

SCIENCE FOR SUCCESS

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The best soybean management practices by extension researchers from across the United States

Soybean Yield Response to Nitrogen (N) and Sulfur (S) Fertilization: Contribution of Soil N and Biological N Fixation Processes

Take Home Messages:

- Biological N fixation contributed 40% of the total crop N demand.
- The average contribution of nitrogen (N) from biological N fixation at R4 was 70 lb/ac.
- The application of S could be explored as a way to boost N fixation and nutrient use to increase yields under specific site conditions.

Objectives

Soybean presents a high demand for nitrogen (N) and sulfur (S), with a clear interaction between nutrients and with S improving plant N utilization. During the 2021 season, 26 trials across twelve US states were conducted under a unique fertilization protocol. The specific aims of this study were to:

- Develop a consistent experimental design and network of trials;
- Study soybean yield response to N and S application;
- Quantify the contribution of biological N fixation and soil N supply.

The sites were split into two groups based on the yield response of the “Full” relative to the “Check” treatment (yield gap). If the yield increase was significant, the site was considered responsive, and if not, then the site was categorized as non-responsive.

Biological N fixation contribution was quantified at the R4 stage, the time in which maximum N fixation occurs and remains considerably stable until the end of the season (<https://www.frontiersin.org/articles/10.3389/fpls.2021.727021/full>).

	TIMING				Total Applied	
	Planting		R3		N	S
	N	S	N	S		
----- LB/AC -----						
Check	-	-	-	-	-	-
N*	26	-	-	-	26	-
S+	-	30	-	-	-	30
NS^	26	30	-	-	26	30
Full±	150	15	150	15	300	30

Table 1

Fertilizer nutrient rates (lb/ac) and corresponding fertilizer sources applied to each treatment during the season.

*(Urea, 46-0-0); +(Gypsum, 0-0-0-23.5S); ^(Ammonium Sulfate, 21-0-0-24S); ±(Urea and Ammonium Sulfate).

Results

- Median yield was 60 bu/ac for non-responsive and 64 bu/ac for responsive sites (Fig 1A). Only 8 out of 26 sites resulted responsive to both N and S fertilizer application.
- Yield gap at responsive sites ranged from 7 to 16 bu/ac (Fig 1A).
- At responsive sites, S response ranged from 2 to 13 bu/ac (Fig. 1B).
- Uncertainties for yield response were high, especially at non-responsive sites (up to 38 bu/ac).
- Biological N fixation contributed, on average, 40% of the total crop N demand (Fig. 2). The overall contribution of N derived from biological N fixation averaged 70 lb/ac.

