Increasing Profitability of Corn Production by Improving Phosphorus and Potassium Fertilizer Recommendations: Progress Report for 2010

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Value to Growers: This project will evaluate the effect of phosphorus (P) and potassium (K) fertilizer application rates on corn under current Arkansas cropping practices.

Study Objectives: For corn production under cropping conditions in Arkansas evaluate:
1. The effect of phosphorus (P) fertilizer application rates on corn grain yield,
2. The effect of potassium (K) fertilizer application rates on corn grain yield,
3. The suitability of corn ear-leaf and young plants for predicting plant P status,
4. The suitability of corn ear-leaf, young plants, and lower stalk for predicting plant K status,
5. Phosphorus fertilizer use efficiency,
6. Potassium fertilizer use efficiency.

Progress Report for 2010:
Five corn P fertility trials and four corn potassium fertility trials were conducted at the University of Arkansas research stations or commercial corn production sites. Experiments for each nutrient will be discussed separately.

Procedures for Phosphorus Fertility Experiments

Five replicated corn phosphorous fertility field experiments were conducted on commercial fields and University of Arkansas Research Stations in 2010. Before planting composite soil samples were collected from the 0- to 6-inch depth and composited by replication. Soil samples were dried, crushed, plant available P was extracted with Mehlich-3 solution. Soil pH was measured in a 1:2 (weight:volume) soil-water mixture. Soil particle size analysis was performed by the hydrometer method (Arshad et al., 1996). Important agronomic information is provided in Table 1. Experimental plots were 25 to 40-ft long and 10 to 18.9-ft wide allowing for four or six rows of corn spaced 30 or 38-inch apart, depending on the location. Corn was grown on beds and furrow-irrigated at each site.

Phosphorus application rates ranged from 0 to 160 lb P_2O_5/acre in 40 lb/acre increments as triple superphosphate. Phosphorus treatments were applied to the soil surface in a single application either before planting or shortly after crop emergence. Blanket applications of muriate of potash (0-0-60), urea (46-0-0), and $ZnSO_4$ (18% S and 24% Zn) were made to supply 100 lb K_2O, 260 to 280 lb N/acre, 6.7 lb Zn, and 5 lb S/acre, respectively. At LEZ06 only 190 lb N/acre was applied because of miscommunication. All other experiments were fertilized with a total of 220 to 280 lb N/acre, where 40 to 60 lb N/acre was applied before the 4-leaf stage and the balance of N was applied before the 6-to 8-leaf stage.

At three sites, five representative plants/plot were cut at two inches above the soil surface at the 6-8 leaf stage, dried in an oven at 70°C to a constant weight, and ground to pass through a 60-mesh sieve. Plant samples were digested with concentrated HNO_3 and 30% H_2O_2 (Jones and Case, 1990) and P concentrations were determined. When corn was at the early to mid-silk stage, 8 to 10 ear-leaves per plot were collected and processed as above at all sites except SFZ04 where corn was damaged by wildlife and the plots were abandoned. At the research farms, the middle two rows of each plot were harvested with a plot combine, at commercial sites one 12.5-ft segments in each one of the two center rows was hand harvested and ran through a combine later. The calculated grain yields were adjusted to a uniform moisture content of 15.5% for statistical analysis.

Results of the Phosphorus Fertility Experiments

Soil pH ranged from 5.9 to 7.9 and Mehlich-3 extractable P ranged from 24 to 84 ppm (Table 2). University of Arkansas fertilizer recommendations for corn classified the soil P availability as Low (15-25 ppm) at LEZ06 and SFZ04 and Above Optimum (>50 ppm) at the other three sites with recommended P rates of 100 and 0 lb of P_2O_5/acre, respectively, for a corn yield goal of 175 bu/acre.

Phosphorus fertilization did not influence seedling corn P concentration, dry matter accumulation, or P uptake at MOZ02 and SFZ04 (Table 3). However, P fertilization significantly increased seedling P concentration, dry matter, and P uptake at LEZ06. These results are consistent with the expectation from Mehlich-3 extractable P in the 0-to 6-inch depth of MOZ02 and LEZ06, but not at SFZ04.

