Soybean Nutrient Uptake, Partitioning, and Removal

WI Agribusiness Classic

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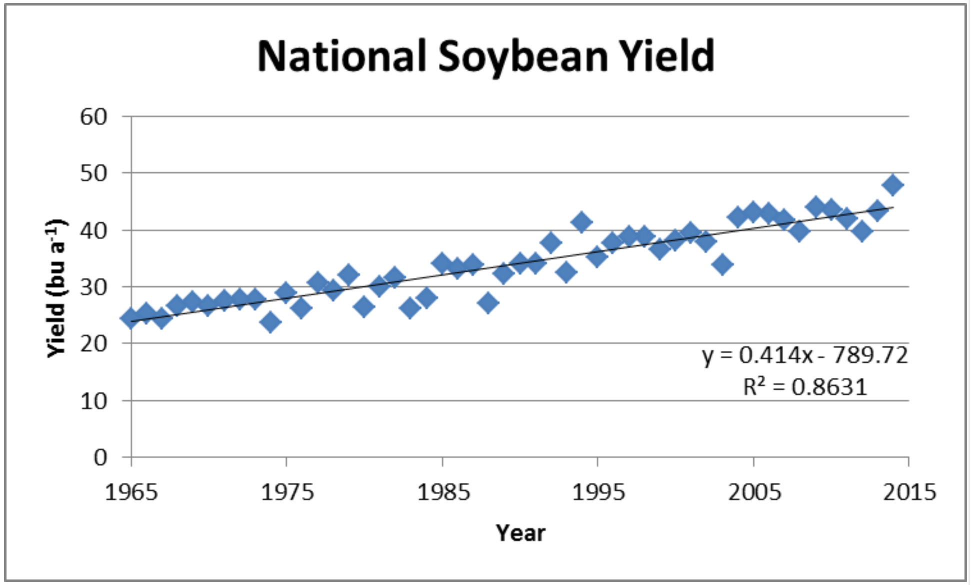
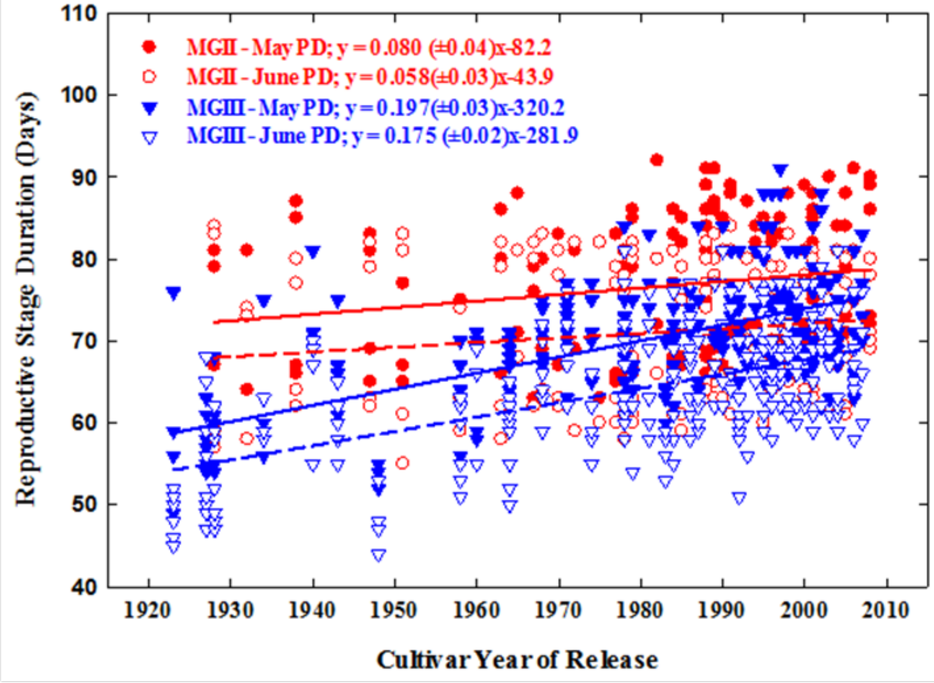
Background and Justification

- Soybean nutrient uptake and partitioning models are primarily built from work conducted in the 1960's……





Background and Justification

- **Gulf Restoration Network v. EPA**
  - Looking to regulate TMDL for N and P across the entire Mississippi River watershed.
  - Covers **>90%** U.S. soybean acres
  - Would require the EPA to set specific guidelines regulating fertilizer use
  - What are crop nutrient requirements?

