Managing Phosphorous for Corn Production

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Introduction

Recent volatility in fertilizer prices accentuate the need for careful management of phosphorous (P) inputs for maximizing grain yield of corn (*Zea mays*) per unit of P applied. Yield response of corn to P application depends on a number of factors including residual soil P level, availability of soil moisture, soil chemical, biological and physical properties, and varieties planted (Stichler and McFarland, 1997). According to Gerardo et al. (2008), interaction of these factors can influence the accuracy of using soil test results to make P fertilizer recommendations for corn production. Availability of water is a primary limiting factor for root growth and therefore, is closely related to the uptake of P and other key nutrients in corn (Hanway and Olson, 1980).

Method of P fertilizer placement may also effect the use efficiency of P in corn production. In a two-year study on two acid soils, Fan and Mackenzie (1994) demonstrated an increase in total N and P uptake, P use efficiency and grain yield of corn by banding urea with monoammonium phosphate or triple superphosphate. Additionally, the residual effects of P fertilizer on grain yield were greater where P was banded with urea. While residual P in the soil profile may significantly affect crop P fertilizer requirements in semiarid regions, the effects may vary in other regions (Barrow, 1980).

Concerns about potential losses of P in the environment emphasize the need that P requirements in the corn plant be predicted with greater accuracy across a range of growing conditions (Brosch et. al., 2009). Another complicating factor is that yield potentials of current corn hybrids can be altered by weather-induced variations from year to year within a region (Derby, et al., 2004). In key growing regions of Texas, additional research has been needed on the response of current corn varieties to P management across multiple environments in response to varying amounts of residual soil P, crop rotations, tillage systems and soil types.

Objective

To assess grain yield response of corn to P application across multiple growing environments based on residual soil P levels to a 15-cm depth and current laboratory recommendations.

Materials and Methods

Corn hybrids adapted to Texas growing conditions were planted on one University and 12 cooperator farms located in the Central Blacklands, Brazos River Valley, and Mid to Upper Gulf Coast regions of Texas between Ferbuary 20 and March 15 during 2008, 2009 and 2010. Representative yield goals for planted corn hybrids were adopted from annual tests conducted on the same or nearby cooperator farms by the Texas AgriLife Variety Testing Program (http://varietytesting.tamu.edu). In January and February, pre-plant soil samples were collected and analyzed for each study site. Establishment of P treatments was based on analysis of residual P in sample cores to 15 cm depths (current University approach) and P fertility recommendations made by the Texas AgriLife Extension Service Soil Water & Forage Testing Laboratory. Phosphorous was determined using the Melich III extractant and ICP. Silt loam, clay loam and clay were among the soil textures represented at study sites within the three growing regions.

All studies were randomized complete block designs replicated four to six times. Plots were four or six rows wide with intra-row spacing of 0.97 or 0.76 m and length of 25.9 to 78.1 m. Statistical significance was determined by analysis of variance and means separated using Fisher's LSD.

Application of liquid, conventional-source P fertilizer was made using a knife-type injector in plots at all study sites. An alternate, high-performance ortho and polyphosphate source at the labeled rate of 11 kg P_2O_5/ha was also included among P treatments at most study sites in 2008 and 2009. Nitrogen treatments were applied at the same time via a second injector mounted on each shank and separate N fertilizer source. Grain yield, test weight and moisture were determined at final harvest.

Across studies, monthly rainfall accumulation during the 2008 and 2009 growing seasons was similar to the long-term averages during February, March, and April (Table 1). However, rainfall amounts declined sharply beginning in June and continued at most study locations till harvest in July and early August.

Table 1. Monthly rainfall during the corn growing season at study sites throughout the Central Blacklands and Brazos Valley regions of Texas. 2008.

