PREDICTION OF CORN AND SOYBEAN GRAIN YIELD RESPONSE TO P IN MINNESOTA USING THE HANEY H3A AND MEHLICH-III TESTS

Daniel E. Kaiser, Leanna M. Leverich, Jeffrey A. Vetsch, and Jeffrey S. Strock
University of Minnesota, St. Paul, Minnesota
dekaiser@umn.edu

ABSTRACT

Minnesota soils are highly variable in P availability due to the wide range of chemical properties. Currently, two soil tests are used to measure soil P in Minnesota, the Bray-P1 for pH<7.4 and the Olsen P for pH$\geq$7.4. The purpose of this study was to correlate crop response in corn and soybean rotations to the Bray-P1, Olsen, Mehlich-III, and Haney H3A extractions and to determine critical concentrations for each extraction method. Soil P tests were also correlated with one another to determine their viability for use in Minnesota soils. This study was conducted at nine field locations throughout the state from 2010 to 2014 with strip trails of 0 or 200 lb P_2O_5 ac^{-1} replicated three to four times within each field. Soil samples (0-6 inch depth) and grain harvest measurements were collected every forty feet along each strip. Critical values for the Bray-P1, Mehlich-III and Haney H3A (colorimetric) were similar near 12 ppm and slightly higher than the Olsen P extraction (9 ppm). All soil tests were strongly correlated when soil pH was <7.4 and less correlated when pH$\geq$7.4, in particular the Haney H3A and Bray-P1 were poorly correlated to the Olsen P on high pH soils. Free carbonates in the soil were affecting the amount of P extracted by the acid soil extractants. All soil tests utilized could be correlated to crop response but calibration is necessary to make the tests useful. The Olsen P soil test is still preferred over acid extractants when soil pH is 7.4 or greater.

INTRODUCTION

Application of phosphorus (P) fertilizer is an integral management strategy for corn and soybean growers in the state of Minnesota. The state's recommendations for P application are determined by crop yield response to P over varying soil test P levels (Kaiser et al., 2011). In Minnesota, two soil tests are used to measure soil test P. The Bray-P1 is suggested for use in soils with a pH<7.4 and the Olsen P is suggested for soils with a pH$\geq$7.4 Soils throughout the state vary greatly in chemical properties, parent materials, and pH. The abundance of basic calcareous soils on the western side of Minnesota increases potential for P fixation and requires a soil P test extractant not liable to neutralization. The high amount of calcium carbonates in these soils can neutralize acid extractants in soil P tests such as the Bray P1, Mehlich 3, and Haney H3A (Haney et al, 2010) leading to inaccurate representations of soil test P. Calcareous soils are commonly derived from the glacial till parent material of Des Moines Lobe till and can be found in South Dakota, Minnesota, and Iowa.

All soil test P methods can measure orthophosphate colorimetrically using a colorizer solution and spectrophotometer. The Mehlich-III and Haney H3A extractants can also be analyzed with an Inductively Coupled Plasma (ICP) spectrophotometer. ICP analysis performs a number of extractions concurrently determining the concentration of several elements including both orthophosphate and organic phosphorus. The detection of both inorganic and organic forms of P often results in higher readings of soil P with the ICP method compared to colorimetric testing. The digression between these two testing methods must be considered when interpreting soil P test results.

The Mehlich-III test has grown in popularity throughout out the United States since it can be used to extract multiple elements at one time. The Haney H3A has gained attention as well for its ability to estimate soil health. However, in Minnesota the ambiguity of these tests due to potential extractant neutralization requires further testing for correlation to crop yield and explicit soil tests such as the Bray-P1 and Olsen P. Such correlations will provide information on the viability of the Mehlich-III and Haney H3A for P recommendations in Minnesota.

The goal of this study is to develop accurate prediction tools for corn and soybean yields in response to P fertilizer using the Bray P-1, Olsen P, Haney H3A and Mehlich-III soil tests. The objectives of this study are: 1) Correlate the Haney H3A, Mehlich-III, Bray-P1, and Olsen P soil test amongst themselves at varying pH levels; 2) Determine critical values (estimated at 95% of maximum yield) for each soil test; 3) Determine effect of calcium carbonates on soil P test methods and their usability.