Mississippi River Watershed

Objectives and Primary Questions

- Our **objective** is to determine soybean nutrient requirements with modern genetics and production practices across a range of yield potential environments.

- Total plant nutrient uptake
- Nutrient partitioning through the growing season
  - How this varies as yield changes?
- Peak nutrient uptake periods and rates
- Nutrient remobilization during grain fill

Total Biomass Collection

Partitioned plant parts for each sampling stage.

	Stems	Petioles	Leaves	*Fallen Petioles	*Fallen Leaves	Pods	Seeds
V4	X	X	X				
R1	X	X	X				
R4	X	X	X	X	X	X	
R5.5	X	X	X	X	X	X	X
R6.5	X	X	X	X	X	X	X
R8	X			X	X	X	X

***Fallen Petioles and Leaves collected every 3 days from R1-R8.**

- **Nutrients Quantified:** N, P, K, S, Ca, Mg, Zn, Mn, B, Cu, Fe, Al, and Na
- 8 varieties + 3 locations
- 240 plots comprised of 6700 tissue samples analyzed

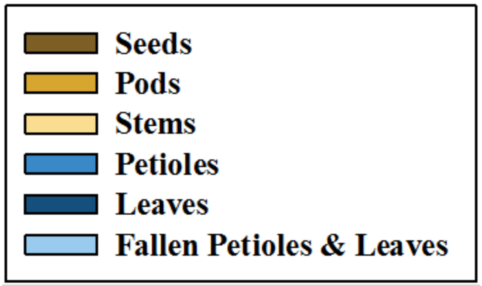
Results

- Analyzed across the whole yield range and a high and low yield level.
- **High** = >75 bu/a   (82 bu avg.)
- **Average** = 66 bu/a (whole data set)
- **Low** = 40 – 60 bu/a (54 bu avg.)
- Mainly focus on NPKS