Trial Location	Precipitation					
	February	March	April	May	June	July
	----------	----------	----------	mm	----------	----------
Hill	49 (71†)	123 (81)	106 (84)	107 (130)	7 (94)	68 (45)
Burleson I	84 (60)	97 (72)	70 (81)	109 (128)	7 (96)	10 (49)
Williamson II	36 (57)	91 (61)	97 (51)	128 (131)	3 (116)	9 (28)
Collin	NA	236 (89)	147 (96)	80 (142)	73 (108)	0 (6)

†Represents 30-year average rainfall (1971-2000; National Oceanic and Atmospheric Administration).

Across most study sites, monthly rainfall accumulation during the 2010 growing season was similar to the long-term averages during February and March (Table 2). However, the Calhoun, Wharton and Williamson sites fell noticeably behind in rainfall during April. In May, the Calhoun, Hill and Williamson sites continued to be dry compared to normal. Rainfall amounts in June and July (silking and grain filling stages) were above normal at the Calhoun, Hill and Victoria but below normal at the Wharton and Williamson sites.

Table 2. Monthly rainfall during the corn growing season at study sites throughout the Central Blacklands, Brazos Valley and Coastal Bend regions of Texas. 2010.

Study Site	Precipitation					
	February	March	April	May	June	July
	----------	----------	----------	mm	----------	----------
Calhoun	99 (43†)	43 (74)	20 (53)	20 (71)	129 (94)	188 (63)
Hill	79 (68)	107 (82)	86 (82)	47 (118)	160 (103)	112 (53)
Victoria	81 (33)	41 (76)	129 (51)	119 (96)	156 (NA)	246 (117)
Wharton	63 (48)	43 (79)	15 (56)	94 (96)	68 (91)	218 (119)
Williamson	91 (59)	71 (70)	39 (69)	23 (120)	69 (90)	55 (48)

†Represents 30-year average rainfall (1971-2000; National Oceanic and Atmospheric Administration).

Results & Discussion

In 2008, the highest yield goal for corn grain and level of residual soil P at planting was represented by Burleson I, an irrigated site (Table 3). Residual soil P levels ranged from 34 to 179 kg P/ha and amount of recommended P addition from 0 to 83 kg P_2O_5/ha across seven study sites. Grain yield at all study sites fell short of crop goals, due in large part to lack of rainfall during the season. Addition of P fertilizer above recommended rates had no effect on corn yield at the Williamson I and Burleson II sites (Table 4). Likewise, corn yield was not reduced with less P fertilizer than recommended at four of five sites. Application of an alternate phosphate source had no effect on corn yield at all six sites.

Table 3. Crop yield goal, soil test P, pH and rates of P fertilizer recommended for corn grain production at study sites in the Central Blacklands and Brazos Valley regions of Texas. 2008.

Study Site	Yield Goal	Residual Soil P	P_2O_5 Recommended	Soil pH
	(kg/ha)	(kg/ha)	(kg/ha)	
Hill	7,530	34	79	7.8
Williamson I	7,530	93	45	6
Williamson II	8,785	42	67	8.2
Burleson I†	11,295	179	0	8.2
Burleson II	9,413	78	34	7.8
Wharton	9,413	54	56	7.9
Collin	7,530	41	83	7.9

†Applied 5 cm furrow irrigation on 25 July and 14 August.

Table 4. Grain yield response of corn to rate of phosphate application as determined by 15 cm soil test results at study sites in the Central Blacklands and Brazos Valley regions of Texas. 2008.

Study Site	Grain Yield				
	No P_2O_5 Added	Recommended P_2O_5	Half P_2O_5 Recommended	Twice P_2O_5 Recommended	Alternate P_2O_5 Source†
	----------	----------	kg/ha	----------	----------
HIll	3,056 a‡	3,219 a	2,981 a	---	3,081 a
Williamson I	---§	4,204 a	---	4,072 a	4,072 a
Williamson II	4,882 a	5,365 a	5,453 a	---	5,045 a
Burleson I	8,910 a	---	---	---	9,099 a
Burleson II	8,158 a	7,906 a	7,342 a	7,530 a	7,781 a
Wharton	7,844 b	8,559 a	8,521 a	---	---
Collin	3,376 a	3,200 a	3,081 a	---	3,357 a

†Represents a high performance, ortho and polyphosphate source applied at the recommended 11 kg P_2O_5/ha.
‡ Within rows, means followed by the same letter are not signficantly different according to LSD (P≤0.05).
Treatments were not initiated or no P_2O_5 was recommended.