Phosphorus application rate significantly increased ear-leaf P only at LEZ06 (Table 4). At LEZ06, ear leaf P concentration of corn receiving no P was less than the proposed critical concentration of 0.25% (Campbell and Plank, 2000) suggesting a yield response to P was possible. Corn grain yields at the four harvested sites were not influenced by P fertilization (Table 4). Yields at LEZ06 were lower than expected and ranged from 122 to 129 bu/acre suggesting that another factor (such as N availability) was more limiting than P availability. The lack of significant grain yield increases to P fertilization is not surprising since the soil test P was either Medium or Above Optimum at the four harvested sites. Although P is recommended for soils having a Medium soil test P level, only a nominal yield increase would be expected as the P recommendation is mostly for ensuring early season vigor and replacing nutrients removed by the harvested grain.

Procedures for Potassium Fertility Experiments

Four replicated field experiments were conducted on representative corn producing soils in 2010. Prior to K application soil samples were taken from the 0-to 6 and 6 to 12-inch depths and composited by replication. Procedures for chemical and physical analysis of soil samples for this potassium study were similar to the P experiments described above. Selected agronomically important information is listed in Table 5. Potassium application rates ranged from 0 to 200 lb K_2O/acre in 40 lb K_2O/acre increments as muriate of potash (KCl) and all of the K rates were surface applied in a single application. Triple superphosphate (0-46-0) was applied at a rate to supply 46 lb P_2O_5 and other nutrients were applied as described for P experiments. At each site, corn was planted on beds and furrow irrigated as needed. All experiments were randomized complete blocks. Young corn seedling and ear leaf samples were collected and processed similar to the corn P experiment. Corn grain harvest procedures for the potassium study were similar to the phosphorus experiment.

Results of the Potassium Fertility Experiments

Mehlich-3 extractable K in the 0-to 6-inch depth ranged from 57 to 142 ppm (Table 6). According to the University of Arkansas soil test interpretation, soil test K was Medium (91-130 ppm) at MOZ03, Low (61-90 ppm) at LEZ07 and DEZ03, and Very Low (<61 ppm) at SFZ05. Current fertilization guidelines recommended 75 and 110 lb K_2O/acre for Medium and Low soil test K levels, respectively, to produce a corn yield goal of 175 bu/acre and increase soil test K. Soil test K in the 6-to 12-inch depth ranged from 43 to97 ppm, which was numerically lower than or comparable to the 0 to 6 inch depth.

At the 6 to 8 leaf stage, corn dry weight was not affected by K fertilizer rate at any of the three sites where plant samples were collected (Table 7). Potassium concentration and uptake were unaffected by K rate at MOZ03, the site with the highest soil test K, but both parameters were increased by K fertilization at LEZ07 and SFZ05. Results suggest that early season K uptake is enhanced by K fertilization for corn grown in silt loams having low soil K availability. .

Corn ear-leaf K concentration was significantly increased by K application at all sites except

MOZ03, the site that the highest surface and subsoil K availability (Table 8). Corn ear leaf concentrations <1.80% K indicate possible K deficiency (Campbell and Plank, 2000). Corn grain yields were significantly increased by K fertilization at all sites except LEZ07 (Table 8). Grain yields at LEZ07 were relatively low and may have been limited by other factors. Compared to corn receiving no K, yields were increased by 12 to 60% by K fertilization at the three K responsive sites. Yields were maximized by application of 40 (DEZ03 and MOZ03) or 80 (SFZ05) lb K_2O/acre. Corn ear-leaf K concentrations at tasseling appear to be a good indicator of the K nutritional status of corn and soil test K appears to be a good indicator of soil K availability.

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Table 1. Previous crops, corn cultivars, planting and P fertilizer application dates, plant sampling and harvest dates for five P fertility trials conducted Chico (CHZ02, CHZ03), Lee (LEZ06), Monroe (MOZ02), and St. Francis (SFZ04) counties during 2010.

Site ID	Soil Series	Previous crop	Cultivar	Planting date	P application date	Sampling date		Harvest date
						Ear-leaf	Whole plant	
CHZ02	Rila silt loam	soybean	Pioneer 175	9-April	20-April	15-June	--	10-Aug
CHZ03	Hebert silt loam	soybean	Pioneer 175	9-April	20-April	6-July	--	10-Aug
LEZ06	Loring silt loam	cotton	Pioneer 31D49	27-April	18-May	6-July	7-June	2-Sep
MOZ02	Bosket fine sandy loam	soybean	-	14-April	5-May	28-June	7-May	23-Aug
SFZ04	Calhoun silt loam	soybean	Pioneer 33D49	9-May	30-April	did not[a]	11-June	NH[z]

[z] NH, not harvested. Crop was damaged by wildlife.