MATERIALS AND METHODS

Table 1. Soil series information, planted crop at each location, and initial potassium soil test data from phosphorus studies conducted from 2010 to 2014. Soil test data was collected in the spring and represent a field average for the 2 acre study areas.

			Soil Test†			Soil Series	
Location	Year	Crop	K	CCE	pH	Major	Minor
			ppm	%			
Blomkest	2010	Corn	190	12.4	8.2	Harps-Okaboji	Canisteo-Seaforth
Foxhome	2010	Soybean	136	3.4	8.2	Elmville	Wyndmere
Lamberton	2010	Corn	143	0.0	6.1	Ves-Storden	--
New Richland	2010	Corn	279	5.4	4.9	Canisteo-Glencoe	Glencoe
Rochester	2010	Corn	158	0.4	7.5	Port Byron	Mt. Carroll
Grand Meadow	2011	Soybean	139	0.0	7.2	Clyde	Protavin
Stewart	2011	Soybean	187	0.8	7.1	Canisteo-Glencoe	Crippin
Staples	2012	Corn	100	0.1	7.2	Verndale	--
New Richland	2013	Corn	216	1.7	7.0	Canisteo-Glencoe	Crippin-Nicollet
Rochester	2014	Soybean	140	0.4	7.0	Mt. Carroll	Oronoco

† K, Soil test potassium (K-ammonium acetate); CCE, calcium carbonate equivalency.

Phosphorus studies were established beginning in 2010 through 2014 (Table 1). Studies consisted of two treatments, either no P or 200 lbs P_2O_5 broadcast in long strips within fields and incorporated prior to planting. All yes/no treatment combinations were replicated three to four times. Any additional nitrogen, K, sulfur, or zinc fertilizer was applied based on needs for the individual locations to keep these elements non-limiting when they were not specifically being studied.

Soil samples were collected prior to treatment application to a depth of six inches. Samples were collected every 40 feet from the center of each paired yes/no strip and consisted of a composite of ten cores. A total of 16 to 21 samples were taken from each strip making the total strip length 640 or 840 feet at each location. An additional 20’ was added to the end of each strip to allow space for application equipment to reach optimum speed prior to entering the research plot area. Strip width varied from 15 to 20' wide at each location. Considering both the yes and no strips, each soil sample would represent a 30 to 40' wide by 40' long area (0.0275 to 0.0367 ac) within the field. This small of an area was chosen in order to limit random variability in yield between each yes/no area.

The center two rows of each 6 or 8 row strip was harvested using a research grade plot combine. Harvest samples were collected every 40' along the strip to be representative of the soil samples collected in Spring. Corn grain yield is adjusted to 15.5% moisture content. Soybean grain yield is adjusted to 13.0%. Soil samples were dried at 65^{o}F in a force air oven and ground to pass through a 2 mm sieve. Samples were analyzed colorimetrically with the Bray-P1, Olsen P, Mehlich-III (Frank et al., 1998), and modified Haney H3A (Haney et al., 2010) methods. Phosphorus in the Mehlich-III and Haney H3A extracts were additionally determined with inductively coupled plasma spectrometry (ICP).

Statistical analysis was conducted using SAS. Critical concentrations for each soil test were determined using PROC NLIN in SAS. The critical concentration is defined as the soil test at which 95% of maximum yield was produced. Data was grouped for analysis to improve correlation between grain yield response and soil test values by averaging soil test and grain yield results from four neighboring yes/no comparisons within the field. All unique combinations of plots in a 2 x 2 arrangement were grouped for analysis. Correlation among the individual soil tests was conducted using PROC CORR and PROC REG.

RESULTS AND DISCUSSION

Soil test variability

Table 2. Summary of Soil Test P varying in location, year and testing method taken prior to fertilizer application. Summary includes average (AVG) and standard deviation (ST) of each testing method from 63-64 sampling areas within each location.