Residual soil P levels ranged from 17 to 146 kg P/ha and amount of recommended P addition from 0 to 101 kg P_2O_5/ha across six study sites in 2009 (Table 5). The addition of P fertilizer above recommended rates had no effect on corn yield at the Burleson I, Burleson II and Colorado sites (Fig. 1a-f). Likewise, corn yield was not reduced with less P fertilizer than recommended at five of six sites. Low soil moisture at key stages of growth likely played the greatest role in the lack of response to P additions with actual yields across sites reaching only 48 to 80 percent of yield goal amounts.

Table 5. Crop yield goal, soil test P, pH and rates of P fertilizer recommended for corn grain production at study sites in the Central Blacklands, Brazos Valley and Coastal Bend regions of Texas. 2009.

Study Site	Yield Goal	Residual Soil P	P_2O_5 Recommended	Soil pH
	(kg/ha)	(kg/ha)	(kg/ha)	
Burleson I	9,413	121	17	7.8
Burleson II†	11,295	146	0	7.9
Wharton	9,413	54	62	8.2
Colorado	8,785	112	17	8
Fannin	7,530	17	101	8
Hill	7,530	26	90	7.8

† Applied 8 cm furrow irrigation on 8 and 22 July.

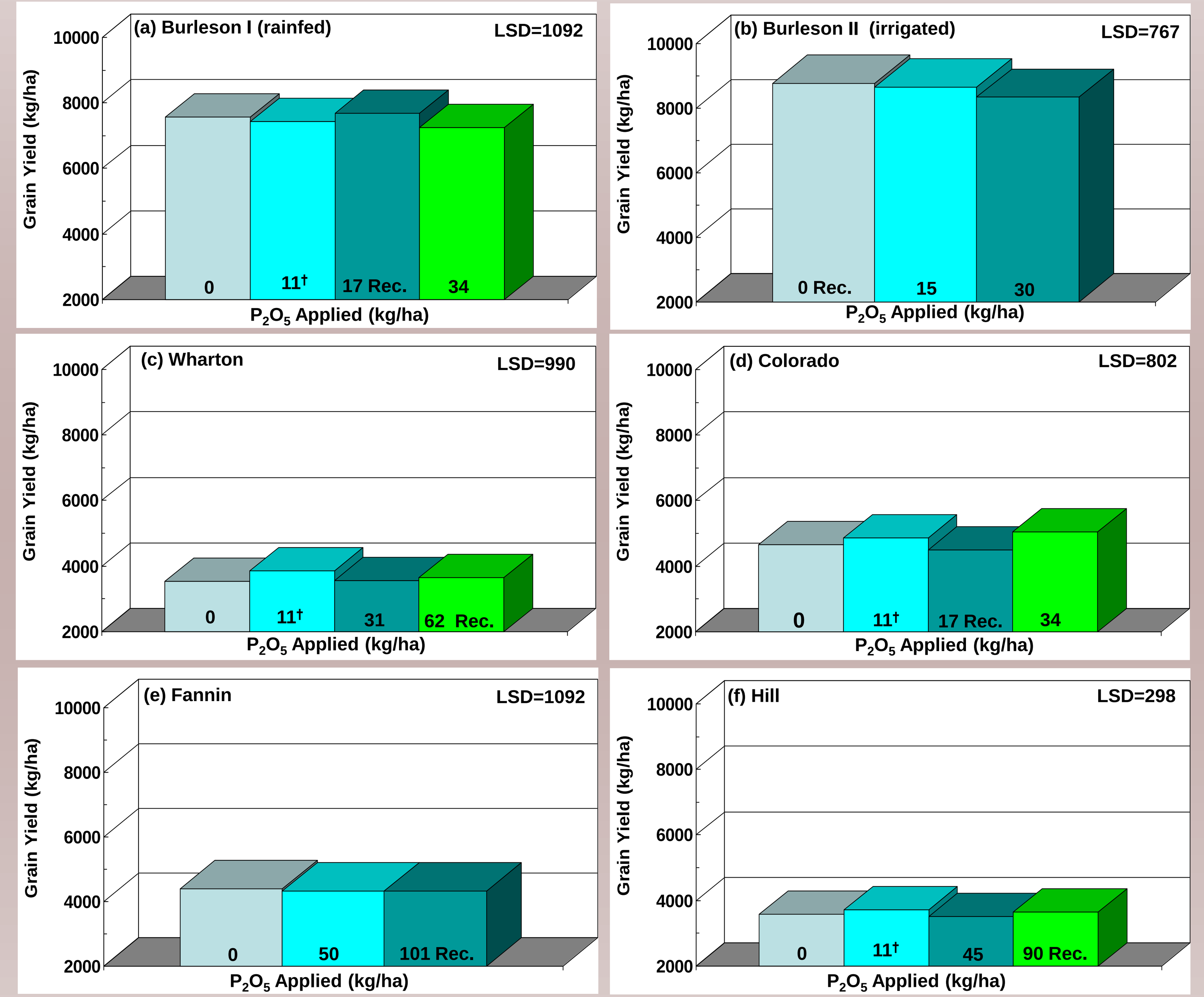

