# Full-Season, Irrigated Soybean Response to Potassium Fertilization in Arkansas

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**Soil test correlation and fertilizer rate calibration studies in Arkansas showed that soil test K is an excellent means of characterizing the need for K fertilization of soybeans on silt loam soils in eastern Arkansas. Significant yield increases with K fertilization occurred at 10 of 19 harvested sites, with soil test K ranging from 46 to 167 ppm. Tissue analyses results indicate 1.8% K may be needed in soybean leaves to achieve 90% of maximum yield.**

About 60% of the 3 million acres of soybeans [*Glycine max* (Merr.) L.] grown annually in Arkansas receive irrigation. Many of the soybeans are rotated with rice (*Oryza sativa* L.) and sometimes double-cropped following winter wheat (*Triticum aestivum* L.). The soils have low (sandy and silt loams) to high (clayey) cation exchange capacities. Many of the silt loams have shallow topsoil, low organic matter (1.0 to 2.5%), and a hardpan (3 to 6 in. deep) which restricts water infiltration and rooting depth.

These soil characteristics are ideal for flood-irrigated rice production, but offer significant challenges for upland crops grown in rotation. Despite these challenges, these soils can produce good soybean yields, with a high level of management.

Existing P and K fertilizer recommendations developed in the 1980s for soybean have been questioned because of higher soybean yield potential, crop rotation changes, and increased fertilizer costs. Field observations and analysis of soybean tissues submitted for nutrient analysis indicate that K deficiency is becoming more common in Arkansas.

**Tissue analyses** results indicate 1.8% K may be needed in soybean leaves to achieve 90% of maximum yield.

The objective of the research reported here was to evaluate full-season, irrigated (as needed or feasible) Group IV (five sites) or V (16 sites) soybean cultivar response to K fertilization on silt loam soils. Before K fertilizer treatments were applied (March to May) a composite soil sample was collected from the 0 to 4 in. depth from each replicate of each study to characterize initial soil properties (**Table 1**). Five rates (up to 150-160 lb $K_2O$/A) of muriate of potash were broadcast to the soil surface shortly before or after planting. Triple superphosphate (~60 lb $P_2O_5$/A) was applied to ensure that P was not yield limiting and granular boron (B) fertilizer (1.0 lb B/A) was also applied to most, but not all, fields. Each trial was a randomized complete block design with 6 to 8 replications. Recently matured trifoliate leaves (20)

**Table 1.** Selected soil and agronomic information from 21 K fertilization trials conducted in Arkansas since 2004 on silt loam soils.

| | | | Unfertilized control data | | | Yield |
|---|---|---|---|---|---|---|
| Soil series | Soil pH | Mehlich 3 soil test K, mg/kg | Actual yield, bu/A | Relative yield, as % of maximum with K, % | Tissue K, % | Significance compared to K treatments, p-value |
| Bonn-Foley | 7.6 | 46 | 26 | 59 | 0.80 | 0.0016 |
| Calhoun | 7.1 | 65 | 42 | 70 | 1.42 | <0.0001 |
| Calhoun | 7.6 | 71 | 40 | 76 | 1.55 | 0.0003 |
| Hillemann | 8.2 | 72 | 43 | 77 | 1.68 | 0.0008 |
| Calhoun | 7.8 | 73 | 46 | 70 | 1.27 | 0.0197 |
| Calhoun | 7.9 | 85 | 45 | 78 | – | 0.0045 |
| Hillemann | 8.2 | 86 | 49 | 74 | 1.27 | <0.0001 |
| Calhoun | 7.9 | 96 | 47 | 78 | 1.24 | 0.0002 |
| Henry | 7.6 | 98 | 37 | 97 | – | 0.5558 |
| Henry | 6.2 | 101 | 73 | 90 | 1.53 | 0.4139 |
| Calhoun | 7.9 | 102 | 55 | 88 | 1.58 | 0.0244 |
| Henry | 6.8 | 103 | 29 | 88 | 1.68 | 0.1960 |
| Calhoun | 7.9 | 103 | 50 | 81 | 1.53 | <0.0001 |
| Calloway | 7.8 | 104 | 53 | 93 | 1.75 | 0.1041 |
| Henry | 7.9 | 108 | – | – | 1.89 | – |
| Dewitt | 7.4 | 110 | 44 | 92 | 1.66 | 0.8618 |
| Hillemann | 6.5 | 117 | – | – | 1.71 | – |
| Dewitt | 5.4 | 125 | 30 | 97 | 1.94 | 0.3607 |
| Dewitt | 5.3 | 154 | 77 | 97 | 1.71 | 0.4072 |
| Calloway | 7.2 | 154 | 51 | 96 | 2.18 | 0.9108 |
| Calhoun | 7.5 | 167 | 64 | 94 | 2.14 | 0.5215 |

