AGRONOMY RESEARCH UPDATE

Soybean Phosphorus and Potassium Uptake, Partitioning, and Removal

2016

Rationale and Objectives

- Greater genetic yield potential, combined with physiological changes and improved management practices, has lead to annual increases in the average national soybean yield (0.4 bu/acre/year) and greater frequency of growers achieving yields greater than 75 bu/acre throughout the Midwest.
- Phosphorus and potassium fertilization is likely the most critical annual fertility decision growers make. Fertility programs should not limit soybean yield, while still being environmentally sound.
- Therefore, precise knowledge of soybean P_2O_5 and K_2O requirements (specifically crop removal) across a wide yield range is critical for environmentally and economically sustainable fertility programs, while in-season P_2O_5 and K_2O utilization is beneficial for various management decisions.

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:** Phosphorus and potassium, presented in fertilizer equivalents (P_2O_5 and K_2O)
- 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.

Total P_2O_5 and K_2O Uptake

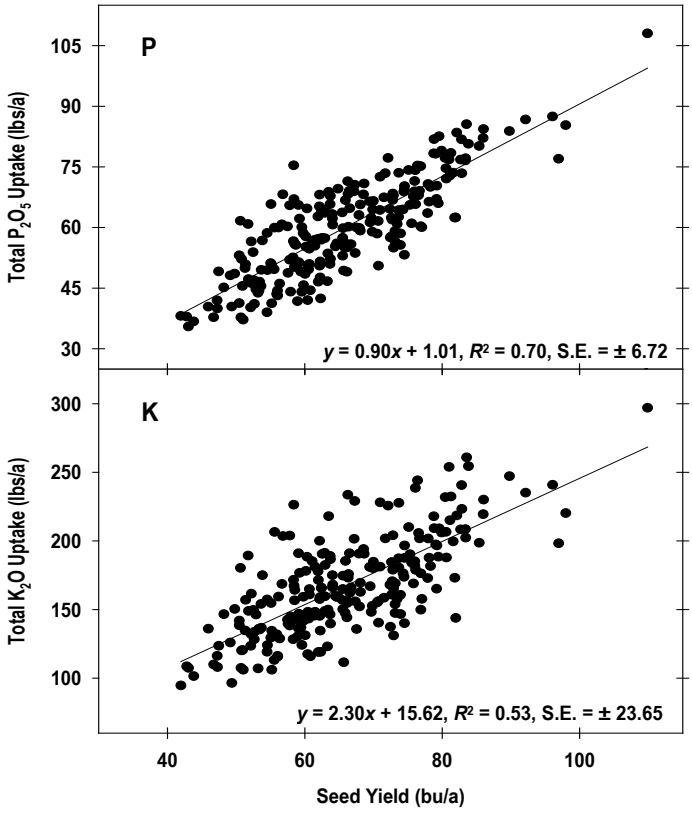

Figure 1. Total whole plant P_2O_5 and K_2O uptake at growth stage R8 (full maturity) across all environments and varieties.

- Across all environments and varieties, the soybean plant took up an average of 0.9 lbs of P_2O_5/bu/acre. Potassium uptake was more than double this at 2.3 lbs of K_2O/bu/acre. Therefore, an 80 bu/acre soybean crop accumulated 73 and 200 lbs of P_2O_5 and K_2O, respectively, by R8 (Figure 1).
- More variability existed in the relationships between P_2O_5 and K_2O uptake and yield than the relationship between N uptake and yield (R^2 = 0.80). This was due to the fact that both P_2O_5 and K_2O uptake were greatly affected by the environment, with K_2O experiencing the greatest variability in uptake associated with environmental differences and therefore lowest R^2 value.
- As displayed in Figure 3, 90% of total K_2O uptake is accumulated by R5 (beginning seed fill) but seeds/m^2 and seed size are far from being determined. This lack of overlap and the fact that soybean is a luxury K_2O consumer certainly contribute to the moderate relationship between total K_2O uptake and seed yield (R^2 = 0.53) (Figure 1).

P_2O_5 and K_2O Uptake Rate

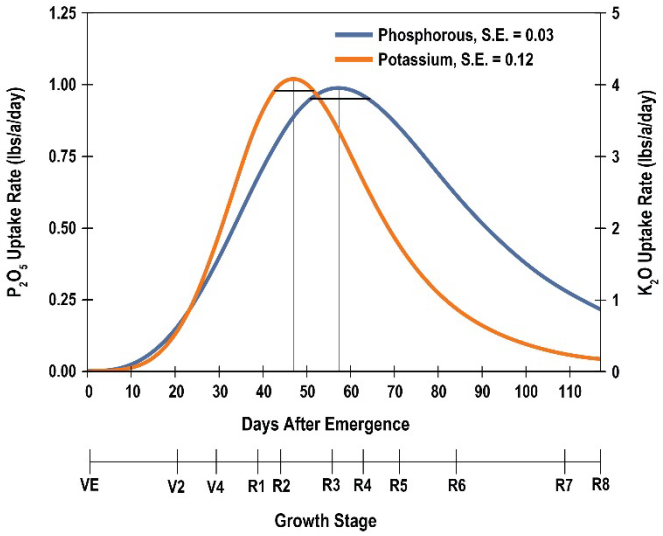

Figure 2. P_2O_5 and K_2O uptake rate through the growing season for a 66 bu/acre soybean crop. Duration of peak uptake period is represented by a horizontal black line.

- The potassium uptake rate accelerated quickly after V2 to a peak rate of 4 lbs K_2O/acre/day at R2 and then sharply decelerated through R6 (Figure 2).
- Phosphorus displayed a more gradual build and decline before and after the peak uptake rate (1 lb P_2O_5/acre/day), which occurred at R3 (Figure 2).

