# Efficient Management of Water and Nutrient Resources: Assessing the Potential for Drip Irrigation Fertigation

**Fred Below, Tryston Beyrer**

**and Ross Bender**

**Crop Physiology Laboratory**

**Department of Crop Sciences, University of Illinois at Urbana-Champaign**

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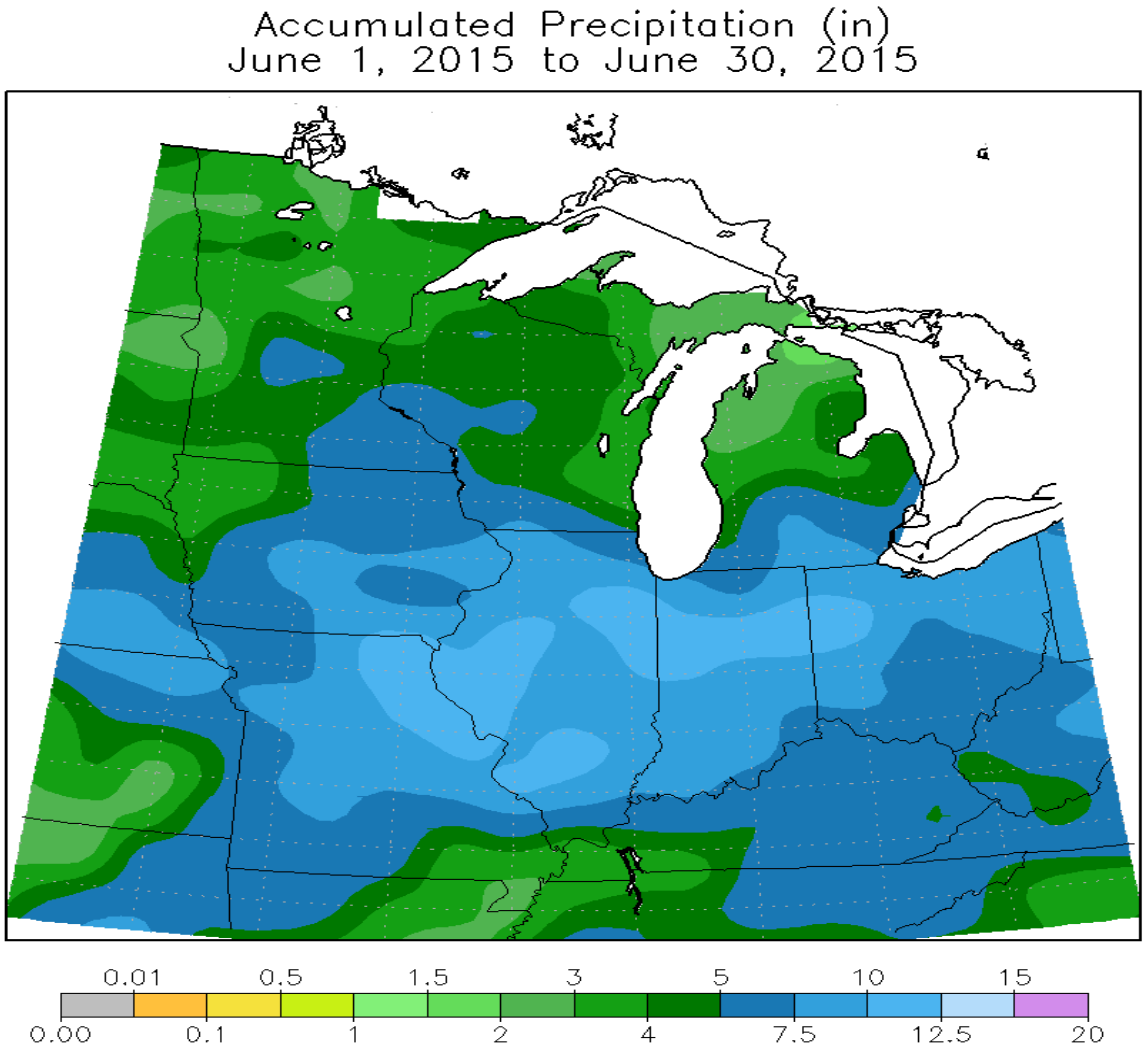
# Test Your Knowledge of High Yield Corn and Soybean

- **What factor has the biggest impact on Corn and Soybean yield each year?**

**Weather**

# Above Average Precipitation during June, 2015




**Source: NOAA Midwestern Regional Climate Center**

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# 2015 Illinois Weather Challenges

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# Adding 60 lbs of N at Various Growth Stages

| Growth Stage at Application Time | Grain Yield |
|---|---|
| | bushels acre$^{-1}$ |
| No Applied N | 140 |
| V2 | 203 |
| V5 | 207 |
| V12 | 208 |
| R2 | 175 |
| R5 | 149 |

LSD 0.05 = 14  Average of two varieties and two years

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# Test Your Knowledge of High Yield Corn

- **What is the record corn yield and what is the corn yield gap?**

# The Corn Yield Gap

- **US average corn yield of about 170 bushels per acre**
- **All 18 National Corn Growers Contest winners in 2015 exceeded 300 bushels, 5 exceeded 400 bushels**
- **New World Record of 532.0271 bushels per acre**

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# High Yield is a Family Affair

## 2015 National Corn Growers Contest Winners

**Randy Dowdy Irrigated 1st, @ 486.2**
**Bridget Dowdy, Irrigated 2nd @ 477.1**
**Dustin Dowdy, Irrigated 3rd @ 444.6**
**Kevin Dowdy, No Till/Strip Till Irrigated 3rd @ 481.1**
**Michelle Dowdy, A Non- Irrigated 1st @ 348.9**

**David Hula, No Till/Strip Till Irrigated 1st @ 532.0**
**Craig Hula, No Till/Strip Till Irrigated 2nd @ 485.4**

**Jill Justice, A No Till/Strip Till Non-Irrig. 1st @ 368.8**
**Jay Justice, A No Till/Strip Till Non-Irrig. 2nd @ 360.3**

