Refining Soil Test Recommendations for Soybean

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Objectives:

1. Test the performance of current University of Missouri soil test recommendations for predicting soybean response to P and K in a statewide network of experiments.
2. Explore the possibility that subsoil test values, soil type, or soil region could be used to improve our fertilizer recommendations and make them more site-specific.
3. Evaluate soybean response to S and B in Missouri, and evaluate factors that might help predict where responses to S or B are likely (including soil test S and B).
4. Test soybean response to N at planting or at early pod fill in a statewide network of experiments.

Methods:

- Experiments were added to an existing statewide network of 20 soybean variety trials conducted by the University of Missouri in 2000 and again in 2001. Variety testing personnel planted and harvested the experiments, as well as controlling weeds.
- Five experiments were located in northern Missouri, 5 in central Missouri, 5 in southwest Missouri, and 5 in southeast Missouri each year (Figure 1).
- Fields used in 2001 were different than fields used in 2000, though mostly on the same farms.
- N, P, K, S, and B fertilizers were hand-applied to separate plots at rates of 25 lb N, 80 lb P_2O_5, 120 lb K_2O, 20 lb S, and 1 lb B/acre. These rates should be high enough to produce full yield response. Two separate N timings were applied: at planting and at early pod fill.
- Two unfertilized check plots were used in each replication.
- Five replications were used.
- Soil samples were taken at depths of 0 to 6, 6 to 12, 12 to 24, and 24 to 36 inches in each experiment and analyzed for pH, NO_3^-, NH_4^+, P, K, S, and B.
- One well-adapted variety was used at each location (Tables 1 and 2).
- All experiments followed a previous crop of corn.
- 2001 experiments are in different fields than 2000 experiments.
- Eight experiments with N applications to soybean that were conducted by Bill Wiebold at the Bradford Research Center near Columbia are also included in analyzing the effects of N applications on soybean yield.