	Bray-P1		Olsen-P		M3P-C		M3P-ICP		H3A-C		H3A-ICP	
	AVG	ST	AVG	ST	AVG	ST	AVG	ST	AVG	ST	AVG	ST
	ppm											
Blomkest	2.9	2.2	7.1	2.7	11.3	6.3	30.1	8.8	5.7	3.1	10.0	3.6
Foxhome	4.5	3.7	4.8	2.3	13.8	6.9	31.9	7.3	8.8	4.1	12.4	4.7
G. Meadow	20.3	10.8	11.2	5.7	18.4	8.8	42.5	9.9	16.6	7.9	31.5	9.8
Lamberton	16.9	7.0	12.5	4.2	15.3	6.0	31.7	8.2	13.7	6.5	25.8	7.2
New Rich.'10	5.6	3.2	6.4	1.2	6.1	2.5	20.5	4.4	10.0	5.2	17.3	8.1
Roch. '10	23.0	12.3	12.1	5.4	20.0	10.6	38.0	13.0	20.2	10.2	32.8	12.5
Stewart	24.5	14.1	13.8	6.8	25.2	11.3	37.0	12.6	25.3	11.2	32.7	12.6
Staples	34.3	15.6	14.8	6.7	33.7	18.3	54.8	23.2	24.9	15.3	34.7	17.8
New Rich.'13	13.7	8.5	7.5	4.1	15.8	4.7	31.6	7.3	16.5	8.4	22.3	9.7
Roc.'14	15.3	5.4	9.0	3.3	13.6	5.9	28.8	8.2	15.2	5.5	23.8	5.6

Average and the standard deviation of individual soil samples taken from each location are given for the Bray-P1, Olsen P, Mehlich-III colorimetric, Mehlich-III ICP, Haney H3A colorimetric, and Haney H3A ICP soil P tests in Table 2. Locations varied in average initial soil test P categories from Low to Very High according to the Bray-P1 soil test. Soil test values across the trial areas were Low to Very Low at Blomkest, Foxhome, New Richland and Stewart. According to past research there is a high probability of a large grain yield response at each of these locations from applied P fertilizer. Soil test values averaged High at Grand Meadow and Lamberton and Very High at Rochester and Staples. These locations along with Stewart had the highest variation in soil P across the trials as indicated by the larger standard deviations.

Critical P soil test values

The primary purpose of this study was to compare grain yield with and without P to determine relative grain yield and relate it to the soil test value measured from the area encompassing the yes/no comparison. This comparison was used to determine the critical soil test P level or the value at which crops do not respond to applications of fertilizer P. Routine phosphorus soil tests do not measure the all pools of P within the soil depth sampled, thus values can vary between soil test methods. In addition, ICP analysis differs from colorimetric analysis in its ability to measure both organic P and inorganic P (orthophosphate). The P extraction from both soil pools results in a higher value for soil test P when using ICP analysis. Since the soil tests extract different amounts of nutrients, the critical soil test levels may be different for each test method.

Table 3. Critical soil test P levels for various soil test methods summarized by relative yield level for all corn and soybean data. The critical level is summarized for 95% of maximum grain yield.

Soil Test	Corn	Soybean
	-------------------------------ppm-------------------------------	
Bray-P1	12	12
Olsen	9	8
Mehlich-III: Color	14	17
Mehlich-III: ICP	32	39
H3A: Color	12	12
H3A: ICP	22	21

Figures 1 and 2 show the correlation of relative yield (yield with no P as a percentage of yield with P) with all soil test methods: Bray-P1, Olsen P, and Mehlich-III colorimetric, Mehlich-III ICP, Haney H3A colorimetric and Haney H3A ICP for corn and soybean, respectively. Shading of the data points represent differences in soil pH for soils with pH greater than or equal to or less than 7.4. The best correlation between relative corn or soybean yield and individual soil tests was for the Bray-P1 test for both crops (R^2=0.53 for corn and 0.41 for soybean). The poorest correlation was for the Mehlich-III test (ICP and color analysis) and soybean grain yield. The poor correlation for the Mehlich-III test was due to an over extraction of P at one location with a soil high in carbonates (not shown). The R^2 values for the remaining tests were mostly between 0.3-0.4.