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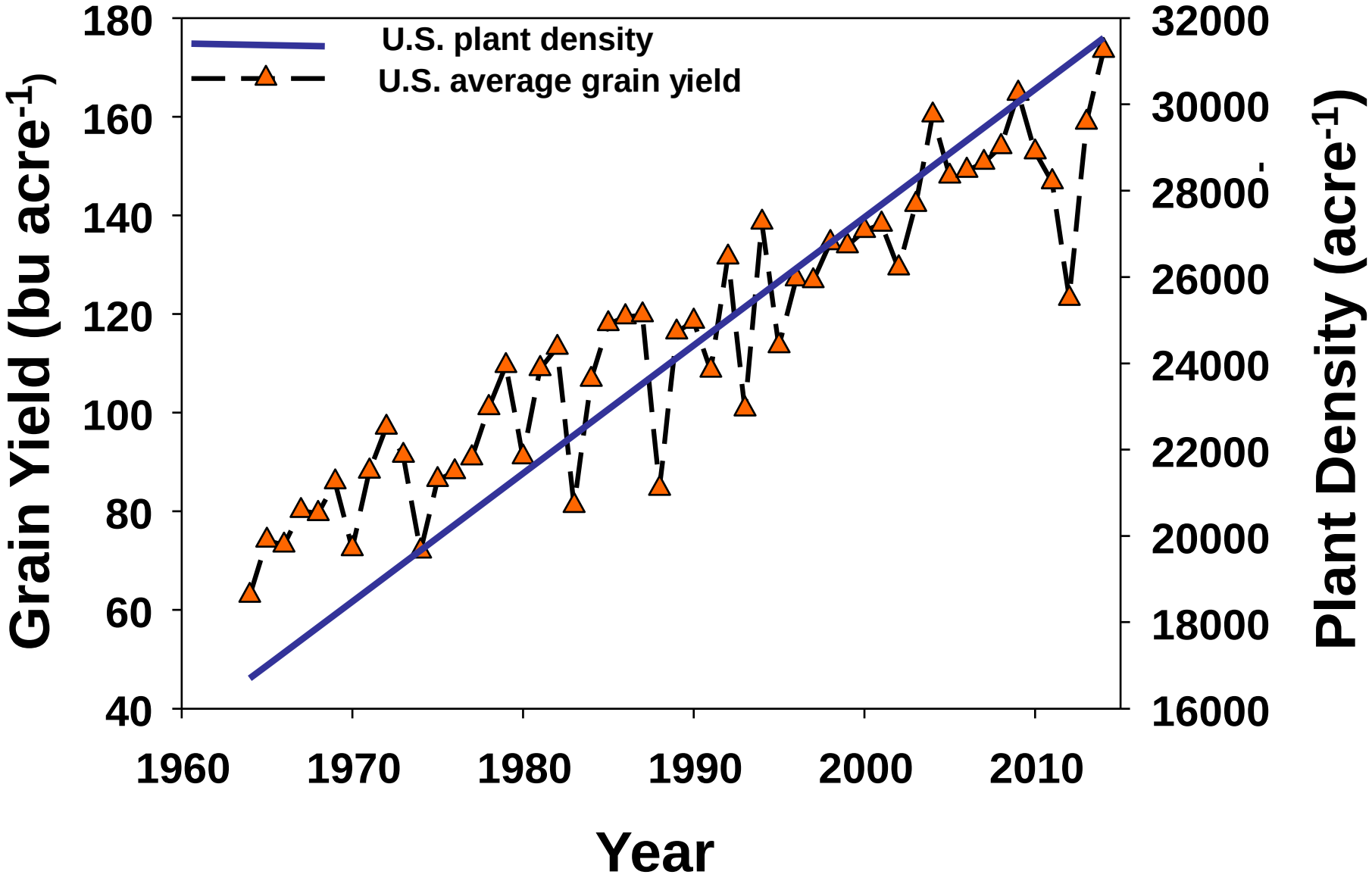
# Strategy for Winning the Corn Yield Contest

- **Feed (better plant nutrition) and protect a much higher density of plants of the best 'racehorse' hybrids**
- **Make sure the crop is never stressed**

# How Have Corn Yields Increased?




Source USDA

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# Fertility Needs for Corn Based on Soil Test Data

- **Soil test values calibrated to yield in the 60's and 70's**
- **Do higher plant populations and more productive germplasm necessitate better fertilization strategies for corn?**

# High Plant Density = Smaller Roots

## Normal Population
## 32,000 plants/acre

## High Population
## 45,000 plants/acre

Champaign, IL 2012

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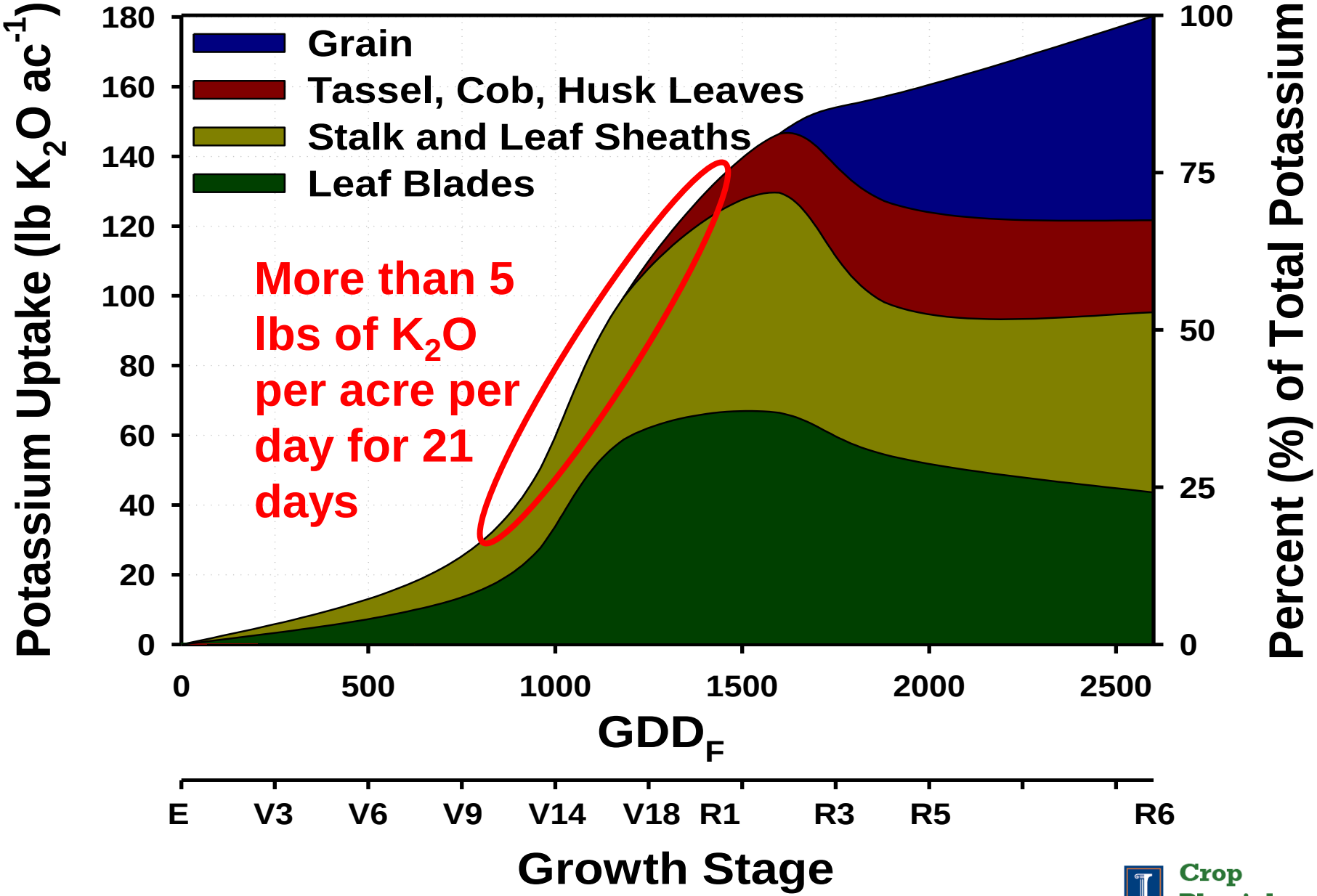
# Corn & Soybean Fertility Recommendations

