AGRONOMY RESEARCHUPDATE

PIONEER agronomy

Soybean Nitrogen and Sulfur Uptake, Partitioning, and Removal

Rationale and Objectives

- Soybean growers are often concerned that soybean yield is restricted by limitations on biological N2 fixation and soil nitrogen (N) mineralization.
- Atmospheric sulfur (S) deposition has been reduced, but the wide-spread availability of animal manure has many growers questioning the need for application of additional S.
- Proper management of these two soil-mobile nutrients throughout the growing season is critical for high yielding soybeans.
- The objective of this study was to characterize actual soybean N requirements and utilization across a wide seed yield range for modern soybean production systems.

Study Description

- **Test Environments:** 2 years at 3 locations with non-limiting fertility levels, resulting in 6 different testing environments.
- **Soybean Varieties:** 8 Pioneer® brand soybean varieties (RM 1.0-2.5)
- **Planting Dates:** Early and late May
- **Plant Sampling:** Collected at the V4, R1, R4, R5.5, R6.5, and R8 growth stages and partitioned into the following parts:
  - Stems
  - Leaves
  - Seeds
  - Petioles
  - Pods
  - Fallen Leaves/Petioles
- **Nutrients Quantified:** Nitrogen and Sulfur
- 6,672 tissue samples analyzed that span a yield range of 40 to >100 bu/acre

Catch container used to collect all fallen leaves and petioles throughout the growing season from each plot.

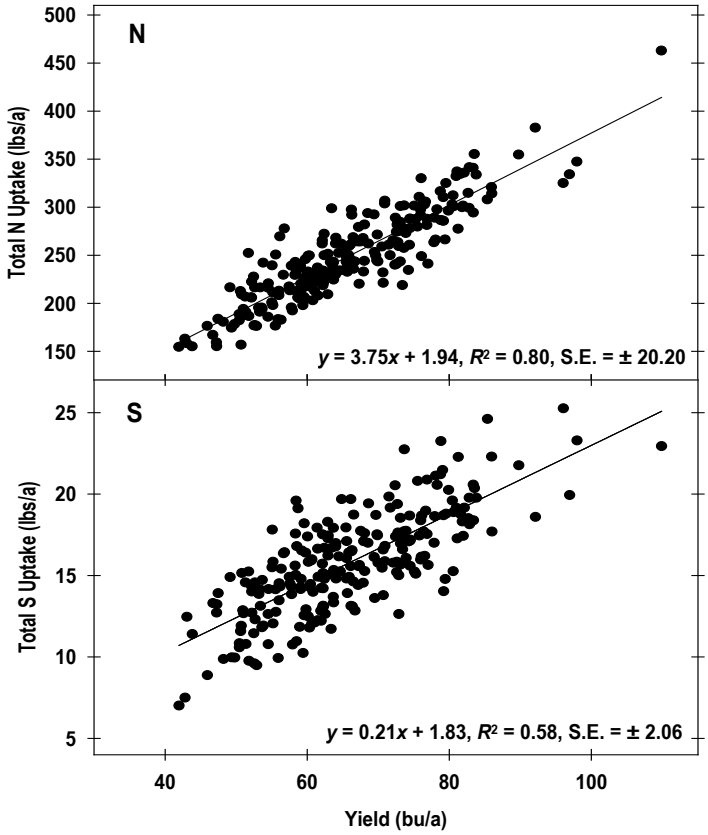

Figure 1. Total whole plant N and S uptake at growth stage R8 (full maturity) across all environments and varieties.

Total N and S Uptake

- The soybean crop required 3.75 lbs of N/bu/acre and 0.21 lbs of S/bu/acre, meaning an 80 bu/acre soybean crop would require 302 lbs/acre of N and 19 lbs/acre S (Figure 1).
- Current estimates of biological N2 fixation (300 lbs of N/acre) and annual mineralization capacities (20 lbs N / 1% organic matter) have the potential to supply enough N for yields approaching 100 bu/acre.
  - Therefore, N supply is rarely the limiting factor for high yielding soybeans.
- More variability existed in the yield – S relation, but this relation was not affected by the environment or variety. In comparison the yield – N relation was much stronger (R2 = 0.80), however, total N uptake did vary by the environment (Figure 1).
  - Therefore, N and S uptake requirements are independent of the variety used, while total N uptake is field- and year-specific.

N and S Uptake Rate

- N and S uptake rates lagged until V2 and then accelerated to peak rates (3.5 lbs N/acre/day and 0.25 lbs S/acre/day) from R2-R5 (Figure 2).

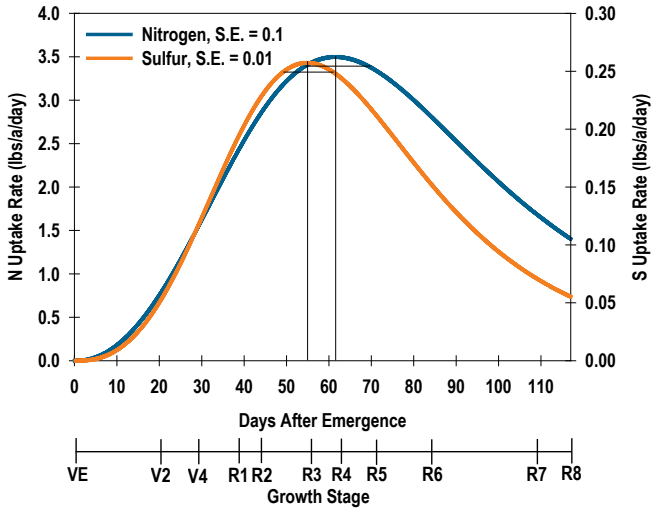

Figure 2. N and S uptake rate through the growing season for a 66 bu/acre soybean crop. Duration of peak uptake is represented by the horizontal black line.