Fig. 1a-f. Effect of recommended and alternate rates of P_2O_5 on grain yield of corn grown in the Brazos Valley (a & b), Coastal Bend (c & d) and Central Blacklands (e & f) of Texas, 2009. Means within a location were not significantly different according to LSD (P≤0.05). †Represents a high-performance ortho and polyphosphate source at labeled rate.

In 2010, residual soil P levels ranged from 29 to 149 kg P/ha and amount of recommended P addition from 0 to 90 kg P_2O_5/ha across six study sites (Table 6). Addition of P fertilizer above rates recommended by soil tests had no effect on corn yield at the Calhoun, Colorado, Victoria, Wharton and Williamson sites (Fig. 2a-f). However, corn yield also was not reduced without P fertilizer at the Hill, Victoria and Wharton sites where additional P was recommended.

Table 6. Crop yield goal, soil test P, pH and rates of P fertilizer recommended for corn grain production throughout the Central Blacklands, Brazos Valley and Coastal Bend regions of Texas. 2010.

Study Site	Yield Goal	Residual Soil P	P_2O_5 Recommended	Soil pH
	(kg/ha)	(kg/ha)	(kg/ha)	
Calhoun	8,152	141	0	5.4
Colorado	8,785	111	0	7.9
Hill	7,530	29	90	7.9
Victoria	8,152	88	22	7.7
Wharton	9,412	81	28	7.2
Williamson	7,530	149	0	4.7