- **Current = N (for corn) based on expected yield and P and K based on soil tests**

- **Future = Use application and fertilizer technologies to supply required crop nutrition**

# K Uptake & Partitioning for 230 Bushel Corn




Average of 6 hybrids in Champaign and DeKalb IL in 2010

Agron. J. 105:161-170 (2013)

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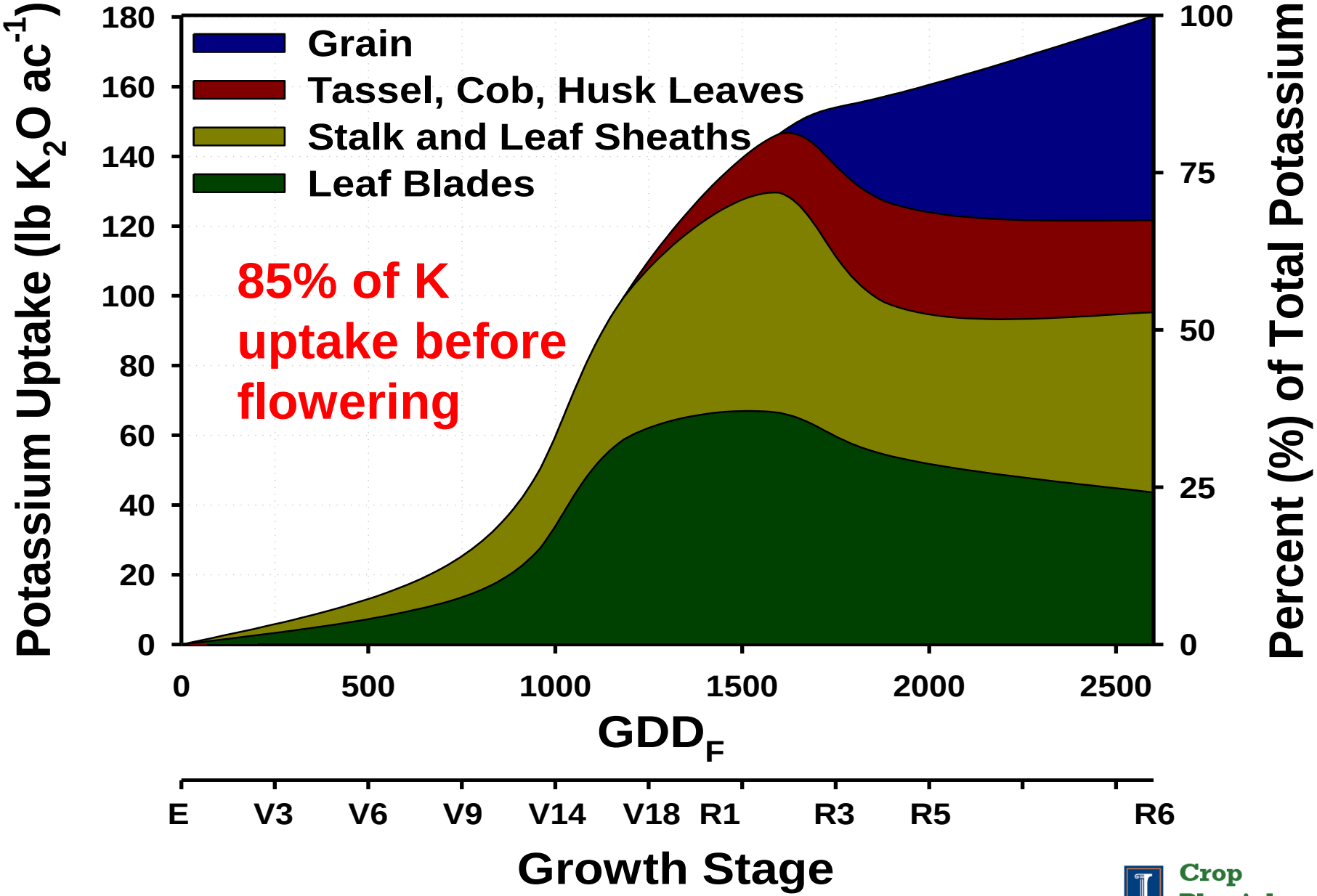
# K Uptake & Partitioning for 230 Bushel Corn