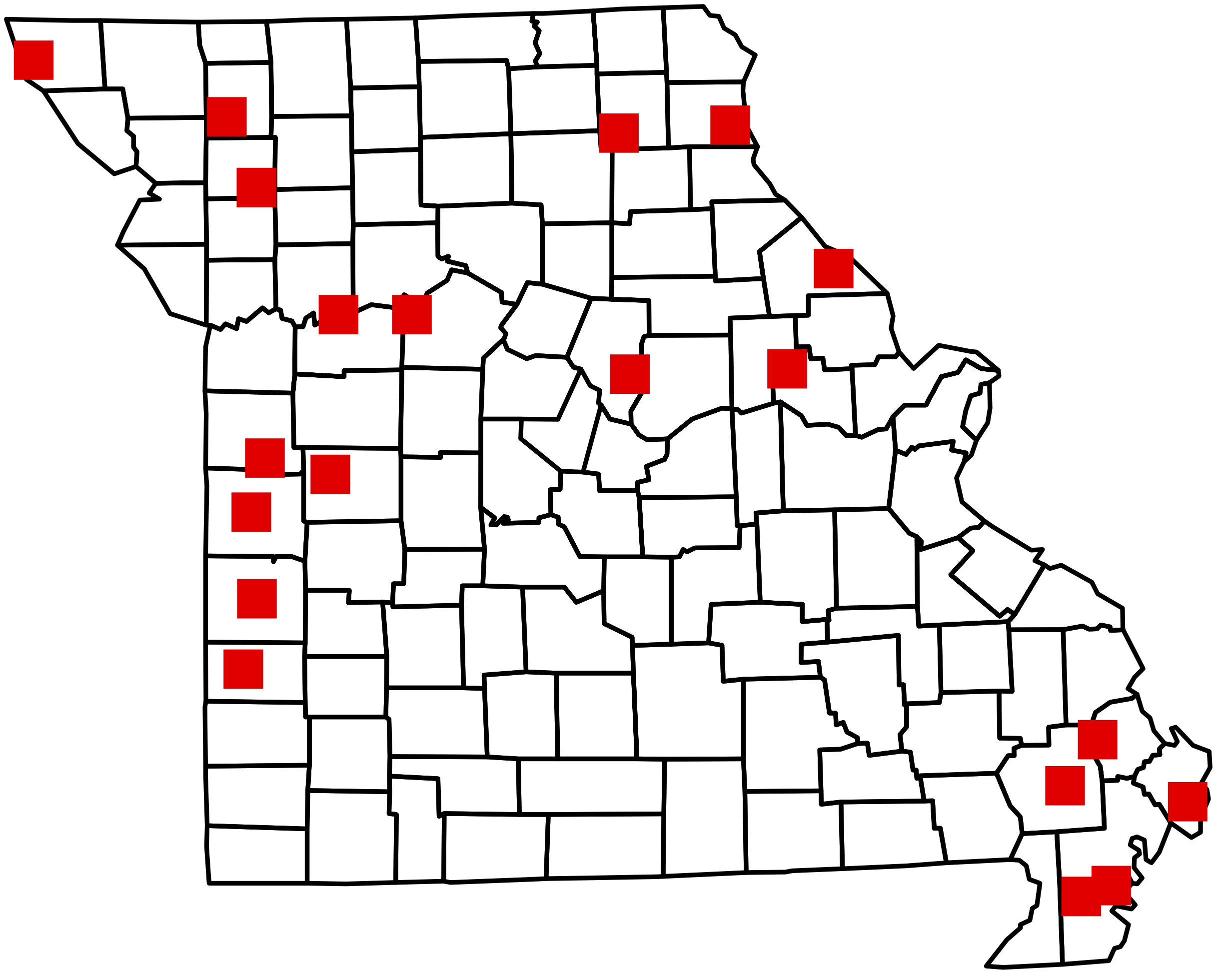

Figure 1. Locations of soybean fertility experiments in 2000. Locations in 2001 were approximately the same.

Table 1. 2000 EXPERIMENTAL SITES

LOCATION	COUNTY	SOIL SERIES	VARIETY
Corning	Atchison/Holt	Salix Silty Clay Loam	Asgrow 3302
Albany	Gentry	Grundy Silt Loam	Pioneer 93B82
Osborn	DeKalb	Grundy Silt Loam	Pioneer 93B82
Novelty	Knox	Putnam Silt Loam	Asgrow 3701
LaGrange	Lewis	Westerville Silt Loam	Pioneer 93B82
Henrietta	Ray	Aholt Clay	Asgrow 3701
Grand Pass	Saline	Haynie Silt Loam	Pioneer 93B82
Columbia	Boone	Mexico Silt Loam	Asgrow 3701
Truxton	Montgomery	Mexico Silt Loam	Asgrow 3701
Annada	Pike	Tice Silt Loam	Pioneer 93B82
Garden City	Cass	Haig Silt Loam	Pioneer 93B82
Butler	Bates	Kenoma Silt Loam	Asgrow 4301
Urich	Henry	Hartwell Silt Loam	Asgrow 4403
Nevada	Vernon	Barden Silt Loam	Novartis S46-W8
Lamar	Barton	Parsons Silt Loam	Novartis S46-W8
Oran	Scott	Commerce Silt Loam	Stine 4790
Wyatt	Mississippi	Commerce Silt Loam	Pioneer 9492
Morehouse	Stoddard	Sharkey Clay	Pioneer 9594
Portageville	Pemiscott	Portageville Clay	Asgrow 4602
Portageville	Pemiscott	Dundee Silt Loam	Pioneer 9594

Table 2. 2001 EXPERIMENTAL SITES

LOCATION	COUNTY	SOILSERIES	VARIETY
Grand Pass	Saline	Haynie Silt Loam	Pioneer 94B01
Truxton	Montgomery	Mexico Silt Loam	Kruger K-369RR/SCN
Corning	Atchison	Salix Silty Clay Loam	Asgrow 3302
Albany	Gentry	Grundy Silt Loam	Asgrow 3302
Henrietta	Ray	Haynie Silt Loam	Pioneer 94B01
LaGrange	Lewis	Westerville Silt Loam	Asgrow 3302
Annada	Pike	Tice Silt Loam	Asgrow AG3701
Novelty	Knox	Putnam Silt Loam	US Seeds 3701
Oran	Scott	Sharkey Silty Clay	Garst D484
Lamar	Barton	Barden Silt Loam	Delta King 4868
Garden City	Cass	Haig Silt Loam	MFA 4478SCN
Urich	Henry	Hartwell Silt Loam	Pioneer 94B53
Butler	Bates	Kenoma Silt Loam	Asgrow AG4301
Osborn	DeKalb	Grundy Silt Loam	Croplan RC3838
Nevada	Vernon	Parsons Silt Loam	Asgrow AG4403
Morehouse	New Madrid	Sharkey Clay	Asgrow 5501
Columbia	Boone	Mexico Silt Loam	Dekalb 36-51
Portageville	Pemiscot	Portageville Clay	MFA 4809
Portageville	Pemiscot	Tipton Silt Loam	Asgrow AG4902
Wyatt	Mississippi	Commerce Silty Clay Loam	MPV 457NRR

Results:

- Average yield across all 20 locations was 45 bu/acre in 2000, 50 bu/acre in 2001. Drought stress caused yields in the southwest experiments to be low in 2000. Overall, yield levels were representative of good production practices and conditions for Missouri.
- Soil test levels were also representative of good production practices.
  - Soil test P was low in 1 field, medium in 18 fields, and high in 21 fields according to MU soil test interpretations.
  - Soil test K was medium in 21 fields and high in 19 fields.
  - The target soil test level for MU fertilizer recommendations is at the border between medium and high, so equal numbers of fields testing medium and high is considered ideal.
- Only two of 20 locations had statistically significant (90% confidence) yield response to fertilizer treatments in 2000 (Table 3). Both responses were to potassium. Early-season drought stress led to numerous reports of K deficiency in Missouri soybeans, reduced K availability to crops, and probably contributed to the yield responses.
- Seven of 20 locations had statistically significant (90% confidence) yield response to fertilizer treatments in 2001 (Table 4), including responses to P, K, N at planting, N at early pod, S, and B.
- All results that follow come from analyzing all 40 experiments together.