N and S Partitioning and Utilization

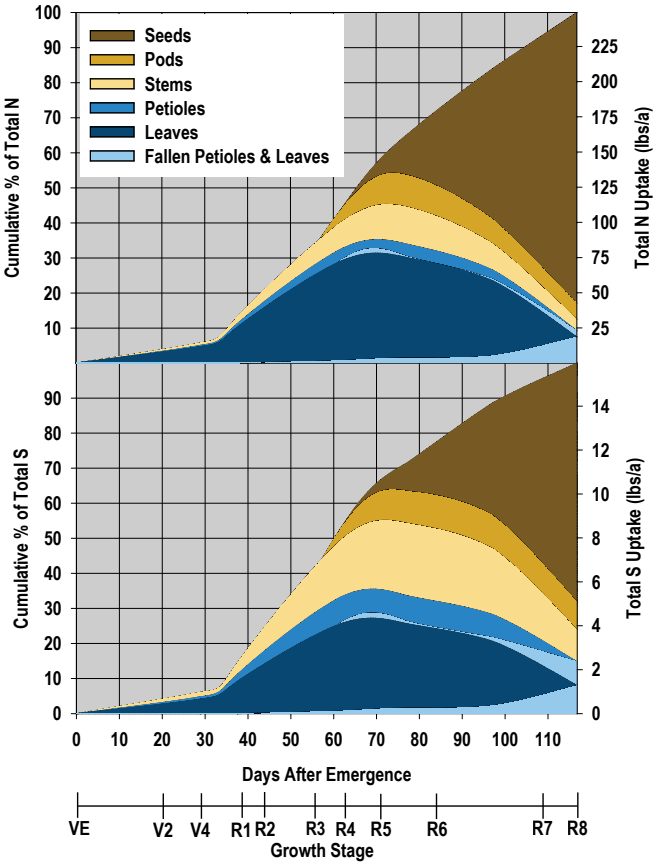

Figure 3. N and S uptake, partitioning, and remobilization through the growing season for a 66 bu/acre soybean crop.

- Uptake prior to R1 was minimal. Leaves were shown to be large storage organs for N and S, while stems also held large amounts of S. After R5.5, 68 and 50% of vegetative N and S, respectively, were remobilized to the seed (Figure 3).
- This remobilization, combined with large amounts of seed N and S acquired from uptake after R5.5, resulted in nutrient harvest indexes of 83 and 68% for N and S, respectively (Figure 3).

N and S Removal with the Grain

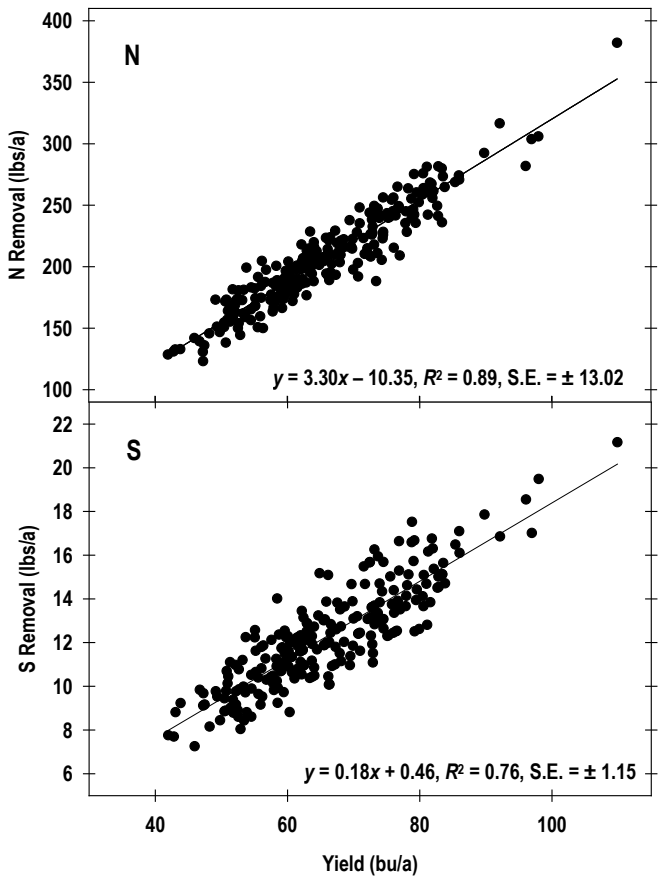

Figure 4. Total N and S removal with the seed at growth stage R8 (full maturity) across all environments and varieties.

- Total removal with the harvested grain was 3.30 lbs of N/bu/acre and 0.18 lbs of S/bu/acre, resulting in an 80 bu/acre soybean crop removing 254 and 15 lbs of N and S, respectively (Figure 4).
- N removal per bushel of grain didn't differ between varieties or environments. S removal did vary by variety, but differences were small enough to have no meaningful management implications.

Conclusions

- Total soybean N requirements were less than previously reported due to greater vegetative remobilization, increased uptake directly to the seed after R5, and a higher nitrogen harvest index.
- Early season N and S applications are likely non-beneficial as peak uptake occurred near R3-R4, while approx. 50% of total N uptake happened after R5.
- Growers should focus on building organic matter and maximizing N2 fixation to provide a season long N supply rather than focusing on a single in-season N fertilizer application.

Research conducted by Adam Gaspar and Shawn Conley, University of Wisconsin-Madison as a part of the Pioneer Crop Management Research Awards (CMRA) Program. This program provides funds for agronomic and precision farming studies by university and USDA cooperators throughout North America. The awards extend for up to four years and address crop management information needs of Pioneer agronomists, sales professionals and customers.