Average of 6 hybrids in Champaign and DeKalb IL in 2010

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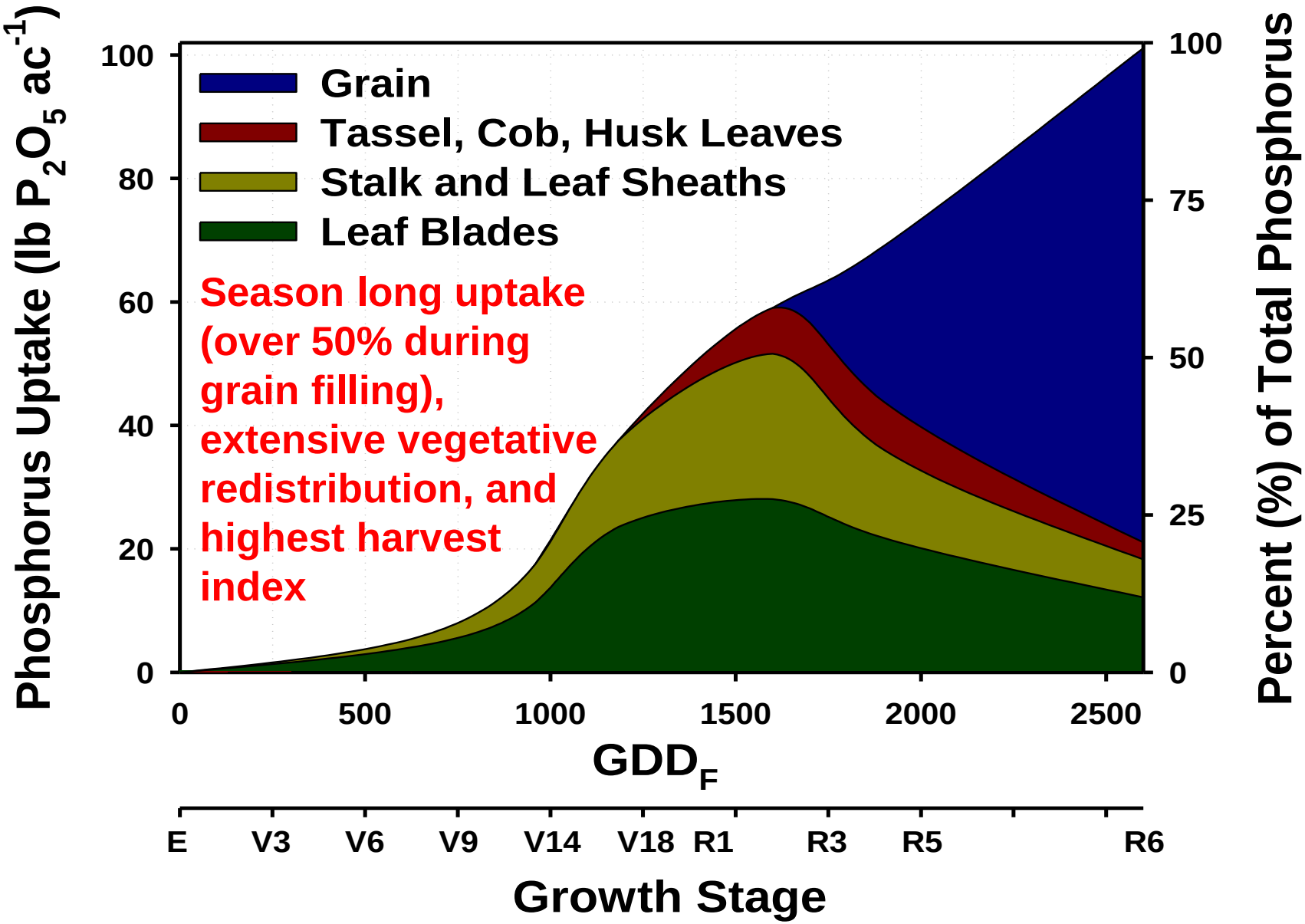
# P Uptake & Partitioning for 230 Bushel Corn

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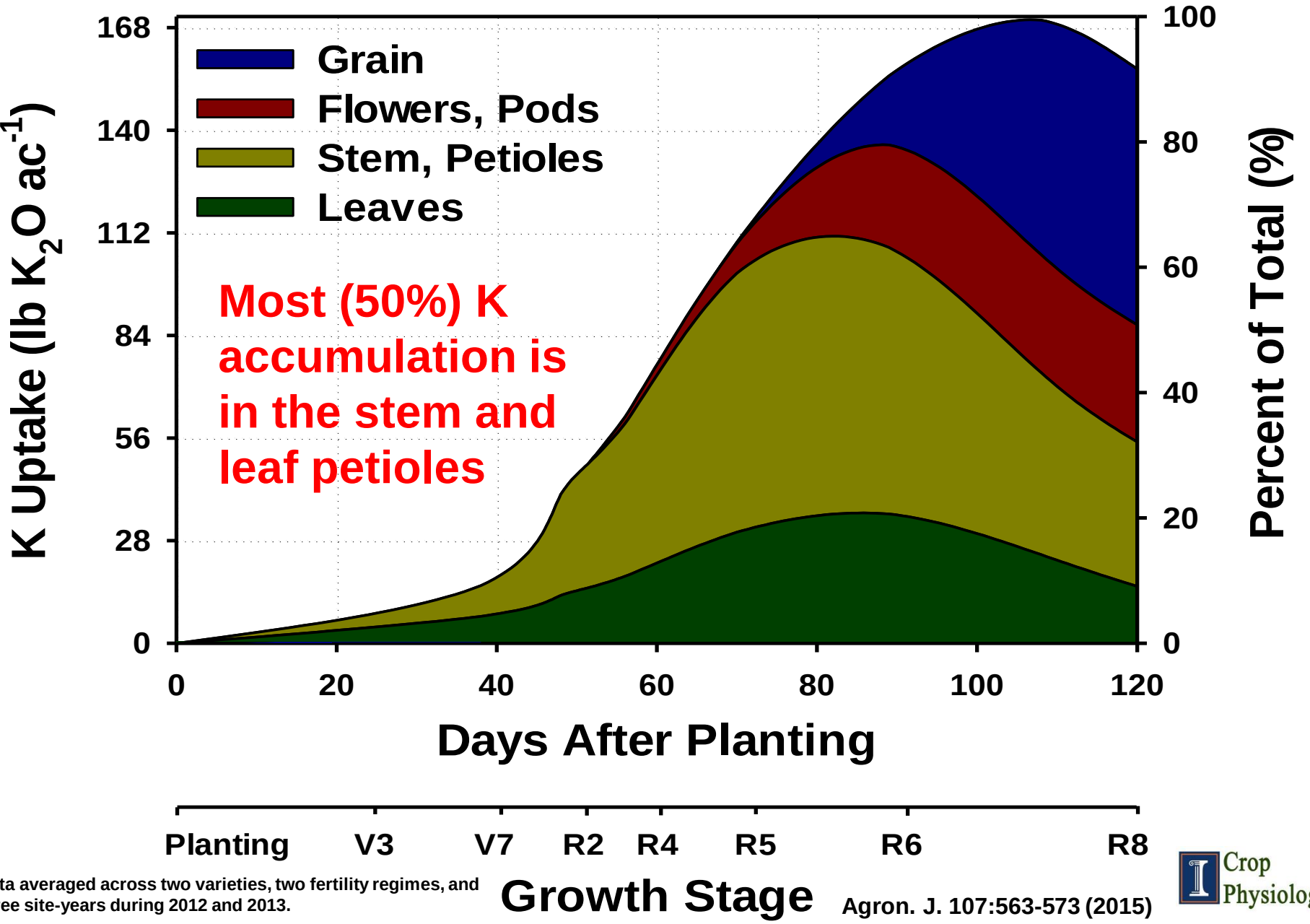
# K Uptake & Partitioning for 60 Bushel Soybean




Data averaged across two varieties, two fertility regimes, and three site-years during 2012 and 2013.