Utilizing individual yes/no comparisons results in a great degree of variability within the relationship between yield response and soil test value. Subtitle variation in population could result in a large variation in yield that may not be related to the treatment itself. To reduce the variation the data was analyzed using average values for a set of four adjacent yes/no comparisons. For corn, the critical soil test according to the Bray-P1 test was 12 ppm while the Olsen test was 9 ppm (Table 3). For soybean, the Bray-P1 critical level was 12 ppm and the Olsen value was 8 ppm. The current corn and soybean P guidelines for Minnesota do not state a critical P soil test level for the Bray-P1 or Olsen soil tests (Kaiser et al., 2011). However, broadcast P fertilization is not suggested when soil test above the High soil test classification for corn (15-20 ppm Bray P1 or 12-15 ppm Olsen) or above the low classification for soybean (6-10 ppm Bray-P1 or 4-7 ppm Olsen). However, this study indicates the current guidelines may be slightly overestimating the critical level for corn, and underestimating the critical level for soybean.

Critical soil test P values for the Mehlich-III and Haney H3A tested colorimetrically for corn and soybean were similar to the critical values of the Bray-P, as shown in Table 3. The critical values remained fairly similar between corn and soybean in all tests with the exception of the Mehlich-III, analyzed both colorimetrically and with ICP. The critical values when using the Mehlich-III extractant indicated a higher demand for P in soybeans than corn. Colorimetric and ICP analysis specified critical values 3 ppm and 7 ppm higher respectively for soybean than for corn. All other soil test P methods indicated no increase (Bray-P1, Haney H3A Color) or increase by 1 ppm (Olsen-P, Haney H3A-ICP) between corn and soybean critical values.

Bray-P1 and Haney H3A colorimetric resulted in the same suggested critical value for both corn and soybeans at 12 ppm. The same critical value between the two tests, Bray-P1 and Haney H3A colorimetric, may indicate similarities between the two tests as acid extractants. The Mehlich-III soil P test measured colorimetrically was also similar to the Bray-P1 with values for corn of 14 ppm and 12 ppm respectively. For soybean, the Mehlich-III showed greater divergence from the Bray-P1 with a critical value of 17 ppm in comparison to 12 ppm for the Bray-P1. ICP analysis for the Mehlich-III and the Haney H3A resulted in critical values nearly doubled compared to colorimetric analysis, as well as the Bray-P1. This may be attributed to the additional organic P also measured in ICP analysis. Compared to the Olsen P, all acid extractant tests (Bray-P1, Mehlich-III, Haney H3A) measured colorimetrically resulted in slightly higher values than those of Olsen P test which was expected. The strong similarities among the Bray-P1, Mehlich-III, and Haney H3A colorimetric critical values suggest similar interpretations and calibrations could be used for the three tests. This suggests the acid extractants access similar pools of P and all extractions should provide similar interpretations of soil P availability to corn or soybean. However, soils with a pH ≥ 7.4 with free carbonates may cause issues in for acid extractants and these testing methods. The Olsen P test is still suggested for use in Minnesota for soils with high pH and carbonate content.