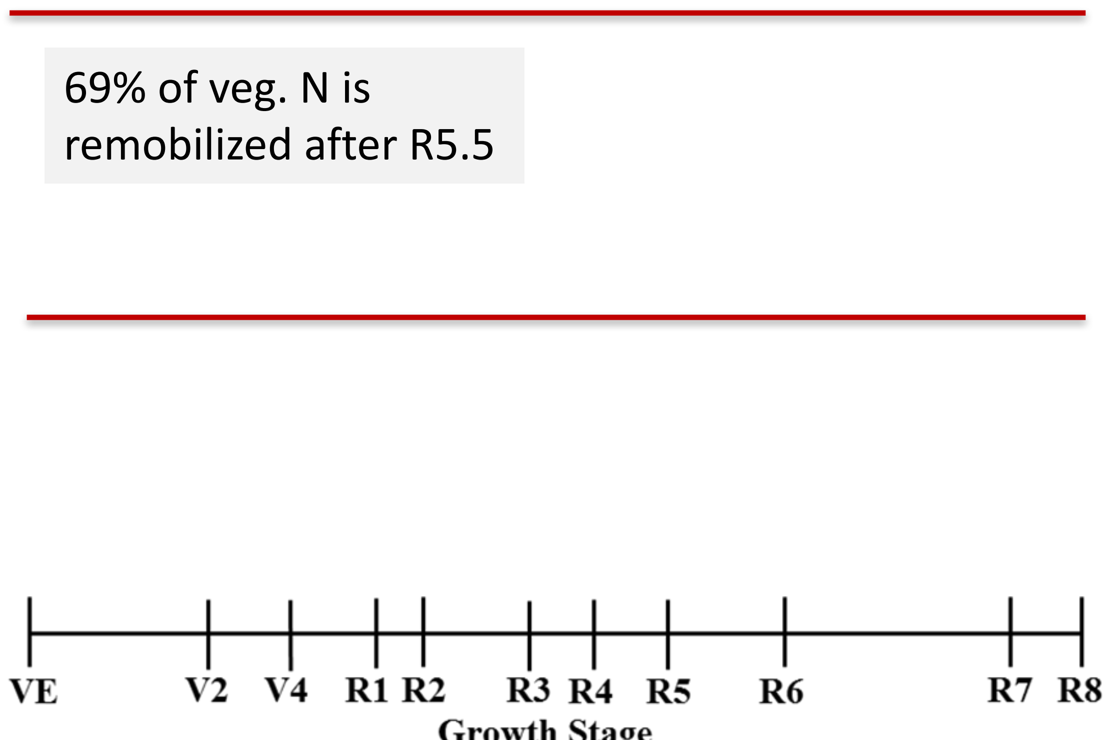
Nitrogen Uptake – Extension Version

300 lbs/a
+
75 lbs/a
=
Enough for
100bu/a

Nitrogen Partitioning: Low

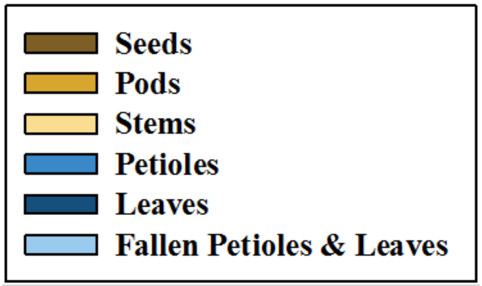


- Uptake after R5.5 = 29.7%

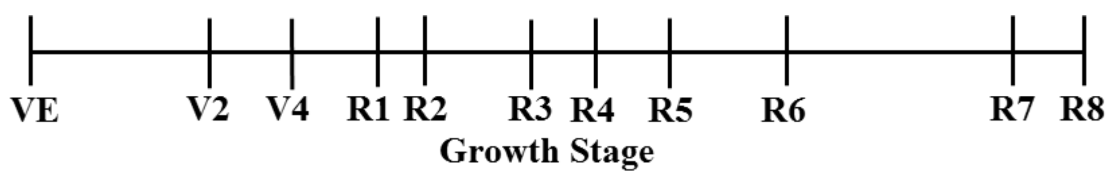


How does this differ from corn N uptake?????