P_2O_5 and K_2O Partitioning and Utilization

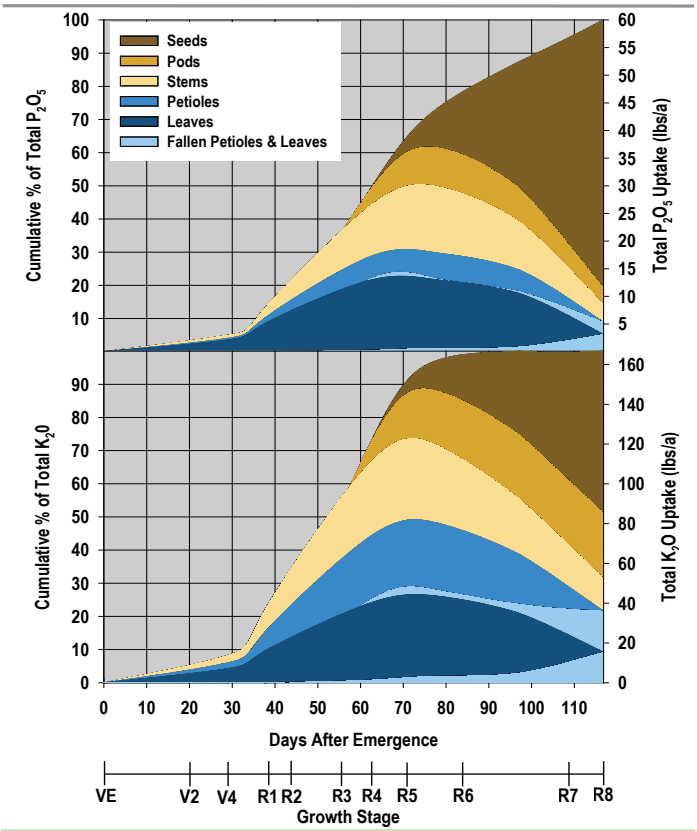

Figure 3. P_2O_5 and K_2O uptake, partitioning, and remobilization through the growing season for a 66 bu/acre soybean crop.

- Relative uptake prior to R1 was minimal for P_2O_5 (13%), but greater than 25% for K_2O. Leaves and stems were large storage organs for P_2O_5, while K_2O was more equally distributed to all plant parts.
- Seed K accumulation relied more heavily on vegetative remobilization compared to P_2O_5 (76 vs. 52%), yet the nutrient harvest index (HI) was much higher for P_2O_5 (81%) than K_2O (49%) and was similar to the N HI (83%) at the same yield level (Figure 3).
- The large K_2O uptake requirement (2.3 lbs K_2O/bu/acre) and low K_2O HI makes stover removal a major pathway for K_2O removal and soil K_2O depletion if not replaced with fertilizer.

P_2O_5 and K_2O Removal with the Grain

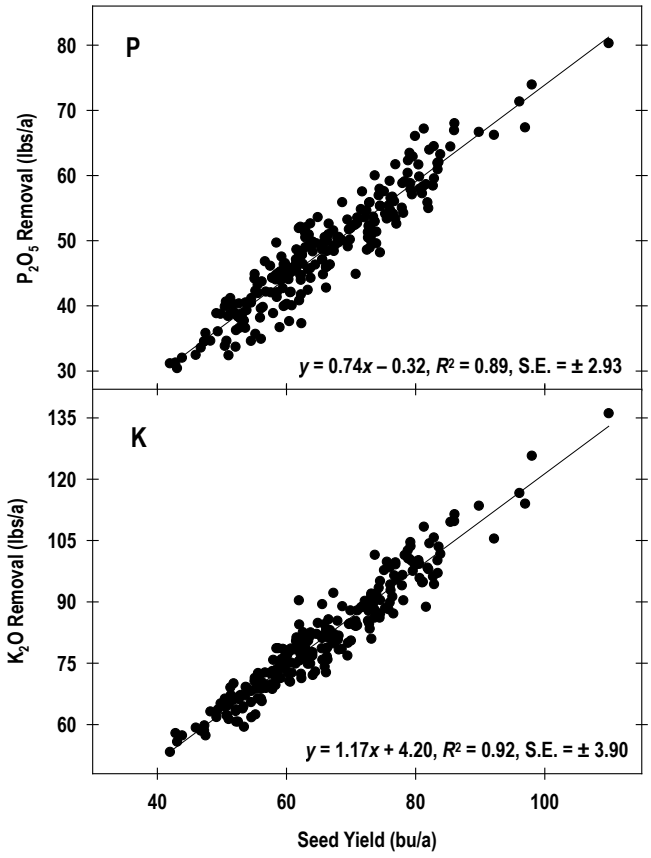

Figure 4. Total P_2O_5 and K_2O removal with the seed at growth stage R8 across all environments and varieties.

- Total P_2O_5 (0.74 lbs./bu/acre) and K_2O (1.17 lbs/bu/acre) removal with the grain was consistent across all varieties and environments. Therefore, an 80 bu/acre soybean crop removed 59 and 98 lbs of P_2O_5 and K_2O, respectively (Figure 4).
- In comparison a 200 bu/acre corn crop would remove similar amounts of P_2O_5, but only half the amount of K_2O.

Conclusions

- Soybean K_2O uptake varied considerably by environment and was utilized and removed with the grain in greater quantities than P_2O_5.
- Moreover, the K_2O HI was much less than that of P_2O_5, making stover harvest a large avenue for K_2O removal.
- Peak uptake rates occurred at R2 and R3 for K_2O and P_2O_5, respectively, with K_2O partitioned more equally between all plant parts compared to P_2O_5, which accrued mainly in leaves and stems.