5-1990

Response of Soybeans to Available Potassium in Three Kentucky Soils

John H. Grove
University of Kentucky, jgrove@uky.edu

William O. Thom
University of Kentucky, william.thom@uky.edu

Lloyd W. Murdock
University of Kentucky, lmurdock@uky.edu

James H. Herbek
University of Kentucky, james.herbek@uky.edu

UNIVERSITY OF KENTUCKY
COLLEGE OF AGRICULTURE
Lexington, Kentucky 40546

COOPERATIVE EXTENSION SERVICE

AGRONOMY NOTES

Volume 23, No. 6 May 1990

RESPONSE OF SOYBEANS TO AVAILABLE POTASSIUM IN THREE KENTUCKY SOILS

J.H. Grove, W.O. Thom, L.W. Murdock and J.H. Herbek

Soybeans are produced in nearly all of Kentucky's soil physiographic regions. Soybean response to potassium (K) fertilization and soil test K varies with soil type and location. This variation may be associated with the wide range in soil chemical and mineralogical properties among the different regions. Of particular interest are differences in that level of soil test K at which no further yield response to K fertilizer application would be expected. The main objective of this work was to evaluate the soil K-soybean response relationship on three different field sites where soybean yields were increased by fertilizer K. Several measures of soil K availability were related to soybean yield.

EXPERIMENTAL METHODS

Some general characteristics of the topsoil at each of the three sites are given in Table 1. The three soils have similar organic matter levels. Though all were classified as silt loams, the Belknap soil has about half as much clay as the other two. The soils are similar in mineralogy, despite their diversity in location. All these soils contain K-feldspar minerals in their silt size fraction, with the Belknap containing the most (20%) and the Maury the least (10%). Soil pH levels were similar and favorable for soybean production. Available phosphorus (P), determined by the Bray I extraction, was different at each location. Further differences in the soils/sites and plot management are detailed below:

Experiment One: Belknap Silt Loam

This somewhat poorly drained (0-2% slope) soil was located in Webster County. The study was begun with soybean in a corn-soybean rotation. The site was chisel plowed in the fall and five rates of fertilizer K (0, 60, 120, 180 and 240 lb K_2O per acre) were surface broadcast and disc incorporated each year prior to planting. Phosphorus fertilizer (80 lb P_2O_5 per acre) was applied to prevent P deficiency. No response to K was observed in the first (soybean) or second (corn) year of study. Mitchell soybeans were planted in 30 inch rows in May of the third year. Four replications of individual plots (10 rows wide and 60 feet long) were used. Plots were combine harvested in late October.

Experiment Two: Maury Silt Loam

This well-drained upland soil (0-2% slope) was located in Fayette County. The study was started in 1963 with three levels of P (0, 45 and 230 lb P_2O_5 per acre) and three levels of K (0, 60 and 240 lb K_2O per acre) in all possible combinations with four replications. Fertilizer applications were discontinued in 1975, leaving residual fertility to be evaluated. Williams soybeans were planted in 12 inch rows in early July, 1981, as a double-crop after wheat using a no-tillage drill. Individual plots were 30 feet wide and 30 feet long. Plots were harvested by combine on October 22.

Experiment Three: Tilsit Silt Loam

This trial was located in Caldwell County. The soil is moderately well drained (0-2% slope) and has a fragipan at a 20 to 24 inch depth. Soybeans were grown continuously for 3 years. Primary tillage was fall or spring chisel plowing. Potassium fertilizer rates were 0, 50, 100 and 200 lb K_2O per acre and were surface broadcast and disc incorporated, along with an annual P application (140 lb P_2O_5 per acre), just before planting. No response to K was observed in the first year. The second year, Pixie soybeans were sown at two row spacings, 9.5 and 30 inches, on June 9. Plot size was 10 feet wide by 30 feet long. The center rows were harvested by combine on October 27. Third year soybean yields were greatly reduced by drought and were not used in this analysis.

Leaf and Soil Sampling and Analysis

An uppermost, fully expanded trifoliate leaf sample was taken from each plot at early flowering. Soil samples were taken to a depth of 6 to 8 inches immediately following harvest. After sample preparation the K concentration of the leaf tissue and the extractable K, calcium (Ca) and magnesium (Mg) levels in the soils were determined. The soils were extracted according to one of the better known soil test procedures using neutral, normal ammonium acetate. Soils were also extracted with a less conventional water extraction using two parts soil and one part water (a watery paste). Cations were determined using atomic absorption spectroscopy.