Nitrogen Partitioning: High



67% of veg. N is remobilized after R5.5



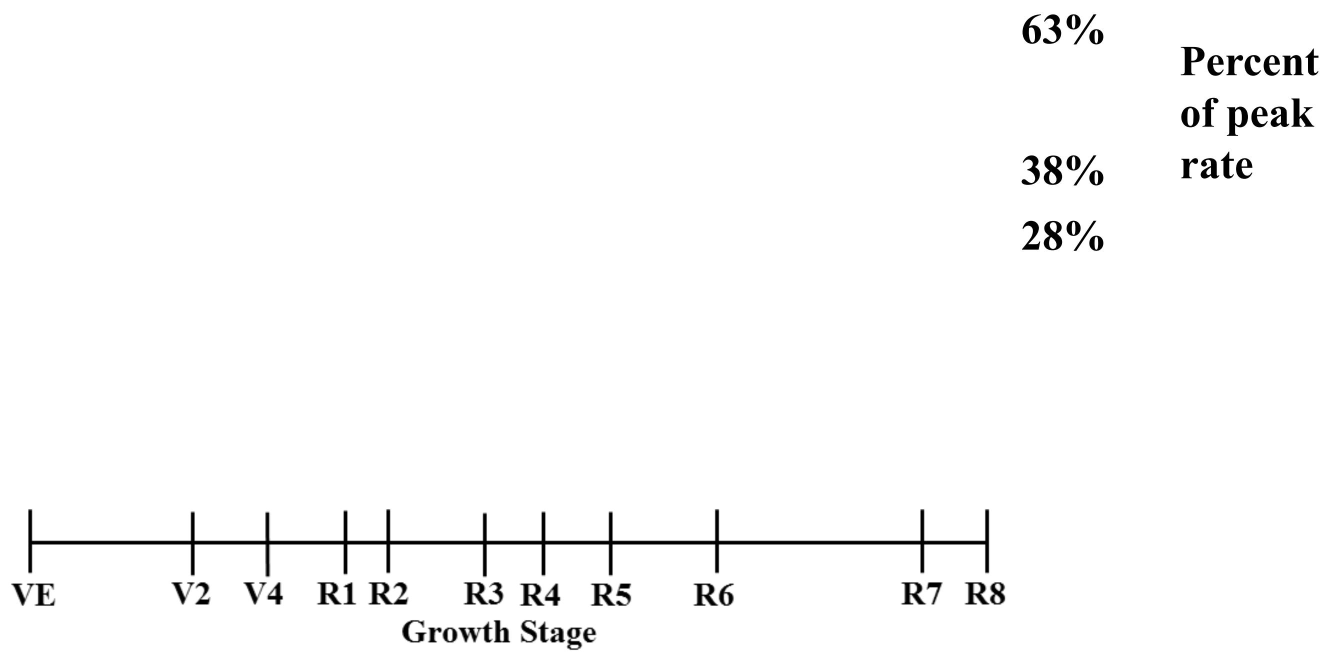
- Uptake after R5.5 = 40.1%

Changes in Veg. Remobilization and Uptake

Shift in seed N supply		
	Current	**1960's**
Vegetative N Remobilization to Grain	68%	55%
% of Total N Uptake after R5.5	35%	25%

– Compared to Hanway and Weber (1971) this suggests a fundamental difference in seed N supply dynamics where old varieties and production practices not only resulted in a **greater percentage of N taken up before R5.5, but also less efficient remobilization of this vegetative N to the seed.**

N Uptake Rate



- Less time in lag phase for greater early season uptake, higher peak rate and longer duration and higher late season rates

Nitrogen Harvest Index

Nitrogen harvest index (NHI) regression over seed yield equations and NHI, within each environment, at three different seed yield levels.

Year	Location	Linear Regression† NHI = A + B(Y)		R^2	Standard Error	NHI Yield level (bu a^{-1})		
						3,000	4,500	6,000
		A	B			%		
2014	ARL	77.6	0.14 b	0.28	2.3	83.2 a	86.6 a	90.0 a
	HAN	74.3	0.15 b	0.23	2.0	80.4 b	84.4 b	88.1 a
	STP	72.8	0.20 ab	0.36	3.3	80.9 ab	86.0 a	91.0 a
2015	ARL	63.7	0.21 ab	0.32	2.5	72.2 c	77.5 d	82.7 b
	HAN	73.4	0.16 b	0.30	2.4	79.9 b	84.0 b	88.1 a
	STP	63.6	0.28 a	0.46	3.0	74.7 c	81.6 c	88.5 a

- Slopes are not similar, but show increasing NHI as yield increases at all environments.
- Is there a possible max NHI near 90%

Nitrogen Removal

- Average seed N content of 6.02%, DM basis

Nitrogen Summary

- Total N uptake varied by environment
- Substantially less than previous reports at a specific yield level. (3.26 lbs N bu^{-1}).

- Greater NHI
- Shift in the N supply dynamics

Greater Efficiency 105 bu/a and no N Fert.

- Improved yields are associated
  - Shorter duration in the lag phase of early season N uptake
  - Higher peak N uptake rate
  - Extended peak uptake period
  - greater late season uptake amounts and rates.

- While N remobilization capacity has increased, higher yields place a greater reliance on uptake past R5.5.

K Results

- Analyzed across the whole yield range and a high and low yield level.
- **High** = >75 bu/a (82 bu avg.)
- **Average** = 66 bu/a (whole data set)
- **Low** = 40 – 60 bu/a (54 bu avg.)