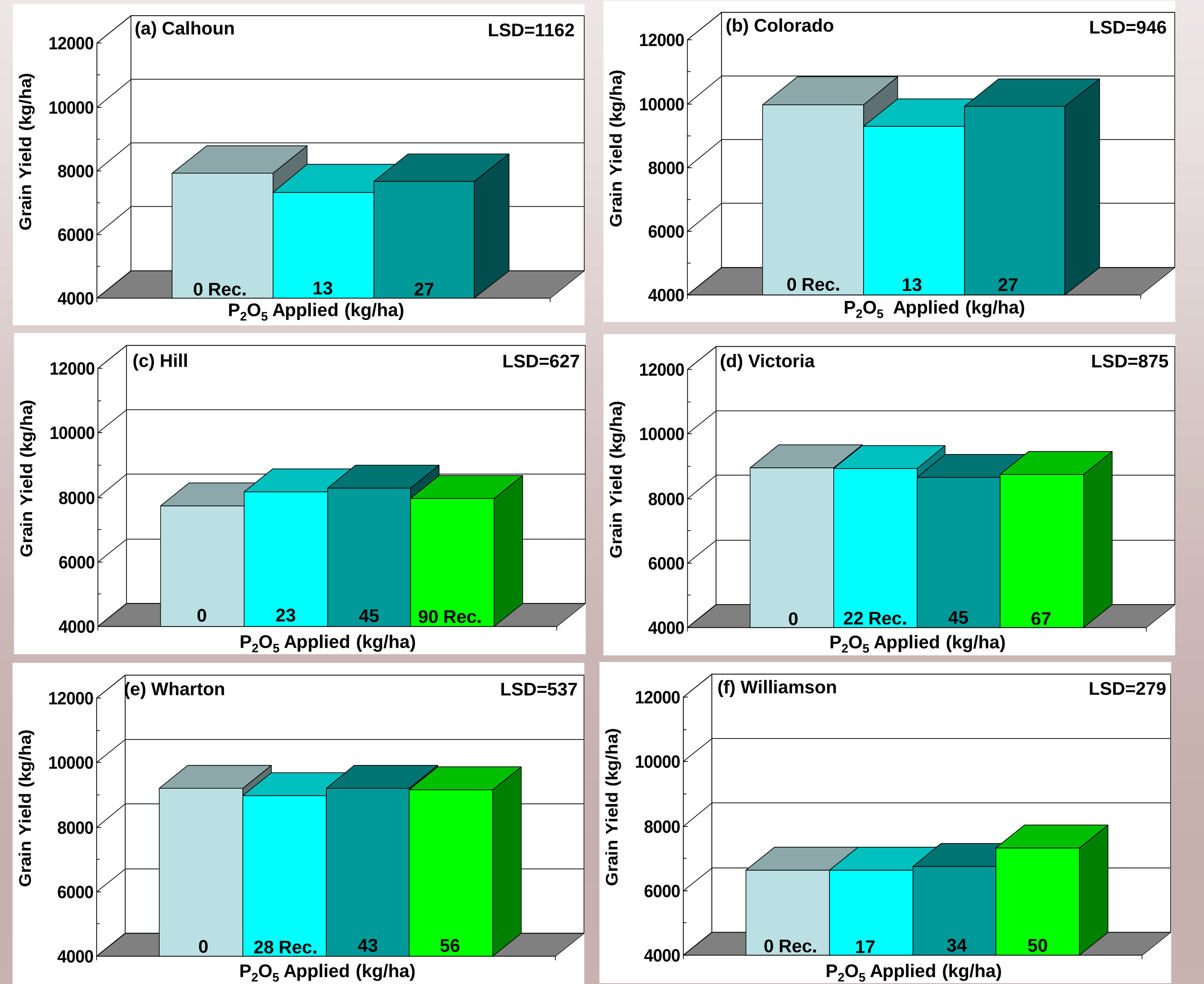

Fig. 2a-f. Effect of recommended and alternate rates of P_2O_5 on grain yield of corn grown in the Coastal Bend (a, b, d & e) and Central Blacklands (c & f) of Texas, 2010. Means within a location weren't significantly different according to LSD (P≤0.05).

Summary

- ✓ **Increasing application rates of P fertilizer above current recommendations did not affect grain yield of corn across 10 site-years.**
- ✓ **Dry conditions in 2008, 2009 and 2010 limited yield potential and thus, corn grain yield response to recommended rates of P fertilizer application across 12 of 13 site-years.**
- ✓ **Grain yield of corn was not affected by application of an alternate, high performance P source.**

Acknowledgements

Appreciation is extended to all grower cooperators involved in these studies. The authors recognize the assistance of Dale Mott, Galen Roberts, Stephen Biles, Stephen Labar, Vince Saladino, Al Nelson, Archie Abrameit, Dr. Dan Fromme, Russell Sutton and cooperating county Extension agents in planning study sites, collecting soil samples, establishing field plots, and collecting data. Liquid N and P sources were donated by Texas Liquid Fertilizer and Agriliance, LLC.

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