<u>Response to P</u>

- Averaged over all 40 locations, there was no yield response to P.
- Statistically significant responses (90% confidence) to P were seen at three locations out of 40; one responsive location tested low, one tested medium, and one tested high for P.
- Soil test P was not a significant predictor of response to P.
  - For the five locations with soil test P < 30 lb/acre, plots receiving P averaged 1.2 bu/acre more than the check plots, but this was not statistically significant (partly because of the small number of locations with P test this low).
  - This is not surprising, since most locations were either in the high range for soil test P, or at the high end of the medium range. Yield responses are expected to be small and infrequent at these soil test levels.
  - This definitely shows that current University of Missouri recommendations for P are high enough to support good soybean yields.
  - These experiments can't answer the question of whether current University of Missouri recommendations for P are higher than is economically optimum for soybean production.
- For the sixteen locations with soil salt pH < 6.0, average yield response to P was 1.4 bu/acre (99% confidence).
  - At lower pH, solubility of iron and aluminum is increased, both of which tend to react with P to make it unavailable.
  - This result agrees with Kansas State research, which has found that much of the yield response that can be obtained by applying lime to low pH soils can also be obtained by making a small band application of P.

Response to K

- Averaged over all 40 locations, there was no yield response to K.
- Statistically significant responses (90% confidence) to K were seen at four locations out of 40.
- Soil test K was related to yield response.
  - For the seven locations with soil test potassium < 200 lb/acre, average yield response to K was 1.4 bu/acre (94% confidence).
  - When soil test potassium was above 200 lb/acre, no yield response was seen.
  - This definitely shows that current University of Missouri recommendations for K are high enough to support good soybean yields.
  - These experiments can't answer the question of whether current University of Missouri recommendations for K are higher than is economically optimum for soybean production.
- Recent research at Iowa State has found quite a few yield responses when soil test K is high. Low soil test K in the subsoil is one factor that helps them to predict when high-testing soils will give yield responses. Our results did not follow this pattern. We did not see many yield responses when soil test K was high, and subsoil fertility was not helpful in predicting where we saw yield responses.

Response to N applied at planting

- Averaged over all 48 locations (including 8 experiments with N treatments only at Columbia), yield response to N applied at planting was 0.5 bu/acre (90% confidence).
- Several factors helped to predict yield response to N applied at planting:
  - For the sixteen locations with salt pH less than 6.0, average yield response to N applied at planting was 0.9 bu/acre (95% confidence). At low soil pH, survival of soil *Rhizobia* is not as good, and availability of soil molybdenum is low. Both *Rhizobia* and molybdenum are required to establish effective N-fixing nodules on soybean roots.
  - When soil nitrate to two feet was less than 50 lb/acre (this was true at eight locations), average yield response to N at planting was 1.0 bu/acre (89% confidence). Previous research in Minnesota has also shown that yield response is higher when soil nitrate is lower, but their yield responses were much larger, between 5 and 10 bu/acre.
  - For the five locations with check yield above 60 bu/acre, average yield response to N at planting was 1.6 bu/acre (80% confidence). Ray Lamond at Kansas State thinks that the N fixation system of soybeans can't keep up to supply all the N needed to produce yields above 60 bu/acre. Our results give a small amount of support to this theory.

Response to N applied at early pod stage

- Averaged over all 44 locations (including 5 experiments with N treatments only at Columbia; we missed making early pod N applications at one of the 40 experiments paired with the variety tests), there was no yield response to N

applied at early pod.
  - We were not able to identify any factors that helped to predict yield response to N applied at early pod.

Response to S
  - Averaged over all 40 locations, there was no yield response to S.
  - Only one of the 40 locations had a significant (90% confidence) yield response to S. Sulfur was the only nutrient for which we saw less than two locations with statistically significant response.
  - We were not able to identify any factors that helped to predict yield response to S.
  - It does not appear that there are any particular regions or growing conditions in Missouri that require S additions to optimize soybean yields.