Table 2. Selected properties of the soil samples collected from 0 -to 6-inch depth before P-fertilizer application for in four K fertility trials conducted in Desha (DEZ03), Lee (LEZ07), Monro (MOZ03), and St. Francis (SFZ05) counties during 2010.

Site	Soil pH [Z]	Mehlich-3-extractable nutrients					Soil physical properties			
		P	K	Ca	Mg	Zn	Sand	Silt	Clay	Texture
		(ppm)					(%)			
CHZ02	6.7	64	178	705	102	3.9	32	56	12	silt loam
CHZ03	6.7	54	190	1031	172	4.2	22	62	16	silt loam
LEZ06	7.0	29	67	939	253	3.0	6	76	18	silt loam
MOZ02	5.9	84	125	621	76	11.9	55	35	15	sandy clay loam
SFZ04	7.9	24	73	3095	303	5.1	6	68	26	silt loam

[Z] Soil pH was measured in a 1:2 (weight:volume) soil-water mixture.
[Y] Standard deviation of soil test P was 2 ppm for CHZ02, 3ppm for CHZ03,5 ppm for LEZ06, 13 ppm for MOZ02, and 1ppm for SFZ05

Table 3. Effect of P_2O_5 application rates on dry biomass, P concentrations and P uptakes by the total above-ground portion of young corn plants sampled at 6 to 8-leaf stage for three P fertility trials conducted in Lee (LEZ06), Monroe (MOZ02), and St. Francis (SFZ04) counties during 2010.

P rate	LEZ06			MOZ02			SFZ04 (correct data for SFZ04)		
	Pconcentration	DW	P uptake	P concentration	DW	P uptake	P concentration	DW	P uptake
lb P_2O_5/acre	%	grams/5 plants		%	grams/5 plants		%	grams/5 plants	
0	0.38	62.3	0.24	0.46	64.8	0.30	0.33	58.3	0.20
40	0.42	69.0	0.29	0.47	71.6	0.34	0.33	52.2	0.18
80	0.43	60.8	0.26	0.47	68.4	0.32	0.33	59.7	0.20
120	0.43	58.0	0.25	0.44	73.2	0.32	0.34	59.5	0.20
160	0.49	63.5	0.31	0.44	69.0	0.31	0.34	57.5	0.20
P value	0.0004	0.0995	0.0073	0.162	0.26	0.36	0.8423	0.315 3	0.5640
LSD0.10	0.03	6.5	0.03	NS [z]	NS	NS	NS	NS	NS

[z] NS, not significant (P>0.10)

Table 4. Effect of P_2O_5 application rates on corn grain yield and ear-leaf P concentration at the silking -stage in four P fertilization trials conducted in Chico (CHZ02 and CHZ03), Lee (LEZ06), Monroe (MOZ02), and St. Francis (SFZ04) counties during 2010.

P_2O_5 rate	CHZ02		CHZ03	LEZ06		MOZ02	
	Grain Yield	leaf P	Grain Yield	Grain Yield	leaf P	Grain Yield	leaf P
lb P_2O_5/acre	bu/acre	%	bu/acre	bu/acre	%	bu/acre	%
0	194	0.31	191	126	0.21	156	0.34
40	199	0.35	180	129	0.23	171	0.33
80	191	0.37	176	123	0.24	161	0.34
120	194	0.37	191	129	0.23	177	0.34
160	-[Z]	0.40	193	122	0.24	168	0.34
P value	0.3523	0.2610	0.1559	0.2649	0.010	0.2520	0.4510
LSD 0.10	NS[Y]	NS	NS	NS	0.02	NS	NS

[Z] data was not collected because treatments were misapplied or samples were lost in transport
[Y] NS, not significant (P>0.10)

Table 5. Previous crop, corn cultivar, planting and K application date, plant sampling and harvest date for K fertilization trials conducted in Desha (DEZ03), Lee (LEZ07), Monroe (MOZ03), and St. Francis (SFZ05) counties during 2010.