RESULTS

Potassium fertilizer application significantly increased soybean leaf K concentration and grain yield (Table 2) at all three locations. Yield levels ranged widely due to differences in cultivars, planting dates and production environments. Reducing the row spacing from 30 to 9.5 inches raised yields an average of 8.9 bushels/acre on the Tilsit soil. The lowest yield of the Pixie soybeans on the Tilsit soil was higher than the highest yields at the other two locations. Because of this, plot yield values were expressed as a percentage of the highest mean treatment yield (relative yield) for each experiment (within row spacing in the third experiment). This enabled combination of yields from the three locations for further evaluation.

Leaf K concentrations of 1.78 to 2.35% corresponded to a relative yield range of 90 to 100%. This is similar to the "sufficiency range" established for soybean K nutrition previously. Close inspection of the data in Figure 1a suggests that the three experiments, though similar, behave somewhat individually. When relationships were determined for each trial separately (not shown here) the leaf K concentrations associated with a relative yield of 95% were 2.46, 2.06 and 1.75% for the Mitchell, Williams and Pixie cultivars, respectively. It is not clear whether such differences were due more to the soil and climatic environment or to genetic differences among the cultivars.

The relationship of relative yield to ammonium acetate extractable soil K is shown in Figure 1b. The derived equation predicts that an extractable soil K level of 84 ppm (168 lb/A) is required for 95% of maximum yield. The Belknap soil was particularly different from the other two soils, and would reach 95% relative yield at a lower level of extractable K. Therefore, the equation in Figure 1b appears to greatly overestimate the level of extractable soil K needed for a relative yield of 95% on this soil.

In an effort to find a better relationship with yield, extractable soil K was combined with extractable soil Ca and Mg in ratios (K/Mg, K/Ca and K/K+Ca+Mg). Such ratios are used to determine "cation balance" in the soil. No ratio was better related to relative yield than extractable K alone (Fig. 1b). The ratio of extractable K/K+Ca+Mg was not at all related to soybean yield.

Even though the amount of water soluble K found in the soil-water paste extraction was much lower than that removed by ammonium acetate extraction (Fig. 2a), it was clearly better related to relative yield. However, the Belknap soil still appears to respond a bit differently from the others in Figure 2a. Including water soluble Mg in a ratio (K/Mg) improved the relationship across the three soils (Fig. 2b).

CONCLUSIONS

The extractable K/K+Ca+Mg ratio is closely related to the basic cation saturation ratio (BCSR) method of soil test interpretation. The lack of relation between this ratio and soybean yields indicates that Kentucky soybean growers should avoid K fertilizer recommendations based upon exchangeable cation balance. Unlike the exchange phase, the balance between K and Mg in the *soil solution* appears to be of considerable importance. The response curve (Fig. 2b) suggests that once the water soluble K is high enough, the K/Mg ratio has little or no impact on soybean yields. If solution phase K availability falls, then a greater level of water soluble Mg will cause greater K deficiency.

Soybean yields were better related to water soluble K (Fig. 2a) and water soluble K/Mg (Fig. 2b) than to traditional ammonium acceptable extractable K (Fig. 1b). Though these results are useful, additional research on other crops and other soils is needed before the soil-water paste method becomes an established soil test procedure. Current recommendations for soybeans in Kentucky call for no K fertilizer application to soils with extractable K levels greater than 125 ppm K (equal to a soil test value of 300 lb/A using the new Mehlich III extractant). That guideline is supported by these results (Fig. 1b). There appears to be a reasonable allowance for errors in soil sampling and fertilizer application. Careful inspection of Figure 1b suggests that growers may achieve optimal soybean yields on Belknap and related soils at considerably lower average extractable soil test K levels.

Figure 1. Relative yield versus leaf K concentration (a) and ammonium acetate extractable soil K (b). Correlation coefficient (r) significant at the 99% level of confidence.