Agron. J. 107:563-573 (2015)

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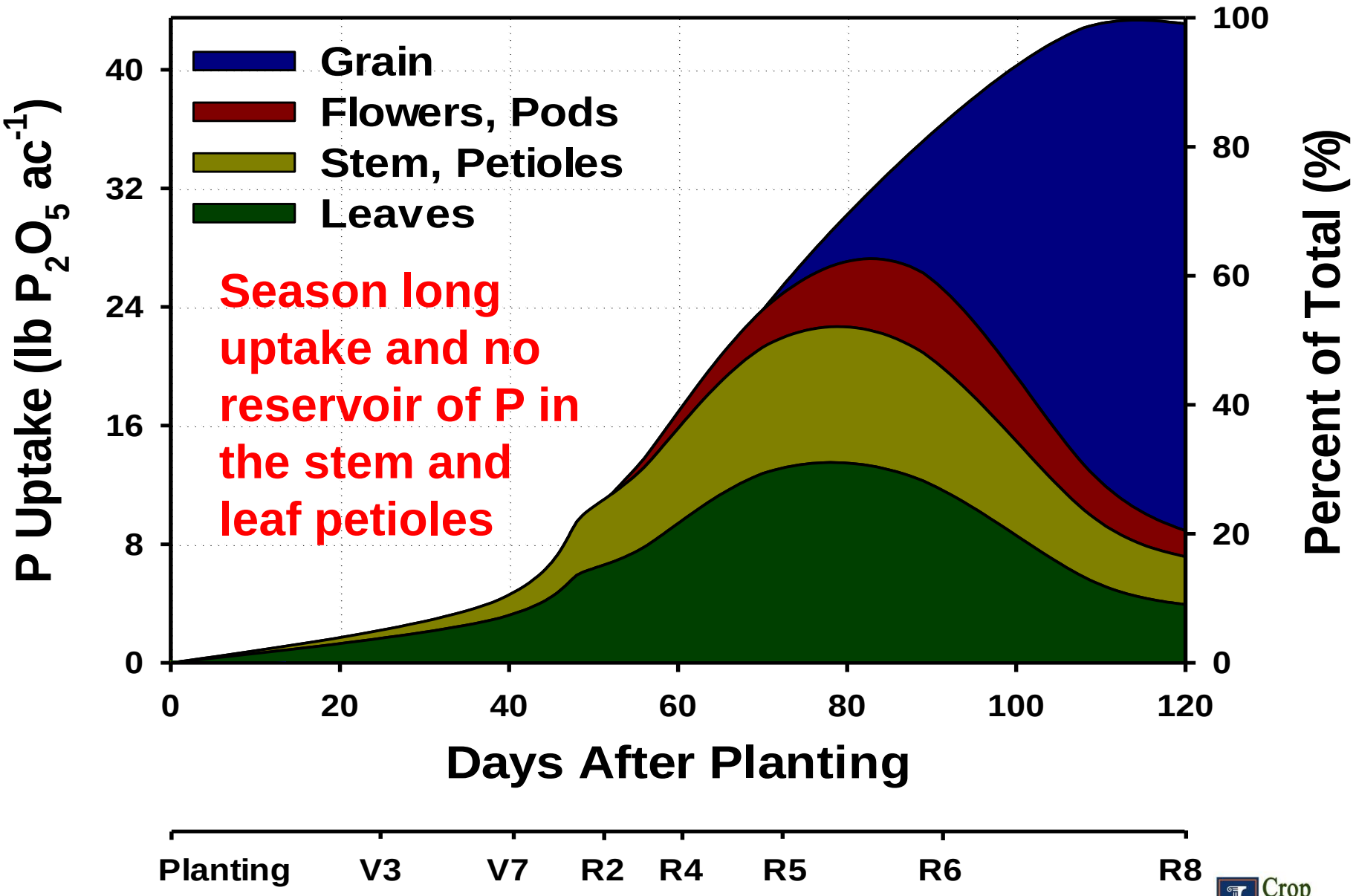
# P Uptake & Partitioning for 60 Bushel Soybean




Data averaged across two varieties, two fertility regimes, and three site-years during 2012 and 2013.

Agron. J. 107:563-573 (2015)

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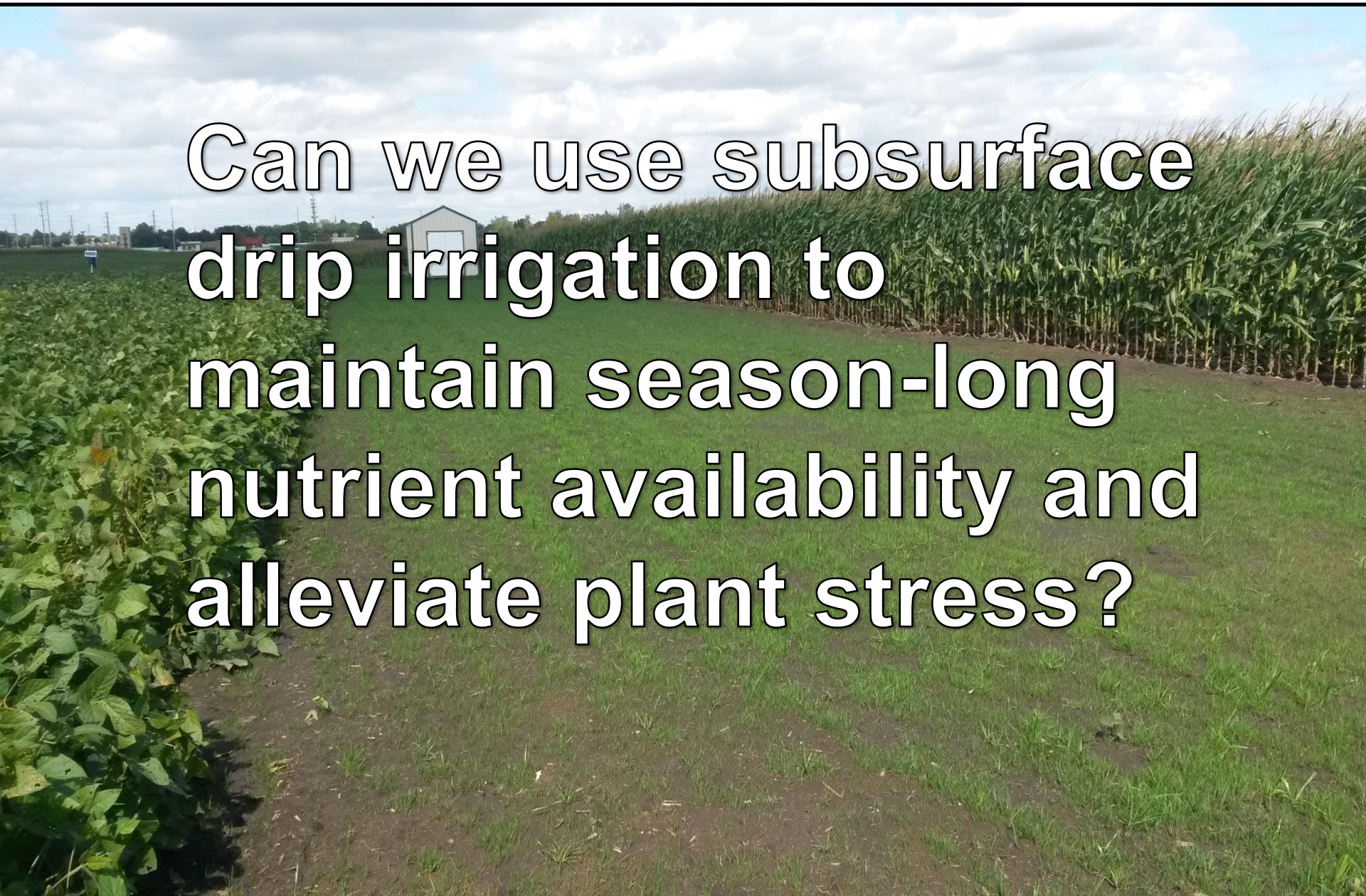
# Research Objectives