**Abbreviations and notes for this article:** K = potassium; P = phosphorus; ppm = parts per million;

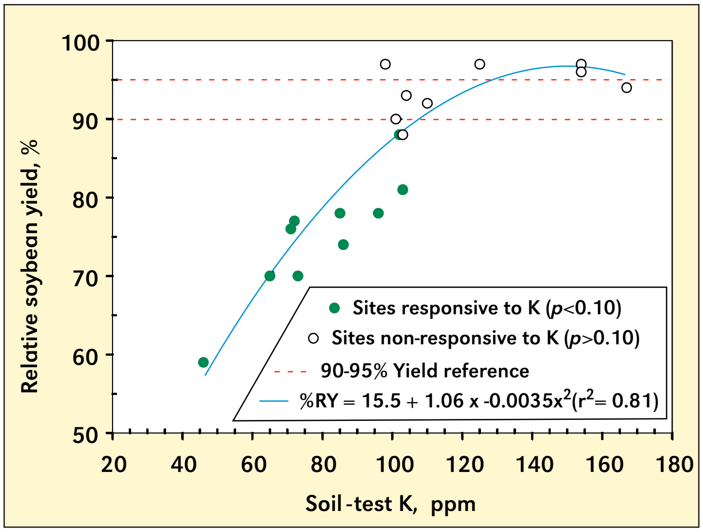


**Figure 1.** Relationship between soil test K (0 to 4 inches) and relative yield of soybean grown on silt loam soils in Arkansas.

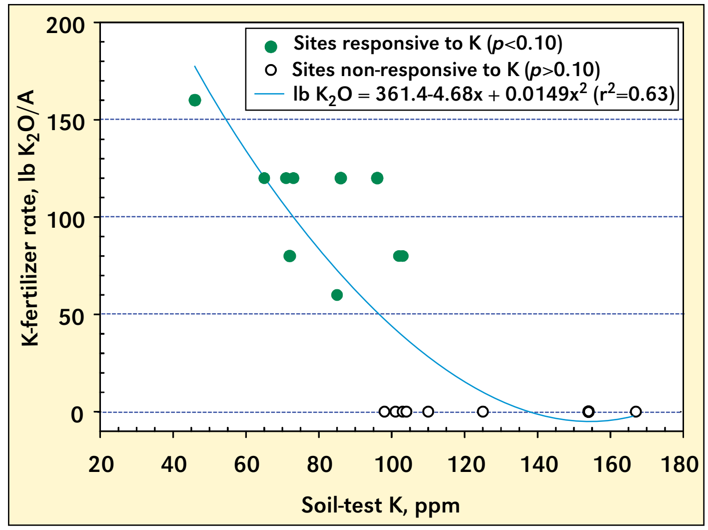


**Figure 2.** Relationship between soil test K and $K_2O$ rate (lb/A) needed to produce 95% relative yield of soybean grown on silt loam soils in Arkansas.

were collected from each plot at the R1-R2 growth stage and analyzed for nutrient concentrations. The middle of each plot was harvested with a plot combine at maturity and actual yields were converted to percent relative yield, by dividing the unfertilized control yield by the highest yielding treatment receiving K fertilizer at each site, multiplied by 100.

Significant ($p<0.10$) yield increases from K fertilization occurred at 10 of the 19 harvested sites (**Table 1**). All sites showing positive and significant yield increases to K fertilization had 0 to 4 in. soil test K <110 ppm. Only four harvested sites had soil test K >110 ppm, none of which showed significant yield increases to K fertilization. Sypmtoms of K deficiency were observed on about half of the responsive sites, which may suggest that growers have been unaware of hidden K hunger.

The analyses showed that 81% of the variability in soybean yield was explained by soil test K (**Figure 1**). Soils with soil test K from 111 to 137 ppm produced 90 to 95% of soybean maximum yield potential without K fertilization. Based on this estimate of a critical soil test K, over 50% of the soil samples submitted for soybean production in Arkansas require K fertilization to reach maximum yield potential.