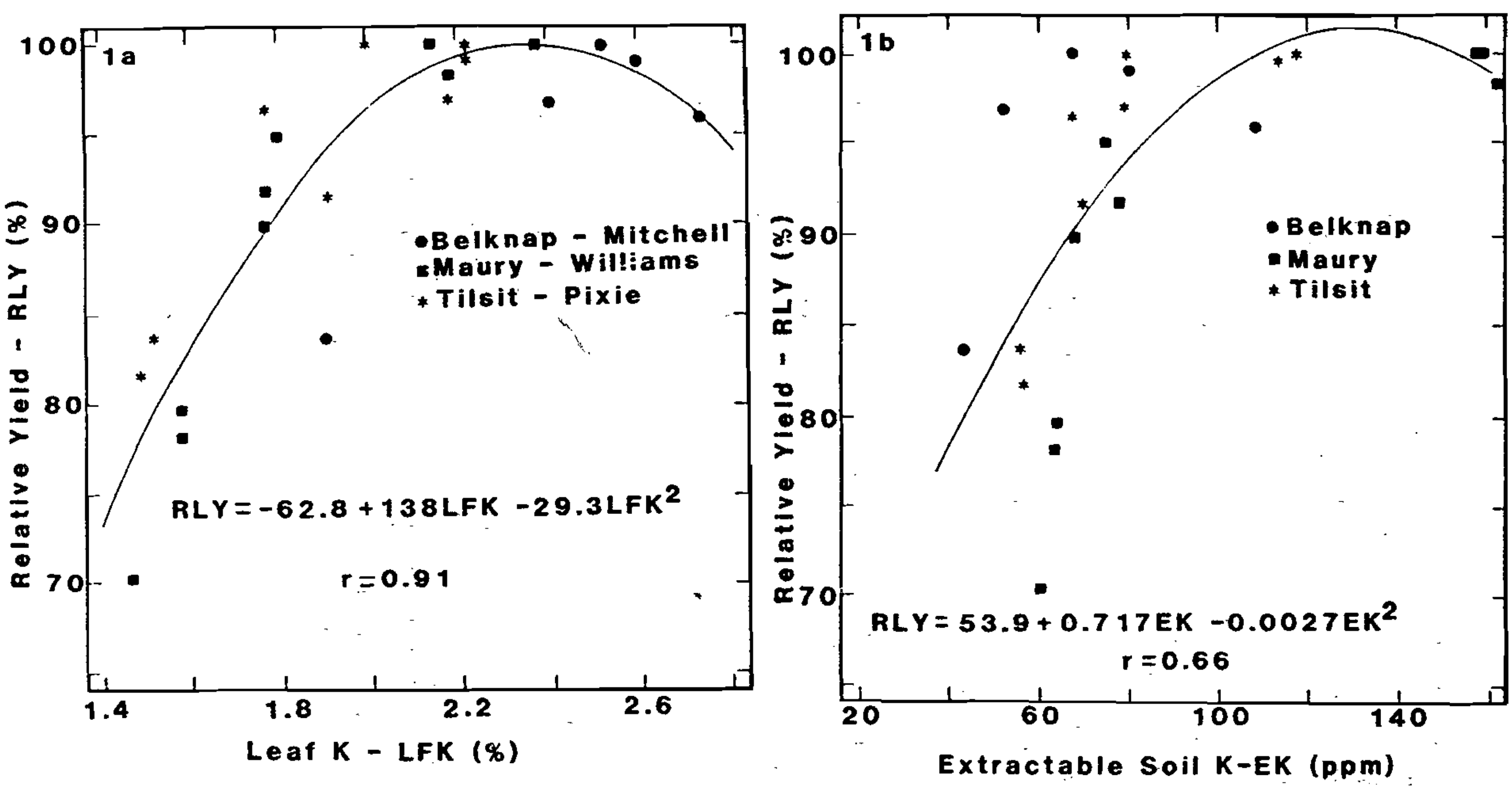

Figure 2. Relative yield versus water soluble K (a) and water soluble K/Mg (b). Correlation coefficient (r) significant at the 99% level of confidence.