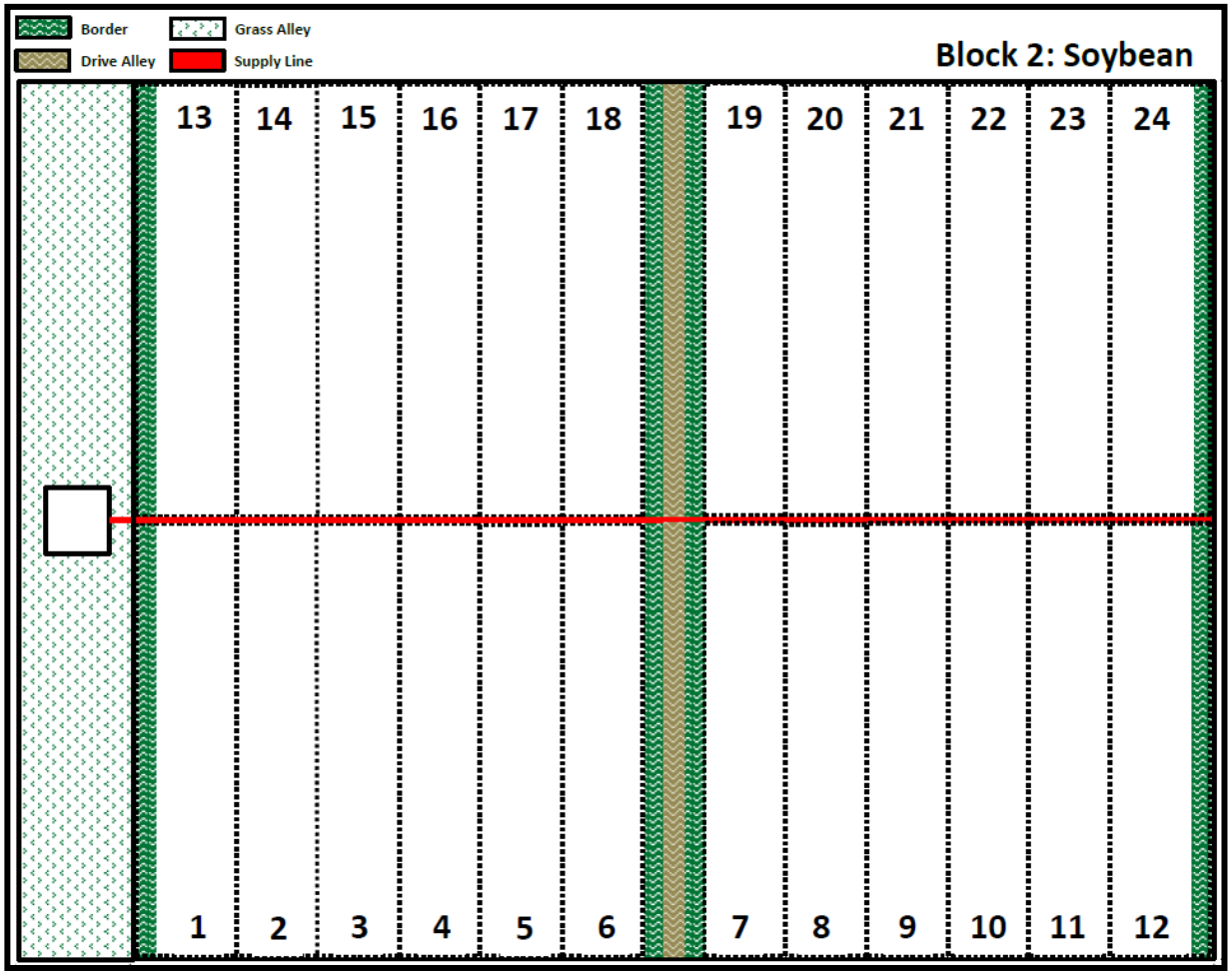


# Hypothesis for Better Nutrient Use with Subsurface Drip Irrigation

- **Even when water from irrigation is not needed, we can increase corn yields by 30 bushels and soybean yields by 5 bushels by better timing nutrient availability with plant needs**

# University of Illinois SDI System

- Five acres of corn and five acres of soybean with 48 equally sized zones
- Zones regulated for differential application of irrigation and fertigation
- Completed May, 2014

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# Innovative Subsurface Drip System

- **Dripperline spaced every 30” buried ~14-16” below ground**
- **24 different zones for each crop allows for precise application of nutrients according to plant needs**

# University of Illinois Capabilities

- **Electronic pressure reducer, flow meters**
- **NMC-Pro: Controls 64 relays (zones/injectors/ reducers)**
- **Three injectors ranging in capacity from 0.10 to 10 gal/hr**
- **Electronic solenoid and reducers for each zone**

# Nutrient Fertigation in Corn - 2014

- **Evaluated four hybrids ranging in population from 24,000 to 48,000 plants/acre**
- **Nutrients N, K, and S were fertigated (No P during 2014) based on known patterns of nutrient accumulation**
- **Control Treatment: 180 lbs N/acre at V4**
- **Fertigated Treatment: Applied (80 – 0 – 70 – 14S) between V6 and R2**

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# Visual Fertigation Response


**All treatments balanced for water. Champaign, 2014.**

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# Fertigation Improved Yield Over Base Fertility

| Population | Irrigated | Fertigated | Δ |
|---|---|---|---|
| plants acre$^{-1}$ | bushels acre$^{-1}$ | | |
| 24,000 | 174 | 191 | +17* |
| 30,000 | 182 | 197 | +15* |
| 36,000 | 181 | 198 | +17* |
| 42,000 | 175 | 197 | +22* |
| 48,000 | 176 | 194 | +18* |
| Average | 175 | 195 | +17* |

* Significantly greater than zero at α=0.10.

