AGRONOMY RESEARCH UPDATE

Soybean Micronutrient (Zn, Mn, Cu, Fe, B) Uptake, Partitioning, and Removal | 2016

Rationale and Objectives

- In recent decades, growers have become more specialized in specific facets of production. Application of manure has been eliminated on some agriculture land due to the geographical separation of crop production and livestock. Therefore, synthetic fertilizers are the main source of various micronutrients for crop production.
- Furthermore, annual increases in soybean yield and marketing tactics of some agricultural retailers have growers concerned that soybean yield is limited by soil micronutrient supply. Consequently, applications of micronutrients have become more common in recent years, even though there is little research data to support these applications.
- Knowledge of actual soybean micronutrient uptake requirements and utilization across a wide seed yield range coupled with soil and tissue tests would be beneficial for determining when applications of certain micronutrients can be profitable.

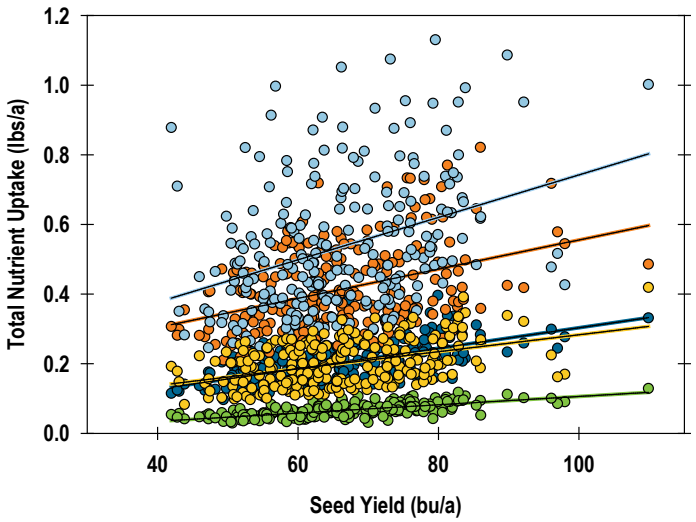
Study Description

- **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
  - -Petioles
  - -Leaves
  - -Pods
  - -Seeds
  - -Fallen Leaves/Petioles
- **Nutrients Quantified:** Zinc, Manganese, Copper, Iron, Boron
- 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.

Research conducted by Adam Gaspar and Shawn Conley, University of Wisconsin-Madison as a part of the DuPont 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 DuPont Pioneer agronomists, Pioneer sales professionals and customers.

Micronutrient Total Uptake



Nutrient	Equation	R^2	S.E.
Zinc (Zn)	$y = 0.003x + 0.009$	0.33	0.05
Manganese (Mn)	$y = 0.004x + 0.136$	0.15	0.11
Copper (Cu)	$y = 0.001x - 0.013$	0.50	0.01
Iron (Fe)	$y = 0.006x + 0.132$	0.13	0.18
Boron (B)	$y = 0.002x + 0.041$	0.19	0.06

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

- Total uptake for a high yielding, 80 bu/acre soybean crop was less than 0.61 lbs/acre for all micronutrients.
- Furthermore, total uptake for each micronutrient was heavily affected by the environment and/or variety, meaning that total uptake was variety by field by year specific.
- These interactions resulted in large variability in estimating total uptake with yield across all varieties and environments (R^2 = 0.13 – 0.50) (Figure 1). However, this variability translates into small differences in actual lbs/acre and therefore, these single equation are sufficient for applicable broad scoping recommendations.
- While actual (lbs/acre) differences are small, the variability may help explain the inconsistent yield responses to foliar micronutrient applications experienced by many growers and documented in multiple studies where different varieties and environments were employed.