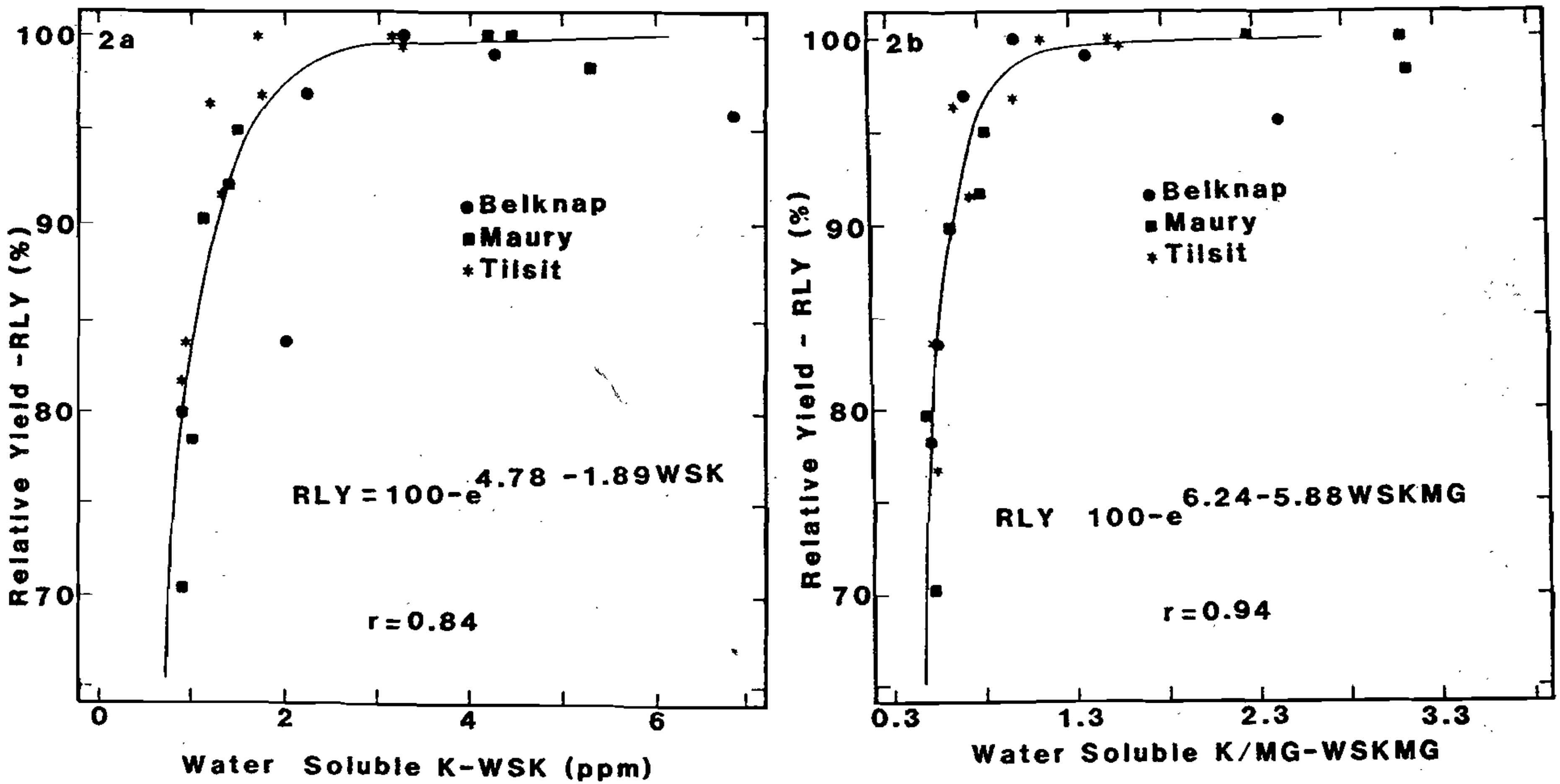

Table 1. Ap horizon properties at the three field sites.

Exp. No.	Soil Series	Content of: Organic C	Clay	Mineralogy of Clay Fraction: MoV*	Mi	K	Soil pH	Extractable P
		---- % ----		-------- % -------				---- ppm -----
1	Belknap	1.2	12	30	30	35	6.6	11
2	Maury	1.4	27	25	30	30	6.4	56
3	Tilsit	1.1	20	30	30	30	6.7	25

* MoV = montmorillonite and vermiculite, including chloritized portions of these minerals; Mi = mica; K = kaolinite.

Table 2. Soybean leaf K concentrations, grain yields and extractable soil K levels for the three experiments.

Annual K_2O Application	Leaf K	Grain Yield	Extractable Soil K
lb/acre	%	bu/acre	ppm
	Belknap silt loam		
0	1.90	35.8	44
60	2.40	41.5	53
120	2.52	42.8	68
180	2.59	42.4	81
240	2.74	41.0	109
LSD (0.05)	0.24	4.6	24
	Maury silt loam		
0*	1.53	31.2	63
60	1.78	37.8	74
240	2.23	40.7	159
LSD (0.05)	0.17	2.8	11
	Tilsit silt loam		
0	1.51	46.7**	57
50	1.84	53.1	69
100	2.09	55.5	79
200	2.22	56.3	115
LSD (0.05)	0.15	4.8	13

* Fertilizer applications discontinued in 1975.
**Average of two row spacings.

William O. Thom
Soils Extension Specialist