Potassium fertilization produced significant yield increases at 7 of 7 sites with soil test K <91 ppm (Low or Very Low soil test K), at 33% (3 of 9 sites) of the fields with soil test K of 91 to 130 ppm (Medium), and 0% (0 of 3 sites) of the fields with soil test K >130 ppm (Optimum). The average K rates needed to produce near maximum yields averaged 160, 87, 31, and 0 lb $K_2O$/A for soils having Very Low, Low, Medium, and Optimum soil test K levels, respectively. Soybean did not respond to K fertilization consistently when soil test K ranged from about 95 to 110 ppm (**Figure 1**).

The $K_2O$ rates needed to produce 95% relative yield were estimated by regressing the K fertilizer rate that produced 95% relative yield against soil test K. For sites with no significant yield differences among K rates, the K rate needed to produce 95% relative yield was entered as 0 lb $K_2O$/A. The rate of K needed to maximize soybean yields increased rapidly as soil test K declined (**Figure 2**), but was nominal as the soil test K approached 100 ppm.

The profitability of K fertilization was calculated using the estimated benefits of K fertilization (**Figure 1**) with the predicted K rates (**Figure 2**) needed to maximize soybean yields, with reasonable price estimates for muriate of potash and soybean (**Table 2**). The economic benefits of K

**Table 2.** Estimated yield potential, K fertilizer rates, and net returns from K fertilization of soybean in Arkansas.

| | Predicted information | | | | | |
|---|---|---|---|---|---|---|
| Mehlich 3 soil test K, ppm | Relative yield[1] % | Actual yield[1] bu/A | $K_2O$ rate[2], lb $K_2O$/A | Fertilizer cost[3], $/A | Net returns from K fertilization @ $6.00/bu soybean[4], $/A | Net returns from K fertilization @ $7.50/bu soybean, $/A |
| 50 | 60 | 32 | 164 | $36.90 | $71.10 | $98.10 |
| 60 | 67 | 35 | 134 | $30.15 | $59.85 | $82.35 |
| 70 | 73 | 38 | 107 | $24.08 | $47.93 | $65.92 |
| 80 | 78 | 41 | 82 | $18.45 | $35.55 | $49.05 |
| 90 | 83 | 43 | 61 | $13.73 | $28.28 | $38.77 |
| 100 | 87 | 45 | 42 | $9.45 | $20.55 | $28.05 |
| 110 | 92 | 47 | 27 | $6.08 | $11.93 | $16.42 |
| 120 | 94 | 48 | 14 | $3.15 | $8.85 | $11.85 |
| 130 | 94 | 49 | 5 | $1.13 | $4.88 | $6.37 |
| 140 | 95 | 50 | 0 | $0.00 | $0.00 | $0.00 |

[1] Predicted relative (Figure 1) and actual yields when no K fertilizer is applied. Predicted actual yield assumes a maximum yield potential of 50 bu/A when soil test K is >140 ppm.

[2] Predicted rate of $K_2O$ fertilizer/A to maximize soybean yields.

[3] Estimated $K_2O$ fertilizer costs assuming $0.225 per pound of $K_2O$.

[4] Estimated net return above $K_2O$ fertilizer rate when the recommended $K_2O$ rate is applied.

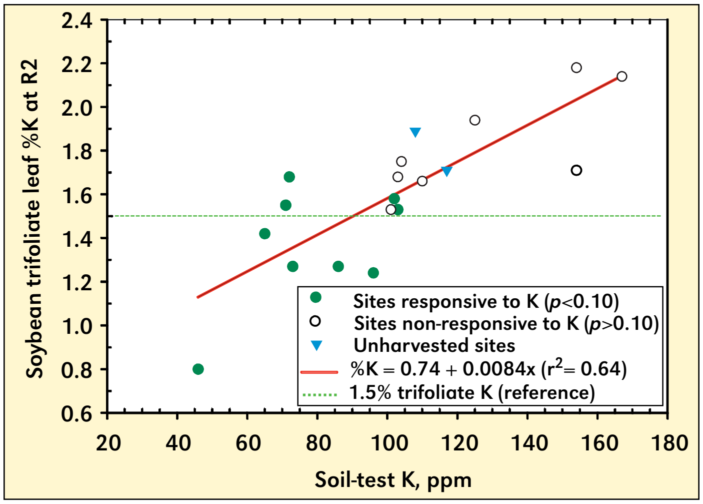


**Figure 3.** Relationship between soil test K (0 to 4 in.) and trifoliate leaf K concentration at R2 stage of soybean grown on silt loam soils in Arkansas.