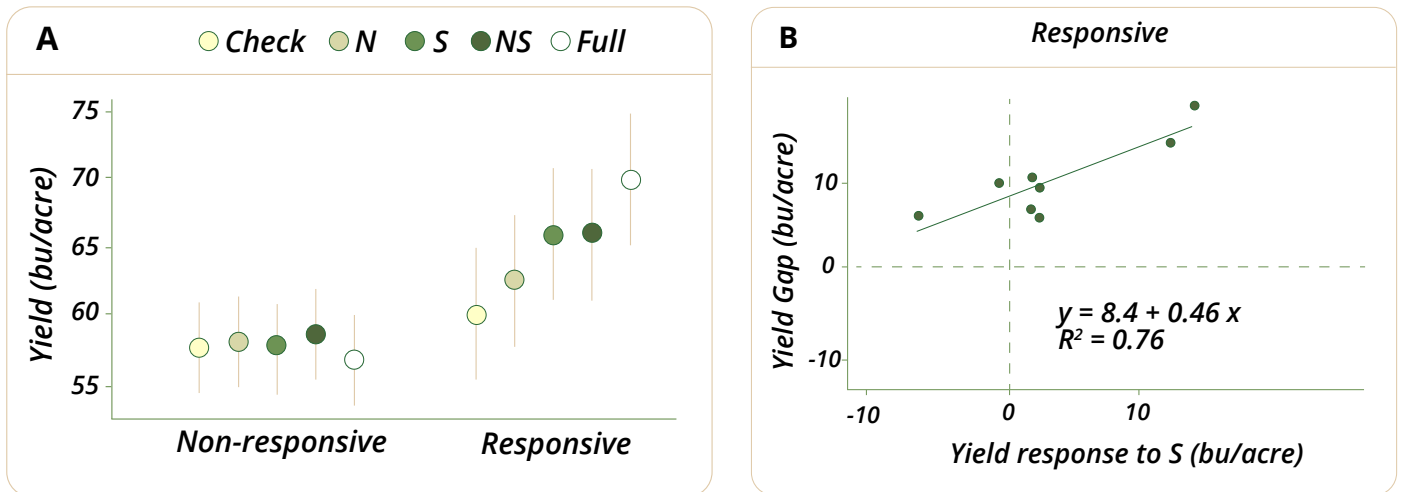


Figure 1

A: Average yield by group of yield response and fertilizer treatment (error bars represent the standard error of the means). B: Yield gap (calculated as the difference between Full and Check) versus yield response to sulfur (S) fertilization at responsive sites. The vertical and horizontal dashed lines represent effect size = 0.

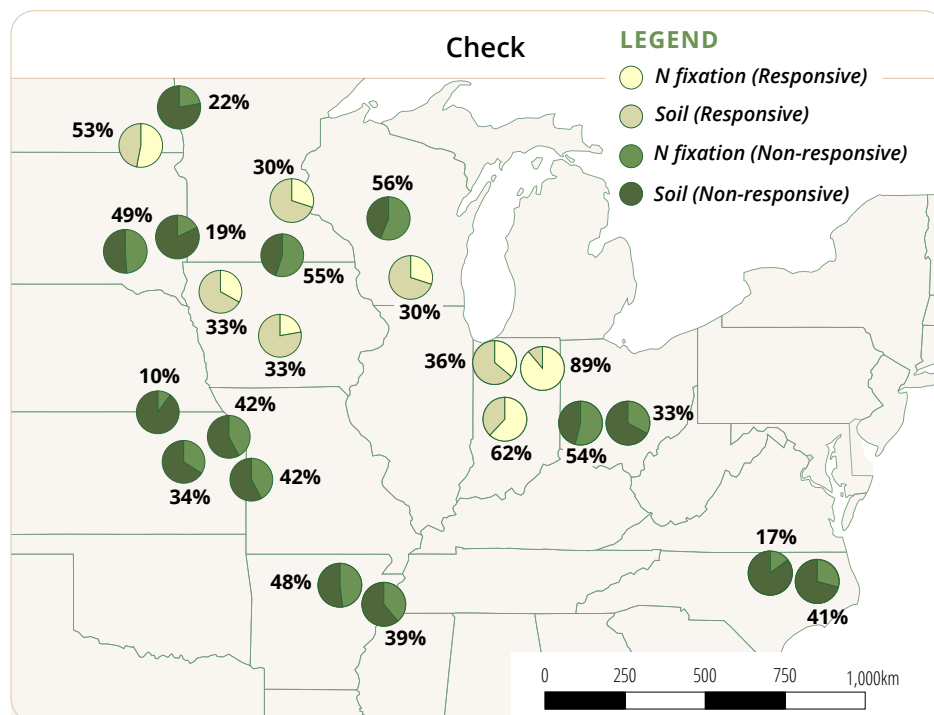


Figure 2

Contributions of soil nitrogen (N) and biological N fixation to the total N demand of soybeans at the R4 stage (full pod formation) across 26 studies conducted in 12 states of the United States. The green and yellow colors distinguish non-responsive and responsive sites, respectively. Inside the pie charts, the dark green and yellow colors represent the soil N contribution, while the lighter colors represent the biological N fixation contribution. The labels next to the pie charts indicate the average contribution of biological N fixation to the total soybean plant N uptake at the site level.

Summary

- This research reinforces that N fertilization is unlikely to improve soybean yields due to the high uncertainty (very low probability) in treatment response.
- The application of S could be explored as a way to boost N fixation and nutrient use to increase yields under specific site conditions.
- Higher yield levels were not associated with more crop N demand derived from biological N fixation process.
- A more thorough understanding of the uncertainties on yield response will help to better understand the main drivers of changes in the partial N and S budgets in soybean.

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