

Potassium and phosphorus fertilization in a long-term rice and soybean rotation

Gene Stevens, Matthew Rhine, and Johanna Nelson

INTRODUCTION

A long-term experiment was conducted in Missouri on fields with rice-soybean rotations to determine the optimum potassium (K) and phosphorus (P) programs for both crops.

Three important soil test factors:

- **Target** is the level of a soil extractable nutrient at which more fertilizer will not increase crop yields.
- **Crop removal** is how much a nutrient is reduced annually in the soil from harvested forage, grain, or fiber.
- **Buildup** is the additional fertilizer needed above crop removal to increase low- and medium-testing soil P and K to the target fertility levels for crop production.



Fertilizer plots were marked with permanent stakes in two adjacent fields rotated annually between soybean and rice.

MATERIALS AND METHODS

Potassium and phosphorus buildup treatments were untreated check, 1-year, 4-year, and 8-year P and K buildup fertilizer programs. Targets were also evaluated. Missouri target soil P buildup for rice was 39 lb Bray-P ha⁻¹ and soybeans was 50 kg Bray-P ha⁻¹. Target ammonium acetate extractable K was 140+ (5.6 x CEC) for rice and 246+ (5.6 x CEC) for soybeans. Rice received 150 lb N acre⁻¹ in a 2-way split application.

P AND K SOIL BUILDUP EQUATIONS

Shown below are the equations used at University of Missouri to calculate the P and K build-up part of soil test recommendations.

$$\text{Build-up } P_2O_5 = \frac{110(X_d^{1/2} - X_o^{1/2})}{\text{Years}} \quad \text{Build-up } K_2O = \frac{75.5(X_d^{1/2} - X_o^{1/2})}{\text{Years}}$$

X_d = target soil test level in kg P or K per ha
 X_o = observed soil test level in kg P or K per ha
 Years = desired time period for build-up



- Plots were soil sampled each March.
- Soil recommendation equations were calibrated based on field experiments to gauge crop response over several years.
- Soil analysis takes the “guess work” out of P and K management.
- Fertilizer is a costly input for farmers. Soil tests provide information on optimum K and P needed.

Table 1. Fertilizer build-up and target effects on rice yields.

Build-up	PK soil target	2004	2005	2006	2007	2008	2009	2010	Mean
	kg ha ⁻¹	-----rice, Mg ha ⁻¹ -----							
N only	--	8.47	7.16	6.60	9.52	6.10	6.96	8.46	7.61
1-year	50/300 [†]	9.68	8.06	6.70	13.55	7.31	8.01	12.45	9.40
4-year	50/300	9.73	8.12	6.85	13.51	6.96	8.11	13.56	9.55
8-year	50/300	9.42	8.01	7.61	12.15	7.56	8.06	10.29	9.01
1-year	39/195	8.67	7.51	7.21	13.81	7.11	7.34	10.31	8.85
4-year	39/195	8.57	8.13	7.56	12.60	7.06	7.51	9.93	8.76
8-year	39/195	8.32	7.81	6.75	13.71	6.85	7.36	10.69	8.78
LSD _{0.05}		0.85	ns	ns	1.45	1.05	0.80	ns	0.60

[†] Soybean soil test target was 50 kg Bray-1 P ha⁻¹ and 300 kg ammonium acetate K ha⁻¹.
 Rice soil test target was 39 kg Bray-1 P ha⁻¹ and 195 kg ammonium acetate K ha⁻¹.

Table 2. Fertilizer build-up and target effects on soybean yields.