Site ID	Soil Series	Previous crop	Cultivar	Planting date	K application date	Sampling date		Harvest date
						Ear leaf	Whole plant	
DEZ03	Hebert silt loam	corn	Pioneer 11845	14-April	7-May	21-June	--	24-Aug
LEZ07	Loring silt loam	cotton	Pioneer 31D49	27-April	18-May	6-July	7-June	2-Sep
MOZ03	Bosket fine sandy loam	soybean	--	14-April	5-May	28-June	7-May	23-Aug
SFZ05	Calloway silt loam	soybean	Pioneer 33D49	9-May	15-April	8-July	11-June	11-Sep

Table 6. Selected properties of soil samples taken from 0 -to 6- and 6- to12-inch depths before K-fertilizer application for K fertilization trials conducted in Desha (DEZ03), Lee (LEZ07), Monroe (MOZ03), and St. Francis (SFZ05) counties during 2010.

Site ID	Sample depth	Soil pH	Mehlich-3-extractable nutrients						Soil physical properties			
			P	K [z]	Ca	Mg	Cu	Zn	Sand	Silt	Clay	Texture
			(ppm)						(%)			
DEZ03	0-6	6.2	31	84	778	128	0.9	5.0	29	57	14	silt loam
	6-12	6.7	16	55	1050	162	0.9	8.3	22	57	21	silt loam
LEZ07	0-6	7.2	44	72	964	256	0.9	1.7	9	75	16	silt loam
	6-12	7.1	27	81	1104	379	0.9	1.0	3	70	27	silt loam
MOZ03	0-6	5.8	81	142	544	63	1.1	10.7	56	28	17	sandy clay loam
	6-12	6.3	85	97	815	92	1.4	11.4	56	28	17	sandy clay loam
SFZ05	0-6	6.8	20	57	1450	188	0.8	3.6	1	75	24	silt loam
	6-12	6.6	13	43	1308	146	0.6	3.6	1	77	22	silt loam

[z] Standard deviation of soil test K in the 0 to 6 and 6 to 12 inch depths was 9 and 5 ppm for DEZ03, 14 and 22 ppm for LEZ07, 8and 6 ppm for MOZ03, and 19 and 8 SFZ05, respectively.

Table 7. Effect of K fertilizer rate on dry weight (DW), K concentration, and K uptake of the aboveground portion of corn plants at 6 to 8-leaf stage in three K fertilization trials conducted in Lee (LEZ07), Monroe (MOZ03), and St. Francis (SFZ05) counties during 2010.

~~K2O rate~~ K rate	LEZ07			MOZ03			SFZ05		
	K concentration	DW	K uptake	K concentration	DW	K uptake	K concentration	DW	K uptake
lb K_2O/acre	%	grams/5 plants		%	grams/5 plants		%	grams/5 plants	
0	2.31	63.1	1.4	2.95	87.0	2.6	1.62	45.3	0.75
40	2.85	60.4	1.7	3.21	84.6	2.7	2.20	47.4	1.05
80	3.74	57.4	2.1	3.22	79.2	2.6	2.27	48.8	1.13
120	3.75	55.3	2.1	3.21	84.4	2.7	2.57	47.2	1.23
160	4.52	56.3	2.5	3.24	78.8	2.6	2.76	49.5	1.38
200	4.43	62.6	2.8	3.14	80.6	2.5	2.57	51.3	1.34
P value	<0.0001	0.4469	<0.0001	0.4576	0.6779	0.82136	<0.0001	0.6537	0.0087
LSD0.10	0.41	NS[z]	0.35	NS	NS	NS	0.32	NS	0.28

[z] NS, not significant at $P \leq 0.1$

Table 8. Effect of K fertilization rate on corn grain yield and ear-leaf K concentration at silk-stage in K fertilization trials conducted in Desha (DEZ03), Lee (LEZ07), Monroe (MOZ03), and St. Francis (SFZ05) counties during 2010.

K rate	DEZ03		MOZ03		LEZ07		SFZ05	
	Grain Yield	Leaf K	Grain Yield	Leaf K	Grain Yield	Leaf K	Grain Yield	Leaf K
lb K_2O/acre	bu/acre	%	bu/acre	%	bu/acre	%	bu/acre	%
0	148	1.35	145	1.83	132	1.35	138	1.20
40	170	1.62	178	2.35	132	1.61	188	1.68
80	165	1.72	159	2.13	136	1.79	221	1.75
120	169	1.88	180	2.22	126	1.80	221	1.88
160	174	1.92	177	2.22	123	1.96	210	2.01
200	177	2.02	176	2.30	126	1.93	217	2.13
P value	0.0038	<0.0001	0.0545	0.4096	0.1219	<0.0001	0.0314	<0.0001
LSD0.10	12	0.15	22	NS^z	NS	0.08	28	0.20

^{z} NS, not significant $P \leq 0.1$