Comparison of P extracted by soil tests

It is recommended to switch to the Olsen P test in Minnesota when soil pH is 7.4 or greater due to the effect that carbonates have on the Bray-P1 test (Kaiser et al., 2011). Comparisons of the soil test P methods were measured using the correlation coefficient for soils with a pH<7.4 and soils with a pH≥7.4, as shown in Tables 4 and 5, respectively. All soil P test methods were strongly correlated for soils with a pH<7.4 (Table 4). Even though all tests were correlated at low pH, there were differences among the tests in the amount of P measured in the extractants. The Bray-P1 and Mehlich-III colorimetric tests showed strong correlation (r=0.96) suggesting that the two soil tests measure soil P similarly. This correlation indicates calibration data for the Bray-P1 soil test could be used for the Mehlich-III soil colorimetric test for soil pH below 7.4. The Mehlich-III ICP correlation between both the Bray-P1 and Mehlich-III color indicated similar relationships, r=0.90 for both. The slightly weaker relationship with ICP analysis can again be attributed to the organic P that is read in ICP testing. The Mehlich-III color and ICP also correlated to the Olsen P (r=0.90 and r=0.84, respectively). However, this relationship is not as strong as the relationship with the Bray-P1. The Mehlich-III and Haney H3A tests exhibited relationships similar to the Mehlich-III- Olsen P correlation, with correlation coefficients (r) between 0.84-0.89 (Table 4). Like the Mehlich-III, the Haney H3A showed strong correlations with the Bray-P1. The correlation coefficients for the Haney H3A colorimetric and Haney H3A ICP with the Bray were both r=0.87, with neither test showing stronger correlation to the Bray-P1. The weakest correlations for the Haney H3A were with the Olsen P, both colorimetrically and through ICP analysis. However, there is still a fairly strong relationship exhibited between the Haney H3A colorimetrically and the Olsen P (r=0.84), and the Haney H3A ICP and Olsen P (r=0.85). When the analysis type was compared between the Haney extractions (ICP and colorimetric), the relationship was evident (r=0.96). These relationships suggest the Bray P1, Mehlich-III C, Mehlich-III ICP, Haney H3A C, and Haney H3A ICP soil test methods are adequate for use in Minnesota soils with a pH<7.4 Calibration data for individual tests may be developed and put into use for Minnesota farm recommendations.

Table 4. Correlation coefficients for soil test P methods when soil pH < 7.4. Correlation values above 0.06 are significant at $P \leq 0.05$. (n=923)

	Soil Test P Method				
	M3–C	M3–ICP	H3A–ICP	H3A–C	Olsen P
Bray P	0.96	0.90	0.87	0.87	0.93
M3–C		0.90	0.87	0.87	0.90
M3–ICP			0.89	0.84	0.84
H3A–ICP				0.96	0.85
H3A-C					0.84

Table 5. Correlation coefficients for soil test P methods when soil pH ≥ 7.4. Correlation values above 0.09 are significant at $P \leq 0.05$ (n=413)

	Soil Test P Method				
	M3–C	M3–ICP	H3A–ICP	H3A–C	Olsen P
Bray P	0.41	0.54	0.88	0.86	0.58
M3–C		0.90	0.55	0.56	0.83
M3–ICP			0.67	0.67	0.83
H3A–ICP				0.98	0.67
H3A-C					0.67

Locations with a pH greater than 7.4 show inconsistent results between soil P test methods, indicating possible neutralization of the acid extractants. As shown in Figure 3, there is clear neutralization of a subset of the samples when Bray extraction is used, resulting in a poor correlation with the Olsen P (r=0.58). At field locations with pH≥7.4, correlation between the Olsen P test and Mehlich-III extracts was evident (r =0.83). However, the correlation showed a strong grouping of data points at the tail of the trendline vector indicating some differences among soils in how the Mehlich-III test relates to the Olsen test (Figure 3). The Mehlich-III ICP analysis yielded similar results to the Mehlich-III colorimetric method. ICP analysis resulted in greater approximations of soil P and correlated to Olsen P nearly as strong as Mehlich-III colorimetric test. The Haney H3A has been growing as a popular soil testing tool for its simultaneous extractions. However, the strong acid extract is suspected to have similar issues to the Bray when used for testing in soils with high pH, which may contain free carbonates. The Haney H3A soil test method showed a weaker correlation to the Olsen P (r=0.67 (C), r=0.67 (ICP)) compared to the Mehlich-III, but a greater correlation than the Bray and the Olsen P (r=0.58). It is speculated that the Haney H3A, measured both colorimetrically and with ICP analysis, underwent a similar reaction to the other acid extractants methods and is partially neutralized when used in soils with a pH$\geq$7.4. While the correlation between the Haney H3A and Olsen P, and Mehlich-III and Olsen P are evident, the correlation with field data does not indicate the either test is a superior to the Olsen P, the current testing method suggested for use in Minnesota for soils with a pH$\geq$7.4.