Micronutrient Uptake Rate

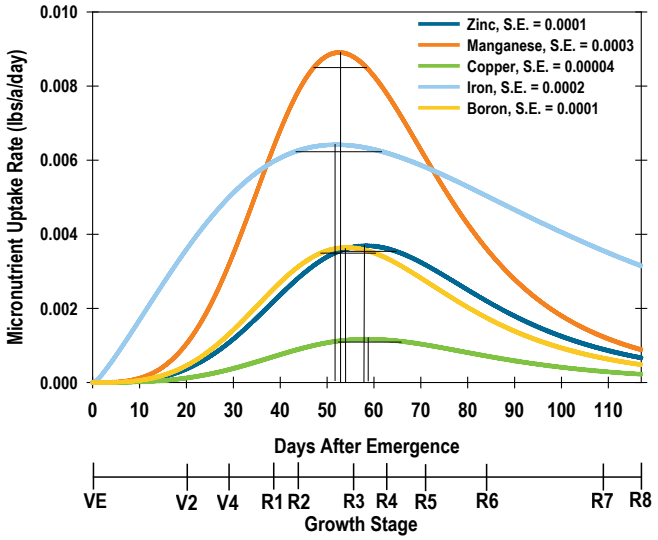
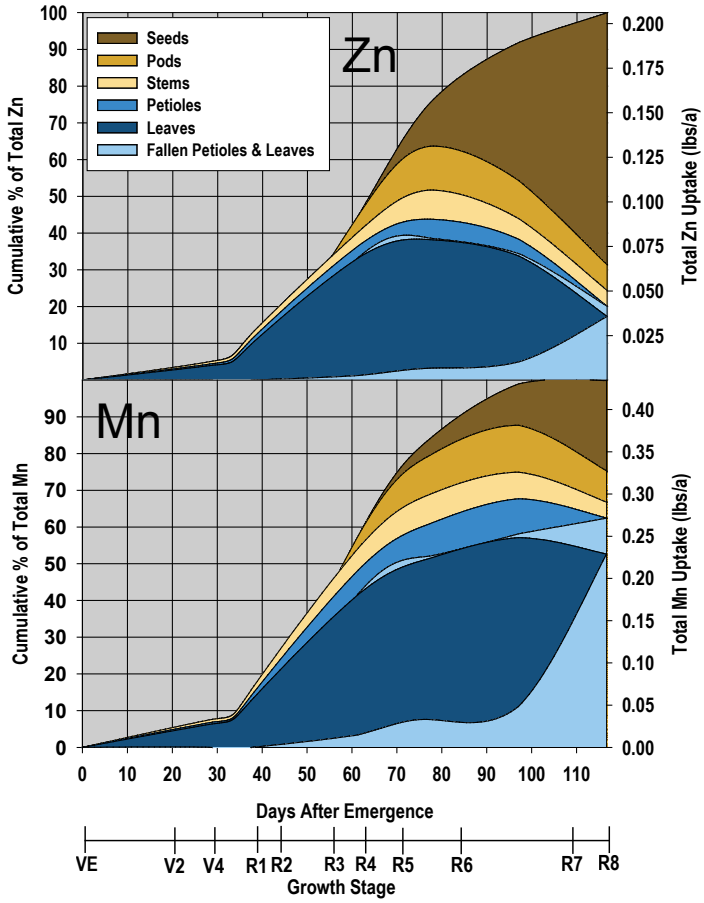


Figure 2. Micronutrient uptake rate through the growing season for a 66 bu/acre soybean crop. Duration of peak uptake period for each micronutrient is represented by a horizontal black line.

- Micronutrient demand during vegetative growth stages was minimal. In contrast, uptake rates peaked between R2-R4 (Figure 2), suggesting that if in-season foliar applications are planned they should be made by R3 to match peak uptake periods to potentially increase the probability of a positive yield response.

Micronutrient Partitioning and Utilization



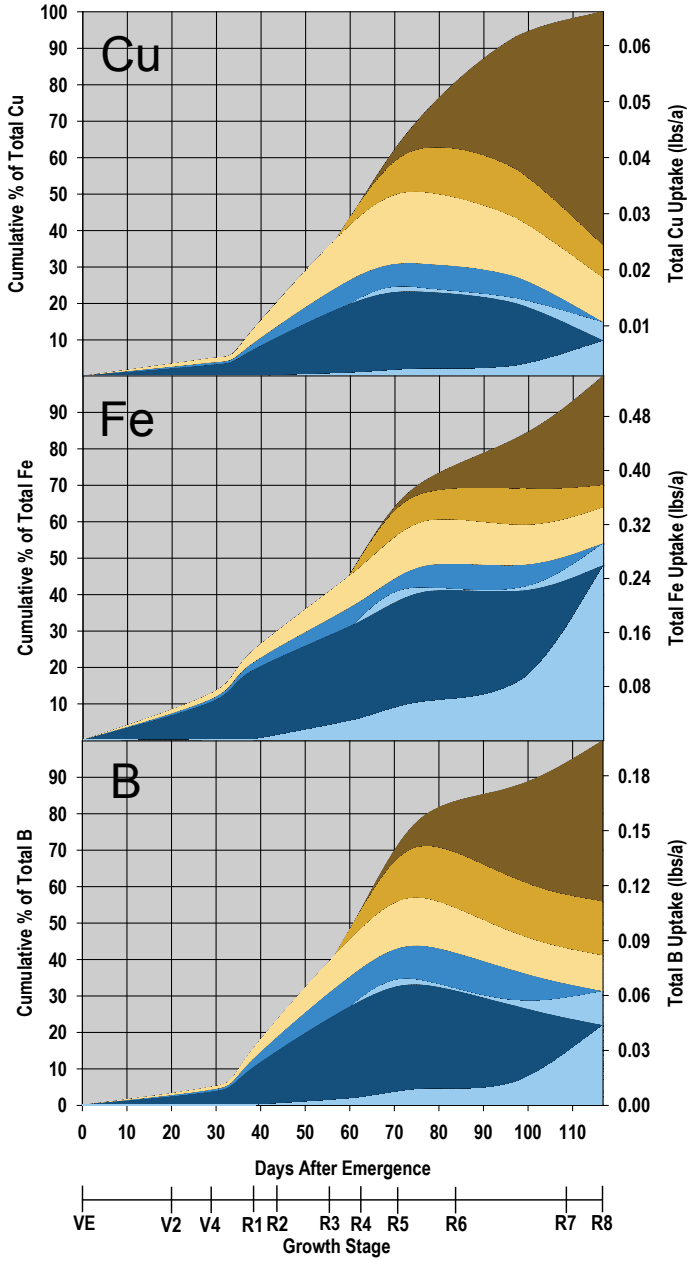
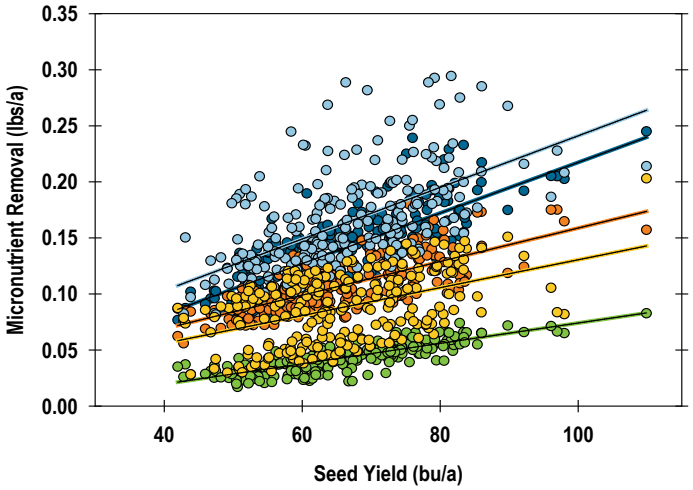