Build-up	PK soil target	2004	2005	2006	2007	2008	2009	Mean
	kg ha ⁻¹	-----soybean, Mg ha ⁻¹ -----						
N only	--	2.69	2.62	3.49	2.02	2.13	4.10	2.84
1-year	50/300 [†]	3.49	3.63	4.23	2.62	2.02	4.03	3.34
4-year	50/300	3.43	3.09	4.01	2.35	1.86	4.91	3.27
8-year	50/300	3.45	2.96	4.14	2.55	1.95	4.50	3.26
1-year	39/195	3.56	3.16	3.83	2.15	1.81	4.70	3.20
4-year	39/195	3.53	3.29	3.70	2.42	1.88	4.10	3.15
8-year	39/195	3.43	3.49	3.82	2.82	1.92	4.50	3.33
LSD _{0.05}		0.47	0.40	0.34	0.54	ns	ns	0.20

[†] Soybean soil test target was 50 kg Bray-1 P ha⁻¹ and 300 kg ammonium acetate K ha⁻¹.
 Rice soil test target was 39 kg Bray-1 P ha⁻¹ and 195 kg ammonium acetate K ha⁻¹.



Missouri recommendations, before this study was conducted, had lower P and K soil test targets for rice than soybean.

CONCLUSIONS

All build-up programs produced more rice and soybean yields than the untreated check (N only for rice). But there was not a yield advantage to increasing P and K levels to target levels faster than 8 years. Rice P and K targets were increased as a result of this research.

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MATERIALS AND METHODS

Potassium and phosphorus buildup treatments were untreated check, 1-year, 4-year, and 8-year P and K buildup fertilizer programs. Targets were also evaluated. Missouri target soil P buildup for rice was 35 lb Bray-P acre⁻¹ and soybeans was 45 lb Bray-P acre⁻¹. Target ammonium acetate extractable K was 125+ (5 x CEC) for rice and 220+ (5 x CEC) for soybeans. Rice received 150 lb N acre⁻¹ in a 2-way split application.

P AND K SOIL BUILDUP EQUATIONS

Shown below are the equations used at University of Missouri to calculate the P and K build-up part of soil test recommendations.

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X_d = target soil test level in lb P or K per acre
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- Plots were soil sampled each March.
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- Soil analysis takes the “guess work” out of P and K management.
- Fertilizer is a costly input for farmers. Soil tests provide information on optimum K and P needed.

Table 1. Fertilizer build-up programs and targets affect on rice yields.

Build-up	PK soil target	2004	2005	2006	2007	2008	2009	2010	Mean
	lb acre ⁻¹	-----rice, bushels acre ⁻¹ -----							
N only	--	168	142	131	189	121	138	168	151
1-year	45/265 [†]	192	160	133	269	145	159	247	186
4-year	45/265	193	161	136	268	138	161	269	189
8-year	45/265	187	159	151	241	150	160	204	178
1-year	35/170	172	149	143	274	141	146	204	175
4-year	35/170	170	161	150	250	140	149	197	173
8-year	35/170	165	155	134	272	136	146	212	174
LSD _{0.05}		17	ns	ns	29	21	16	ns	12

[†] For rice target, P and K fertilizer was applied to build soil test levels to 35 lb Bray-1 P ac⁻¹ and 170 lb ammonium acetate extractable K ac⁻¹. For soybean target, P and K fertilizer was applied to build soil test levels to 45 lb Bray-1 P ac⁻¹ and 265 lb ammonium acetate extractable K ac⁻¹.

Table 2. Fertilizer build-up programs and targets on soybean yields.

Build-up	PK soil target	2004	2005	2006	2007	2008	2009	Mean
	lb acre ⁻¹	-----soybean, bushels acre ⁻¹ -----						
N only	--	40	39	52	30	30	61	42
1-year	45/265 [†]	52	54	63	39	30	60	50
4-year	45/265	51	46	62	35	29	73	49
8-year	45/265	51	44	62	38	29	67	48
1-year	35/170	53	47	57	32	27	70	48
4-year	35/170	53	49	55	36	28	61	47
8-year	35/170	51	52	57	42	29	67	50
LSD _{0.05}		7	6	5	8	ns	ns	3

[†] For rice target, P and K fertilizer was applied to build soil test levels to 35 lb Bray-1 P ac⁻¹ and 170 lb ammonium acetate extractable K ac⁻¹. For soybean target, P and K fertilizer was applied to build soil test levels to 45 lb Bray-1 P ac⁻¹ and 265 lb ammonium acetate extractable K ac⁻¹.



In the Mississippi River Delta region of the United States, rice is rotated with soybean to improve control of diseases and insects.

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