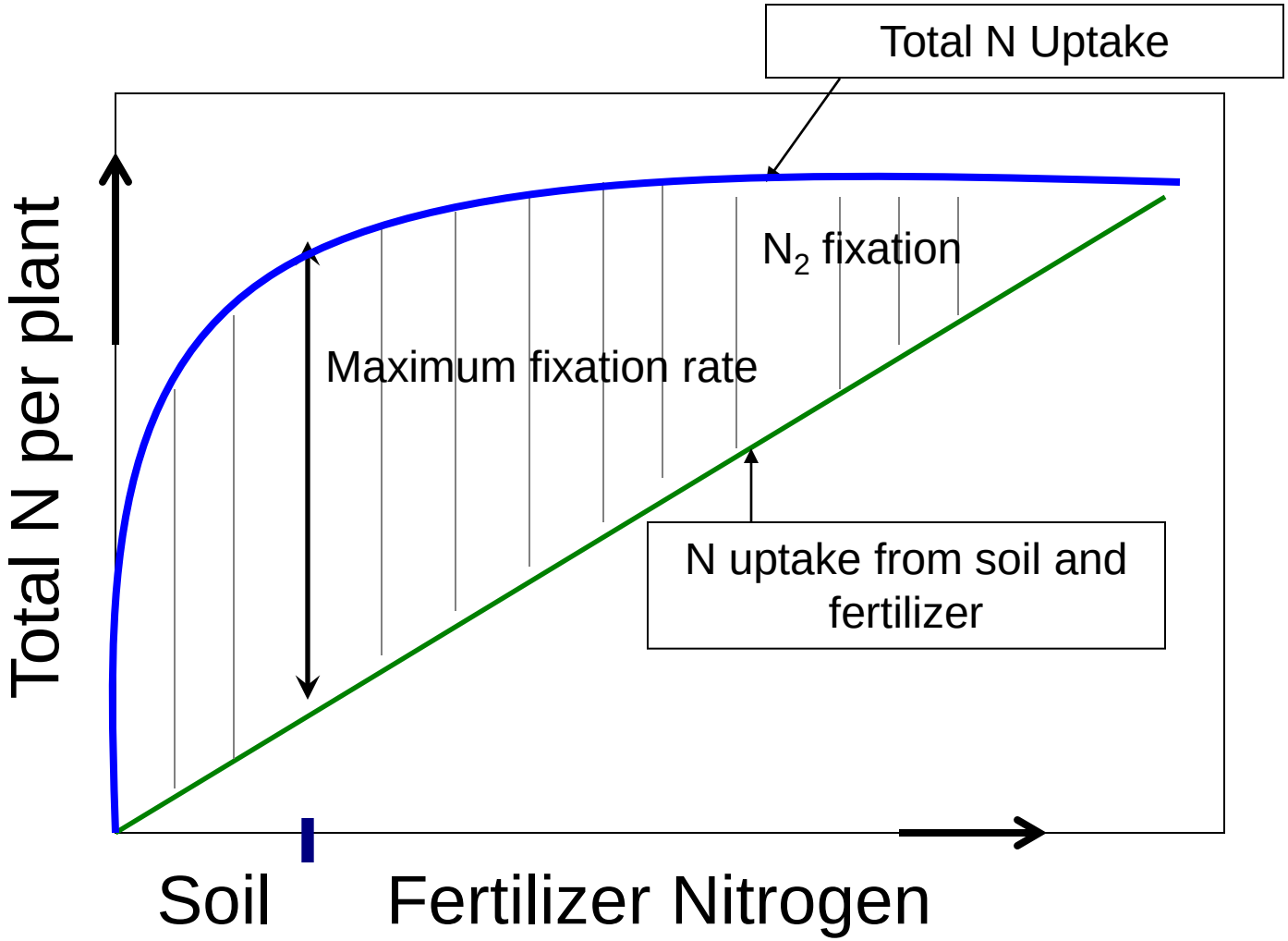


Nitrogen budget of soybean field

- Soybean phase of rotation is N neutral (inputs=outputs)

- Are there any benefits to N fertilizer application?