Figure 3. Micronutrient uptake, partitioning, and remobilization through the growing season for a 66 bu/acre soybean crop.

- Uptake prior to R1 was minimal for all micronutrients except for Fe, which approached 25%. Greater than 80% of all Mn and B was acquired by R5.5, whereas uptake during seed fill was greater for Zn and Cu (Figure 3).
- At R5.5, relatively large portions of total Zn (46%), Mn (52%), and B (35%) were held in leaf tissue while stem tissue accumulated a majority of the Cu (27%) (Figure 3).
- After R5.5, vegetative Zn and Cu remobilization was greatest, while Mn and B remobilization to the seed was minimal and Fe saw no mobility to the developing seed.
- The importance of Mn and Fe uptake after R5 cannot be understated as this accounted for 83 and 100%, respectively, of the seeds' demand for these nutrients. Zn, Cu, and B still met the majority (>50%) of seed nutrient demand through uptake past R5, signifying the importance of season long micronutrient availability, although in small amounts.

Micronutrient Removal with the Grain



Nutrient	Equation	R^2	S.E.
Zinc (Zn)	$y = 0.002x - 0.009$	0.59	0.02
Manganese (Mn)	$y = 0.002x + 0.009$	0.51	0.02
Copper (Cu)	$y = 0.001x - 0.017$	0.66	0.01
Iron (Fe)	$y = 0.002x + 0.01$	0.34	0.04
Boron (B)	$y = 0.001x + 0.006$	0.22	0.03

Figure 4. Total micronutrient removal with the seed at growth stage R8 across all environments and varieties.

- Removal with the grain for an 80 bu/acre soybean crop totaled less than 0.2 lbs/acre for all micronutrients (Figure 4), meaning biennial soybean production is not a large source of removal.
- The variability was less in the nutrient removal – yield relations (R^2 = 0.22-0.66) compared to that of nutrient uptake (Figure 1). However, Zn, Mn, and B removal relations were still affected by the environment and/or variety.
- However, due to the small amount of actual nutrient removal, differences were not large enough to have applicable implications, and thus, single equations are biologically sufficient.

Conclusions

- Total soybean nutrient uptake was less than 1 lb/acre for yields as high as 100 bu/acre. Iron requirements were the greatest followed by Mn, Zn, B, and Cu.
- Like that of all macro and secondary nutrients, soybean demand for these five micronutrients was greatest near R3, while early season demand was extremely low.
- Minimal total uptake (Figure 1) and relatively low nutrient harvest indexes (25-69%) resulted in extremely small amount of micronutrient removal with the seed, even at yield levels above 100 bu/acre.
- In conclusion, the relatively small quantities of these micronutrients required (<0.5 lbs/acre) and removed (<0.15 lbs/acre) at an average soybean yield level (60 bu/acre) are likely met when soil pH and water drainage are managed correctly.
- Specific soil types and environments may require application of specific micronutrients and, in such cases, these findings can be employed to build a sound micronutrient fertility program.