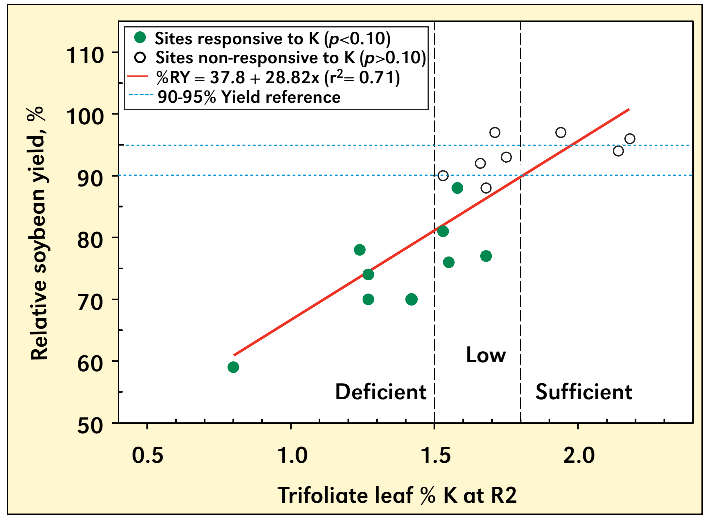


**Figure 4.** Relationship between trifoliate leaf K concentration at R2 stage and relative yield of soybean grown on silt loam soils in Arkansas.

fertilization are clear when soil test K is <90 to 100 ppm. When soil-test K was >90 to 100 ppm, the frequency of significant yield increases from K fertilization was less certain, and application of K rates greater than those predicted for maintaining near maximum yields may be desired to simply replace K removed in harvested grain to sustain soil productivity.

Potassium concentration of recently matured trifoliate leaves at the R2 stage increased linearly as soil test K increased (**Figure 3**, $r^2 = 0.64$, n = 19). Tissue K concentrations at R2 were also excellent predictors of relative yield response to K fertilization (**Figure 4**). These data clearly indicate that unfertilized soybean with <1.5% K at R2 respond positively to K fertilization, but the critical K concentration at R2 for irrigated soybean grown on silt loam soils in Arkansas may be >1.5%, in contrast with much of the published literature. Our data indicate about 1.8% tissue K to achieve 90% relative yield. Significant yield increases from K fertilization occurred at 4 of 9 sites with tissue K concentrations between 1.5 and 1.8%. Two other sites with tissue K <1.8% showed non-significant trends for positive yield responses to K fertilization. Trifoliate leaf K concentrations <1.5% K at initial pod set are clearly deficient and concentrations ranging from 1.5 to 1.8% should likely be categorized as Low.

**Young soybeans** showing K deficiency symptoms.

## Summary

Fertilizer recommendations for irrigated soybean in Arkansas were changed in 2006 to reflect the need for greater K fertilizer rates on soybean grown on sandy loam to silt loam soils with 'Medium' or 'Low' soil test K levels. Mehlich 3 soil test levels of Very Low (<61 ppm), Low (61 to 90 ppm), Medium (91 to 130 ppm), Optimum (131 to 175 ppm), and Above Optimum (>175 ppm) were established with associated recommended K fertilizer rates of 160, 120, 60, 50, and 0 lb $K_2O$/A, respectively. The recommended K rates are aimed at producing near maximal soybean yields while building and maintaining soil test K in the Medium soil test level. Recommendations may be refined in future years as additional data are collected.

An ongoing K study in Arkansas suggests that 60 lb $K_2O$/A/yr, which approximates crop K removal during a 2-year rice-soybean rotation cycle, has maintained the initial soil test K after four rice and three soybean crops with average yields of 163 bu/A for rice and 44 bu/A for soybean. Annual applications of K rates >60 lb $K_2O$/A/yr have increased soil test K by 1 ppm for each 4 lb $K_2O$/A/yr, and in some years have produced greater crop yields than 60 lb $K_2O$/A/yr. Arkansas soybean growers have been encouraged to use these K recommendations as a general guideline and to make adjustments when individual field history indicates higher yields and greater annual K removal rates. BC

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## For further reading


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