- All treatments balanced for water and received base N rate (180 lbs)
- Fertigated treatments received (80-0-70-14S), Champaign, 2014.

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# Nutrient Fertigation in Soybean - 2014

- **15 soybean varieties ranging in maturity group from 2.7 to 4.2**
- **Nutrients N, K, S were fertigated (No P in 2014) based on known patterns of nutrient accumulation**
- **Fertigated Treatment: Applied (50 – 0 – 76 – 16S) between V4 and R7**

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# Varietal Difference in Response to Fertigated Nutrients

| Variety | Control | Fertigated | Δ | Variety | Control | Fertigated | Δ |
|---|---|---|---|---|---|---|---|
| | bu Ac$^{-1}$ | | | | | | |
| 1 | 62.5 | 61.7 | -0.8 | 10 | 64.4 | 67.8 | 3.4* |
| 2 | 61.8 | 61.1 | -0.7 | 11 | 58.9 | 62.9 | 4.0* |
| 3 | 66.1 | 66.3 | 0.2 | 12 | 60.2 | 64.6 | 4.4* |
| 4 | 66.6 | 67.1 | 0.6 | 13 | 61.2 | 66.3 | 5.2* |
| 5 | 59.6 | 60.2 | 0.6 | 14 | 57.0 | 62.5 | 5.5* |
| 6 | 61.4 | 62.1 | 0.7 | 15 | 62.1 | 68.2 | 6.1* |
| 7 | 60.7 | 62.1 | 1.4 | | | | |
| 8 | 59.3 | 61.3 | 2.0 | | | | |
| 9 | 63.1 | 65.6 | 2.6 | | | | |
| | | Average | 0.7 | | | Average | 4.8* |

* Significantly different at $P \leq 0.05$. Trial conducted at Champaign during 2014

# Nutrient Fertigation in Corn - 2015

- **Five hybrids ranging in population from 32,000 to 50,000 plants/acre**
- **Nutrients N, P, K, S and Zn were fertigated based on known patterns of nutrient accumulation**
- **Control Treatment: 180 lbs N/acre at planting**
- **Fertigated Treatment: Applied (113 – 120 – 150 – 12S and 1Zn) between V6 and R5**

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# Nutrient Application Schedule for Fertigation

| Growth Stage | Application Amount/Cumulative Total* | | | | |
|---|---|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ | S | Zn |
| | lbs acre$^{-1}$ | | | | oz acre$^{-1}$ |
| V5&6 | 7/07 | 8/08 | 17/17 | 2/2 | 2/2 |
| V7&8 | 4/11 | 2/10 | 8/25 | 1/3 | 0/2 |
| V11&12 | 12/23 | 0/10 | 75/100 | 5/8 | 6/8 |
| V13&14 | 6/29 | 30/40 | 0/100 | 0/8 | 0/8 |
| VT&R1 | 24/53 | 20/60 | 25/125 | 2/10 | 2/10 |
| R2&R3 | 20/73 | 20/80 | 15/140 | 1/11 | 2/12 |
| R4&R5 | 40/113 | 40/120 | 10/150 | 1/12 | 4/16 |

*In addition to 180 lbs N at planting: Champaign in 2015

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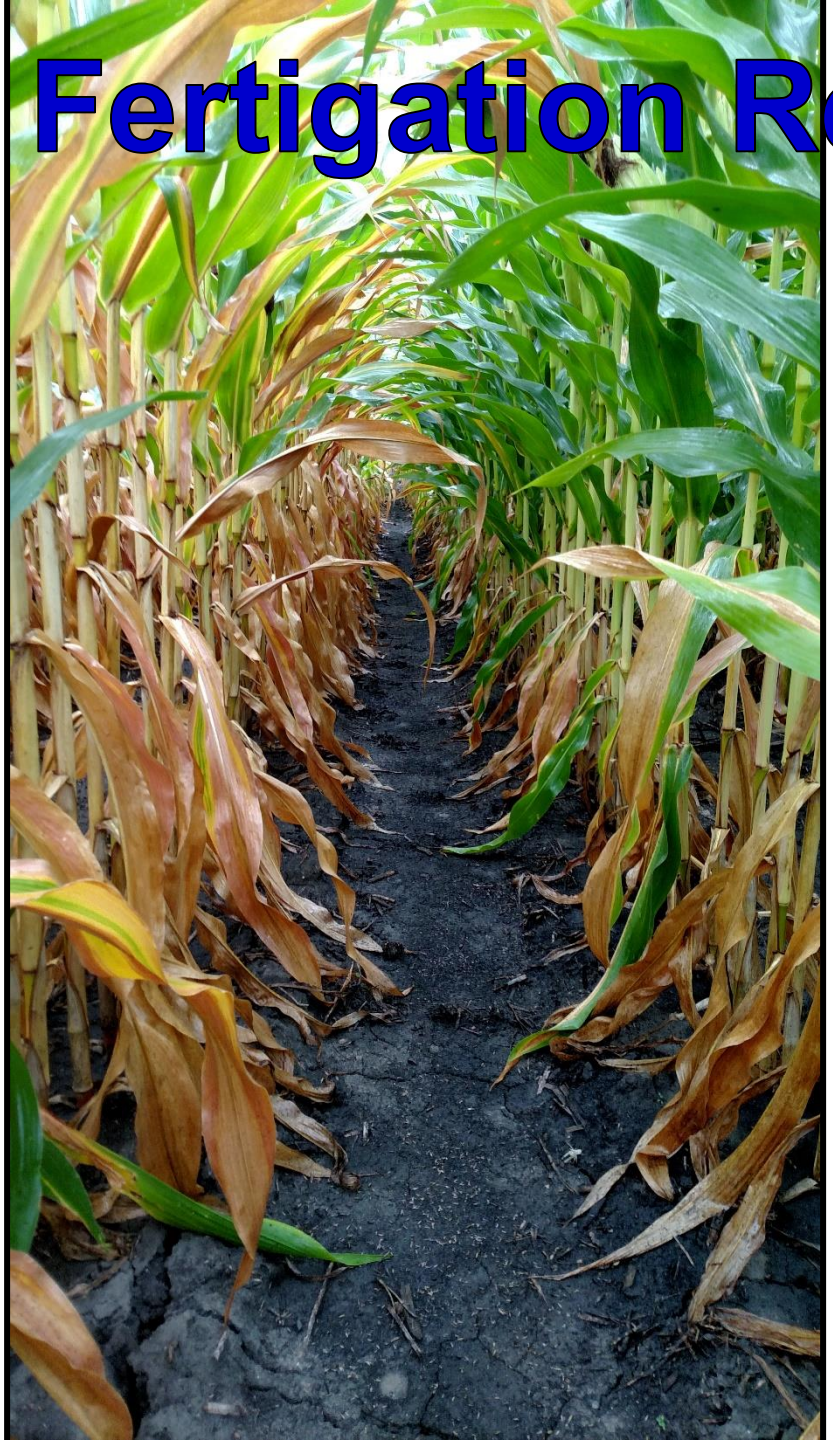
# Visual Fertigation Response