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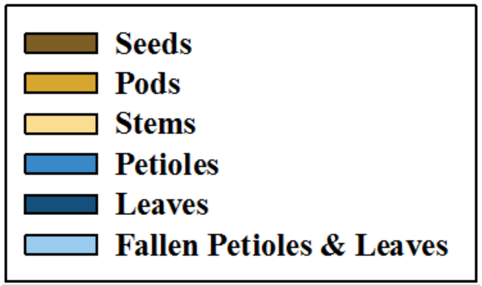
Potassium Uptake (K_2O)

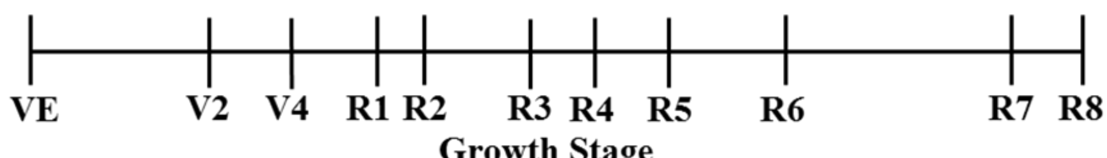
- Tremendous variation in K_2O uptake between environments. ~ 50 lbs a^{-1} differences
- We will see that no matter the yield level..... >90% is taken up before R5.5.
- When is yield determined????

Potassium Partitioning: Low

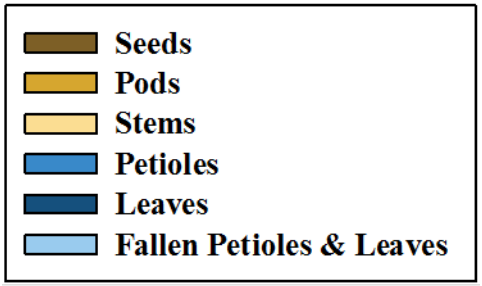


46% of veg. K_2O is remobilized after R5.5

- Uptake after R5.5 = 1%

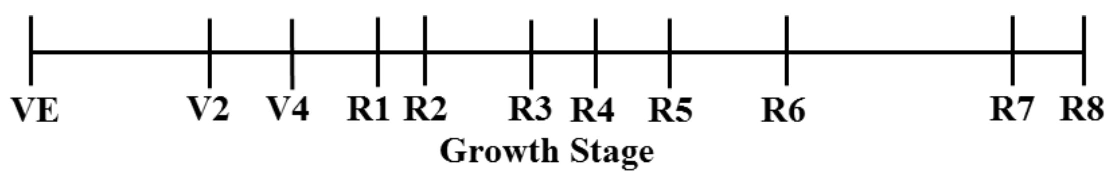


Potassium Partitioning: High



37% of veg. K_2O is remobilized after R5.5

- Uptake after R5.5 = 9.3%

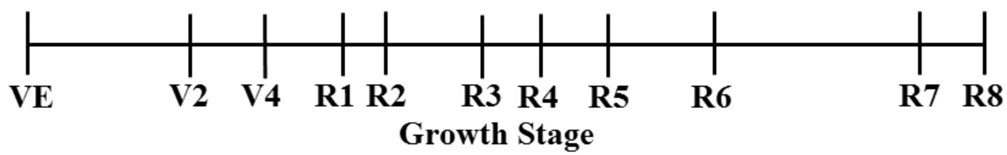


Changes in Uptake Pattern

Shift in seed N supply		
	Current	**1960's**
Vegetative K Remobilization to Grain	42%	45%
% of Total K Uptake after R5.5	3%	30%

– Compared to Hanway and Weber (1971) we see that the main change for K is not greater remobilization capacity and but more so **a shift in uptake before R5.5.**

Potassium Uptake Rate



- Early season uptake rates are the same between yield levels, higher peak rate but similar duration, and not much difference in late season uptake rates

Potassium Removal

Potassium Summary

- Tremendous variation in K_2O uptake between environments. ~ 50 lbs a^{-1} differences
  - Rate was between 1.26 – 2.14 lbs K_2O bu^{-1}
  - Likely due to when K is taken up and seed yield is determined
- Remobilization is key for seed K supply. Late season uptake increases with yield.
- Difference is peak uptake rates was key for Potassium
- K_2O removal was the most closely related to seed yield.

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