Response to B
  - Averaged over all 40 locations, there was no yield response to B.
  - For the sixteen locations with soil salt pH < 6.0, average yield response to B was 1.0 bu/acre (99% confidence).
    - At lower pH, solubility of aluminum is increased, and can be toxic to roots. B is known to help increase root tolerance to aluminum.

Summary and Conclusions:

- Averaged over all experiments, the only treatment that gave a yield response was N applied at planting, and that response was very small. We conclude that there is no need to increase applications of any of these nutrients across the board (i.e. on all fields in the state).
- Current University of Missouri soil test based recommendations for P and K ensure that enough P and K is available to maximize yields. We did not find any regions or soil types that need to have higher recommendations.
- These experiments can't answer the question of whether current University of Missouri recommendations for P and K are higher than is economically optimum for soybean production. Soil test P and K levels were generally well-maintained in these fields, so we didn't expect much yield response to P and K.
- At low soil pH (salt pH < 6.0), small yield responses were seen to P, B, and N at planting. This points out the importance of a good liming program.
- There was a small yield response to K when soil test K was below 200 lb/acre.
- There was a small yield response to N applied at planting when soil pH was low, when soil nitrate was low, or when yield levels were high.
- Subsoil nutrient concentrations did not help to predict yield response to any of the nutrients.

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project happen.

Table 3. Yields From Soybean Fertilizer Trials 2000

LOCATION	COUNTY	YIELD WITH FERTILIZER TREATMENT:						
		unfertilized check	B	K	N-1	N-2	P	S
Albany	Gentry	46	47	46	43	45	44	45
Annada	Pike	52	53	51	54	52	55	50
Butler	Bates	26	26	27§	26	27	27	26
Columbia	Boone	58	53	55	53	52	53	59
Corning	Atchison/Holt	50	47	49	50	46	48	49
DRC-Clay	Pemiscott	55	57	56	56	52	56	55
DRC-Loam	Pemiscott	49	50	48	50	50	48	48
Garden City	Cass	26	26	26	26	26	27	25
Grand Pass	Saline	51	47	52	52	49	51	51
Henrietta	Ray	39	40	42	40	41	39	39
LaGrange	Lewis	55	56	56	58§	55	56	54
Lamar	Barton	25	25	24	24	23	23	24
Morehouse	Stoddard	64	64	68†	68§	66	66	66
Nevada	Vernon	32	32	32	33	32	33	33
Novelty	Knox	61	60	63	62	62	61	60
Oran	Scott	44	43	47§	43	---	44	45
Osborn	DeKalb	50	50	51	50	48	49	49
Truxton	Montgomery	51	51	52	49	52	51	49
Urich	Henry	30	29	32†	31	29	31	32§
Wyatt	Mississippi	35	34	34	36	33	32	35

*This yield is greater than the yield of the unfertilized check with greater than 95% confidence

†This yield is greater than the yield of the unfertilized check with 90 to 95% confidence

§This yield is greater than the yield of the unfertilized check with 80 to 90% confidence

The N-1 treatment is N applied at planting, N-2 is N applied at early pod development (both are 25 lb N/ac)

Table 4. Yields From Soybean Fertilizer Trials 2001

LOCATION	COUNTY	YIELD WITH FERTILIZER TREATMENT:						
		unfertilized check	B	K	N-1	N-2	P	S
Albany	Gentry	48	50	47	51§	50	50	48
Annada	Pike	60	63†	57	60	62	60	59
Butler	Bates	41	43	41	40	40	43	40
Columbia	Boone	34	35	35	33	30	34	33
Corning	Atchison	50	48	45	50	49	50	49
DRC-Clay	Pemiscott	34	36	31	36	35	35	34
DRC-Loam	Pemiscott	46	46	44	48	48	47	45
Garden City	Cass	49	47	47	48	49	48	49
Grand Pass	Saline	62	63	60	62	60	66*	63
Henrietta	Ray	59	57	54	58	62†	61§	58
LaGrange	Lewis	61	62	59	60	62	63	62
Lamar	Barton	43	46†	46†	43	45	46†	43
Morehouse	Stoddard	57	52	56	57	59	56	59
Nevada	Vernon	62	64§	66†	66†	61	67*	66*
Novelty	Knox	45	47*	44	47*	47†	46	45
Oran	Scott	57	54	55	55	56	54	50
Osborn	DeKalb	53	46	48	50	53	51	53
Truxton	Montgomery	55	55	54	55	54	56	54
Urich	Henry	55	52	53	56	52	51	54
Wyatt	Mississippi	41	40	39	39	47†	43	43

*This yield is greater than the yield of the unfertilized check with greater than 95% confidence

†This yield is greater than the yield of the unfertilized check with 90 to 95% confidence

§This yield is greater than the yield of the unfertilized check with 80 to 90% confidence

The N-1 treatment is N applied at planting, N-2 is N applied at early pod development (both are 25 lb N/ac)