Can Fertilizer Nitrogen Applications Increase Productivity of Soybean?

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Question: ***Can fertilizer N applications increase soybean yield and if so what is the most responsive N fertilizer source to apply and when should it be applied?***

Objective: ***Identify the best N fertilizer source and the best time of application to increase soybean yield.***

Introduction:

- Historically, it has been assumed that soybeans (*Glycine max* [L.] Merr) obtain their entire nitrogen (N) requirement via the nodules and biological N fixation, and that they produce excess N that can be used by the subsequent corn crop (i.e. the so-called soybean nitrogen credit).
- However, recent findings suggest that soybean is only able to fix about half of its total N requirement (Salvagiotti et al., 2008 Field Crop Res. 108:1-13), with the remainder having to come from either mineralization of soil organic matter, residual N fertilizer left over from the previous corn crop, or from N fertilizer being applied specifically for the soybean crop.
- Evaluating the soybean yield response to N fertilizer will help develop a better understanding of N use and demand by soybean, while factoring in N fixation capability, soil supply, yield, and weather as a basis for developing N fertilizer recommendations for high yielding soybean.

Research Approach:

Sites in Illinois:
(2015): DeKalb, Champaign, and Harrisburg
(2016): Yorkville, Champaign, and Harrisburg

Planted:
May 21st, 23rd, and 3rd, 2015
May 29th, 22nd, and 5th, 2016, respectively

- Plots were planted to achieve an approximate final stand of 395,360 plants ha^{-1} (160,000 plants acre^{-1}).
- Varieties chosen were adapted to each location.
- At all sites, treatments were arranged in an RCB experimental design with 6 replications.

N Application Timing:
Either preplant, V3, R1, or R3

N Sources:
AN, ammonium nitrate (34-0-0)
AMS, ammonium sulfate (21-0-0-24S)
ESN, controlled release urea (44-0-0)
Limus urea, urea with the urease inhibitor Limus (46-0-0)
UAN, liquid urea ammonium nitrate (28-0-0)
Urea (46-0-0)
AN+KN+AMS, a mixture of ammonium nitrate, potassium nitrate, and ammonium sulfate (30-0-7-2S)
Unfertilized control

N Rate:
112 kg N ha^{-1} (100 lbs of N acre^{-1})

- Fertilizers were hand applied. The granular sources were not incorporated, while the liquid UAN source was diluted and dripped down the center between two rows.

Weather Plays an Important Role:

Table 2. Precipitation during the production season averaged over three Illinois locations in 2015 and 2016. Data obtained from the Illinois State Water Survey.

Month	Total Rainfall mm	Δ from 30-Year Average Rainfall mm
	2015	
April	119.4	+25.4
May	134.6	+10.2
June	205.7	+96.5
July	116.8	+7.6
August	73.7	-22.9
September	116.8	+38.1
	2016	
April	104.1	+7.6
May	157.5	+35.6
June	96.5	-12.7
July	162.6	+53.3
August	132.1	+38.1
September	111.8	+30.5

- **In 2015, the first half of the growing season experienced much higher precipitation than average (Table 2), which may have led to loss of residual N from the soil and/or slowed nodule development; and which may account for the significant N fertilizer-based yield responses observed in 2015 (Table 1).**
- **In 2016, the first half of the growing season experienced closer to average precipitation (Table 2), and less saturated soil conditions in 2016 likely contributed to more mineralization of soil organic matter N and more residual N being utilized by the soybean; and which may have resulted in less of a yield response from fertilizer N applications in 2016 (Table 1).**

Yield Results:

- **In 2015, late-season applications of N (specifically during the R1 and R3 growth stages) produced the greatest yield response.**
- **AN, UAN, and ESN increased yield regardless of application time in 2015.**
- **In 2016, early-season applications of N (especially when applied at preplant) resulted in the greatest yield response.**
- **ESN was the only N source that increased yield at two different timings in 2016.**
- **In both years, in no instance did any of the N fertilizers at any application time decrease soybean yield.**
- **Variation in the N source and the application time that gave the greatest yield increase was evident among the various sites and years, suggesting that soil type and weather conditions play a large role in the response of soybean to individual N fertilizer sources (data not shown).**

Table 1. Increases in soybean grain yield over an unfertilized control from different N fertilizer sources applied at four plant growth stages in 2015 and 2016. Values are averaged over three Illinois locations, three varieties, and six replications. The unfertilized control averaged 4.2 Mg ha^{-1} in 2015 and 4.5 Mg ha^{-1} in 2016.

	Application Time			
N Source	Preplant	V3	R1	R3
	Δ Mg ha^{-1}			
	2015			
AN	0.34*	0.35*	0.45*	0.48*
AMS	0.23	0.13	0.29*	0.27*
UAN	0.29*	0.35*	0.32*	0.26*
Urea	0.19	0.24*	0.27*	0.26*
ESN	0.27*	0.23	0.36*	0.26*
Limus Urea	0.13	0.28*	0.31*	0.35*
AN+KN+AMS	0.22	0.12	0.38*	0.30*
	2016			
AN	0.20*	0.03	0.03	0.01
AMS	0.09	0.07	0.10	0.05
UAN	0.18*	0.11	0.01	0.05
Urea	0.17*	0.12	0.03	0.15
ESN	0.22*	0.18*	0.02	0.04
Limus Urea	0.06	0.07	0.07	0.08
AN+KN+AMS	0.23*	0.08	0.06	0.02

*Significantly different than unfertilized control within an application time, $P \leq 0.10$

Agronomic Implications:

1. Can fertilizer N increase soybean yield?
✓ **Yes, although yield varied according to the year, site location, N source, and application timing there were positive increases in soybean yield.**

2. Was there a best N fertilizer source to increase soybean yield?
✓ **Yes, ESN and nitrate-containing fertilizer N sources were the most consistent in increasing soybean yield.**

3. Was there a best time to apply N fertilizer to soybean?
✓ **Yes, although yield increases were observed for all application times during at least one year, preplant applications were observed over both years.**

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