**Control**

180 lbs N

**Fertigated**

180 lbs N +
(113 - 120 - 150 - 12S - 1Zn)

All treatments balanced
for water.
Champaign, 2015.

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# Fertigation Improved Yield Over Base Fertility

| Population | Irrigated | Fertigated | Δ |
|---|---|---|---|
| Plants Ac$^{-1}$ | Yield (Bu Ac$^{-1}$) | | |
| 32,000 | 190 | 243 | +53* |
| 38,000 | 191 | 247 | +56* |
| 44,000 | 197 | 248 | +51* |
| 50,000 | 196 | 245 | +49* |
| Average | 194 | 246 | +52* |

* Fertigated significantly greater irrigated at α=0.10.
- All treatments balanced for water and received base N rate (180 lbs).
- Fertigated treatments received (113-120-150-12S-1Zn), Champaign, IL 2015.
- Averaged over five hybrids.

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# Hybrid Response to Fertigation

| Hybrid | Irrigated | Fertigated | Δ |
|---|---|---|---|
| | Yield (Bu Ac$^{-1}$) | | |
| 214-45STXRIB | 204 | 238 | +34* |
| 7087VT2P | 179 | 248 | +69* |
| DKC61-54 | 181 | 225 | +44* |
| DKC64-87 | 201 | 257 | +56* |
| N74R-3000GT | 204 | 260 | +56* |
| Average | 194 | 246 | +52* |

* Fertigated significantly greater irrigated at α=0.10.
• All treatments balanced for water and received base N rate (180 lbs).
• Fertigated treatments received (113-120-150-12S-1Zn), Champaign, IL 2015.
• Averaged over four plant populations.

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# Nutrient Uptake and Fertilizer Recovery

| Nutrient element | Irrigated | Fertigated | Δ | Recovery |
|---|---|---|---|---|
| | Nutrient (lbs $Ac^{-1}$) | | | % |
| N | 137 | 210 | +73* | 65 |
| $P_2O_5$ | 59 | 89 | +30* | 25 |
| $K_2O$ | 130 | 177 | +47* | 31 |
| S | 12.8 | 17.4 | +4.6* | 38 |

* Fertigated significantly greater irrigated at α=0.10.
• All treatments balanced for water and received base N rate (180 lbs).
• Fertigated treatments received (113-120-150-12S-1Zn), Champaign, IL 2015.
• Average of five hybrids and four plant populations.

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# Soybean Growth Response to Fertigation

Not Fertigated

Fertigated

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# Treatments to Characterize Soybean Varieties

- 17 commercial soybean varieties, MG 2.5 to 3.9
- Fertigation schedule to provide 75 lbs N, 55 lbs $P_2O_5$, 150 lbs $K_2O$, 25 lbs S, and 18 oz Zn
- Foliar protection (Prixor fungicide and Fastac insecticide) at R3
- Fertigation and Foliar Protection

# Nutrient Application Schedule for Fertigation

| Growth Stage | Application Amount/Cumulative Total | | | | |
|---|---|---|---|---|---|
| | N | $P_2O_5$ | $K_2O$ | S | Zn |
| | lbs acre$^{-1}$ | | | | oz acre$^{-1}$ |
| V3 | 25/25 | 5/5 | 35/35 | 3/3 | 3/3 |
| V7 | 0/25 | 10/15 | 35/70 | 4/7 | 3/6 |
| R2 | 0/25 | 10/25 | 35/105 | 4/11 | 3/9 |
| R4 | 0/25 | 10/35 | 35/140 | 5/15 | 3/12 |
| R5 | 25/50 | 10/45 | 10/150 | 5/20 | 3/15 |
| R6 | 25/75 | 10/55 | 0/150 | 5/25 | 3/18 |

Champaign in 2015

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# Soybean Yield Increase from Foliar Protection and/or Fertigation

| Treatment | Average | Range |
|---|---|---|
| | bushels acre$^{-1}$ | |
| Standard | 70.5 | 57 - 80 |
| Foliar Protection | 74.7 | 59 - 83 |
| Fertigation | 78.6 | 68 - 85 |
| Fert. and Foliar | 80.6 | 70 - 89 |

For 17 commercial soybean varieties with RMs 2.5 to 3.9

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# Variety, Foliar Protection and Fertigation

| Variety | Standard | Foliar | Fert. | Fert + Foliar |
|---|---|---|---|---|
| | | bushels acre$^{-1}$ | | |
| S25-L9 | 59.3 | 59.1 | 70.1 | 72.7 |
| S28-D3 | 57.8 | 67.8 | 74.8 | 78.4 |
| S30-V6 | 67.0 | 70.9 | 68.7 | 69.5 |
| S35-A5 | 75.6 | 82.4 | 83.1 | 89.0 |
| S37-Z8 | 72.6 | 78.9 | 76.4 | 80.1 |

# Conclusions

- **Yield increases on the order of 50 bushels for corn and 8 bushels for soybean from fertigation, even though extra water from irrigation was not needed**
- **Hybrid and variety differences in response to fertigation suggest opportunities for additional yield improvement for better nutrient use**

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# Acknowledgements

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**For more information:**

**Crop Physiology Laboratory at the University of Illinois**

**http://cropphysiology.cropsci.illinois.edu**

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