Fertilizer N vs. N fixation



Adapted from Marshner 1995

Fertilizing soybean with N

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

Potential options:

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

Preplant N application

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

Preplant N application

- **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

- 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	N2 fixation	N from soil
bu/ac		lb/ac	
70	460	267	193

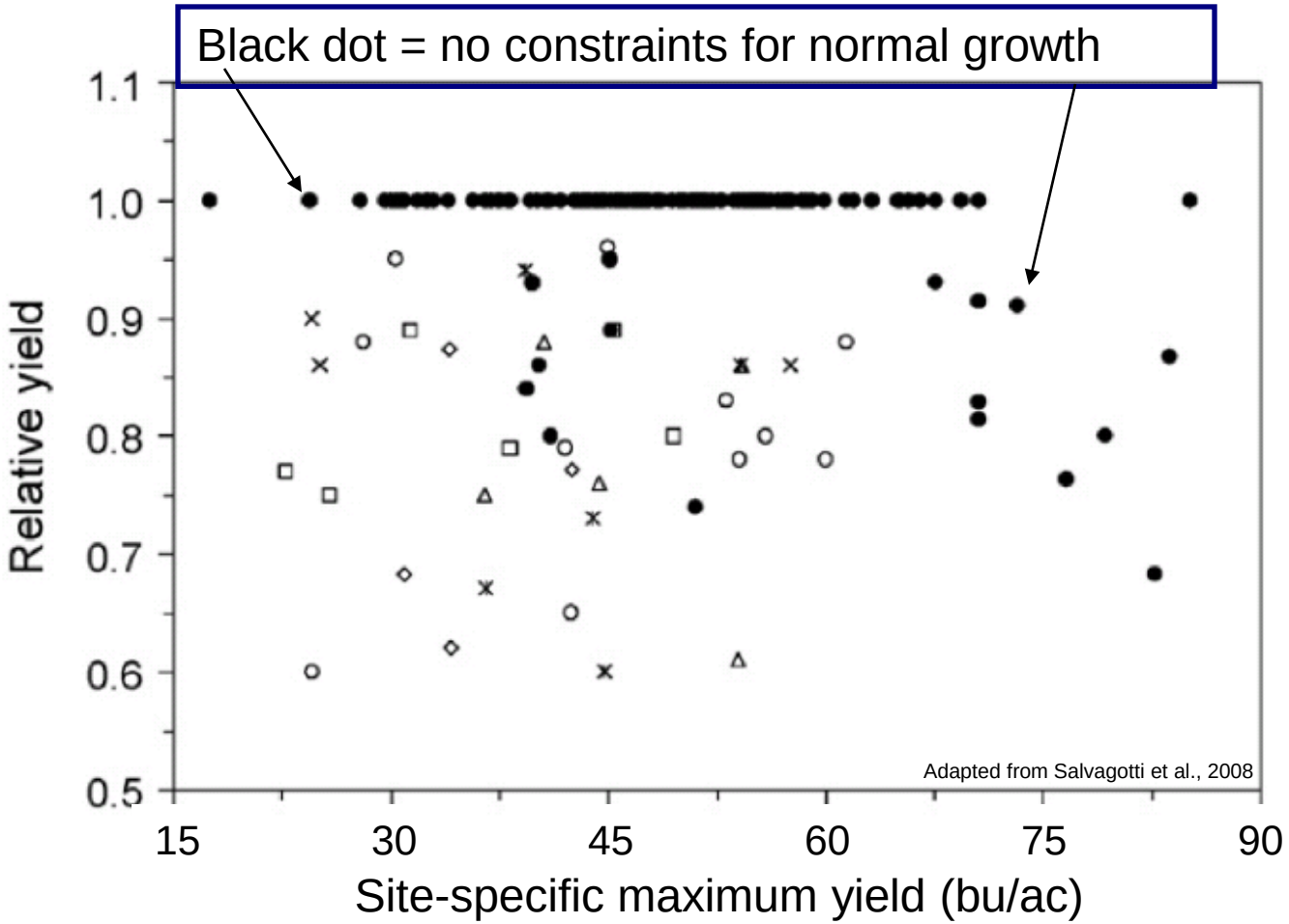
Manure application

- 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

- 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

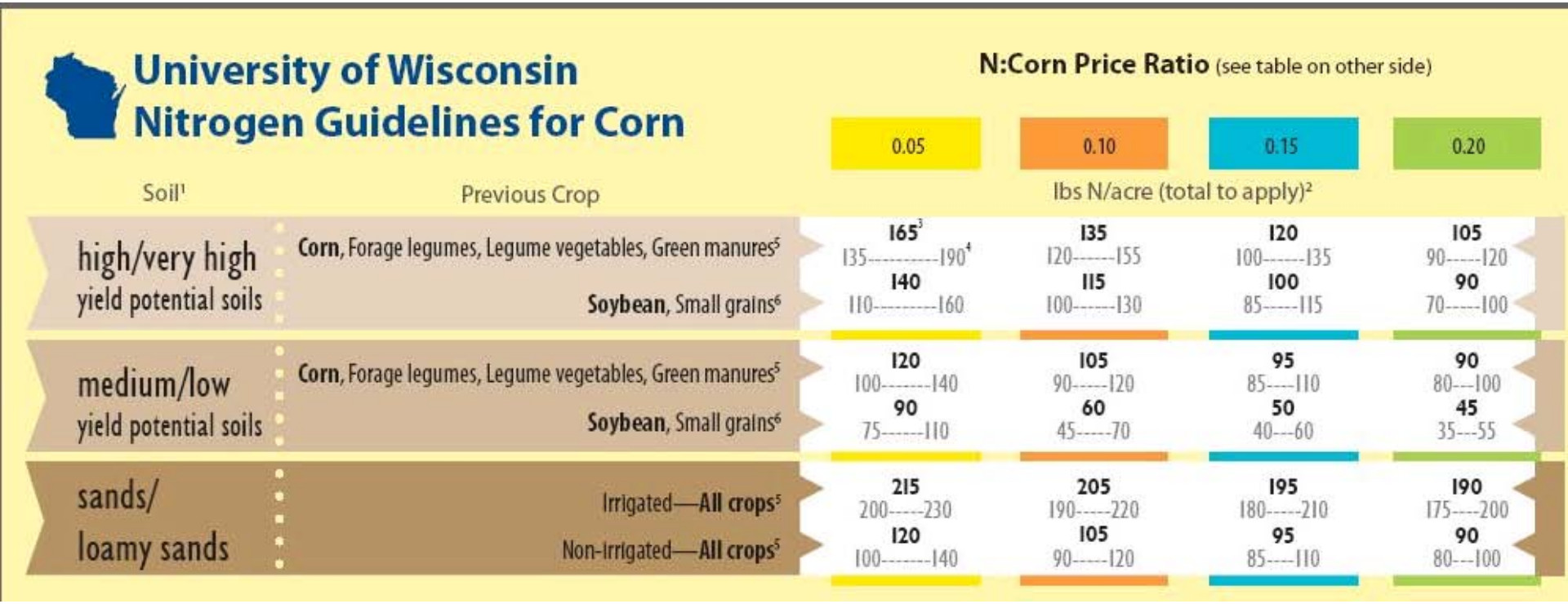
The bottom line...

- 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**

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

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Soybean rotation effect

- 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

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

Soybean N Credits, Cornell Univ., Fact Sheet 30

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
www.soils.wisc.edu/~ruark

References

- 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)
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- Bundy, L.G. 1993. Soybean nitrogen needs and credits. New Horizons in Soil Science. Issue #4-1993