Presence of free carbonates

Soil pH is typically used as a determining factor when deciding what test to use. Data comparing the Bray-P1 test to the Olsen P for soils with a pH greater than or equal to 7.4 show that the Bray under extracts P in some soils but not in all soils. Free carbonates in the soil likely will affect acid extractants such as with the Haney H3A, Mehlich-III and Bray-P1 tests. The difference between the amount of P extracted by the Bray-P1, Mehlich-III, and Haney H3A tests is summarized in Figure 4. Data is only included for the colorimetric tests in Figure 4. The tests analyzed by ICP always resulted in greater concentration of P in the extraction solution but were affected similarly than the colorimetric analysis (not shown). As the calcium carbonate equivalency (CCE) approaches 2.5 to 5 percent $CaCO_3$ the amount of P extracted by the Bray-P1 test was less than the Olsen P. This is atypical, as the Bray-P1 and other acid extractant tests consistently extract higher amounts of P (ppm) than the Olsen P in soils without free carbonates. A similar effect is observed with the Haney H3A colorimetric analysis (Figure 4). The Haney H3A retains its ability to extract more P than the Olsen test in soils with low carbonates, but extracts similar amounts of P as CCE approaches 5 percent and less P as the Olsen P test as CCE increases beyond 5 percent.

It was interesting that the relative difference between the amounts of P extracted by ICP decreased with increasing CCE for the Haney H3A test. This effect was not seen for the Mehlich-III extraction. Soils in this study with free carbonates tend to have lower concentrations of inorganic P. The Mehlich-III test did overestimate P availability at one location. Data can be seen from this location in Figure 4 where the difference between the Mehlich-III and Olsen P test was very high in spite of high carbonates. What is interesting is that the Mehlich-III test never extracted less P than the Olsen P similarly to the Bray-P1 test. In addition, the Haney H3A tended to extract more P than the Olsen P at higher CCE in the soil. This may indicate that the Mehlich-III and H3A tests are better buffered and may be used over a wider range of CCE than the Bray-P1 test. The Olsen test would still be recommended due to the lack of impacts of carbonates on the test.

CONCLUSIONS

If properly calibrated, the Mehlich-III and Haney H3A tests could be used to assess soil P status for corn and soybean in Minnesota. Critical values were similar for corn and soybean for the Bray-P1, Mehlich-III, and Haney H3A tests when measured colorimetrically. Analysis of soil extracts by ICP requires further calibration of the tests to account for additional P measured. All P tests are correlated for neutral to acid soils. All tests can be used equally if properly calibrated and none of the tests proved a definitive advantage for the determination of P status in the soil for corn or soybean. The presence of carbonates in high pH soils affects the extraction of P by the tests with acid extractants. The Olsen P test is suggested for high pH soils as it is less impacted by carbonates.

ACKNOWLEDGEMENTS

The authors would like to thank the Minnesota Agricultural Fertilizer Research and Education Council (AFREC) and the Minnesota Legacy Amendment Fund for providing funding support for this research. We also would like to thank the Department of Soil, Water, and Climate Field Crew for their technical support on the project and Agivse Laboratories for their work on the soil P extractions used in this study.

LITERATURE CITED

Frank, K., D. Beegle, and J. Denning. 1998. Phosphorus. In: J.R. Brown, editor, Recommended chemical soil test procedures for the north central region. North Central Region Res. Publ. 221 (rev.). SB 1001. Missouri Agric. Exp. Stn., Columbia. p. 21–30.

Haney, R.L., E.B. Haney, L.R. Hossner, and J.G. Arnold. 2010. Modifications to the new soil extractant H3A-1: A multinutrient extractant. Commun. Soil Sci. Plant Anal. 41: 1513-1523.

Kaiser, D.E., J.A. Lamb., and R. Eliason. 2011. Fertilizing recommendations for agronomic crops in Minnesota. Univ. of Minnesota Ext., St. Paul. http://www1.extension.umn.edu/agriculture/nutrient-management/nutrient-lime-guidelines/fertilizer-recommendations-for-agronomic-crops-in-minnesota/docs/BU-6240S-PUB.pdf (accessed 22 Sept. 2016).

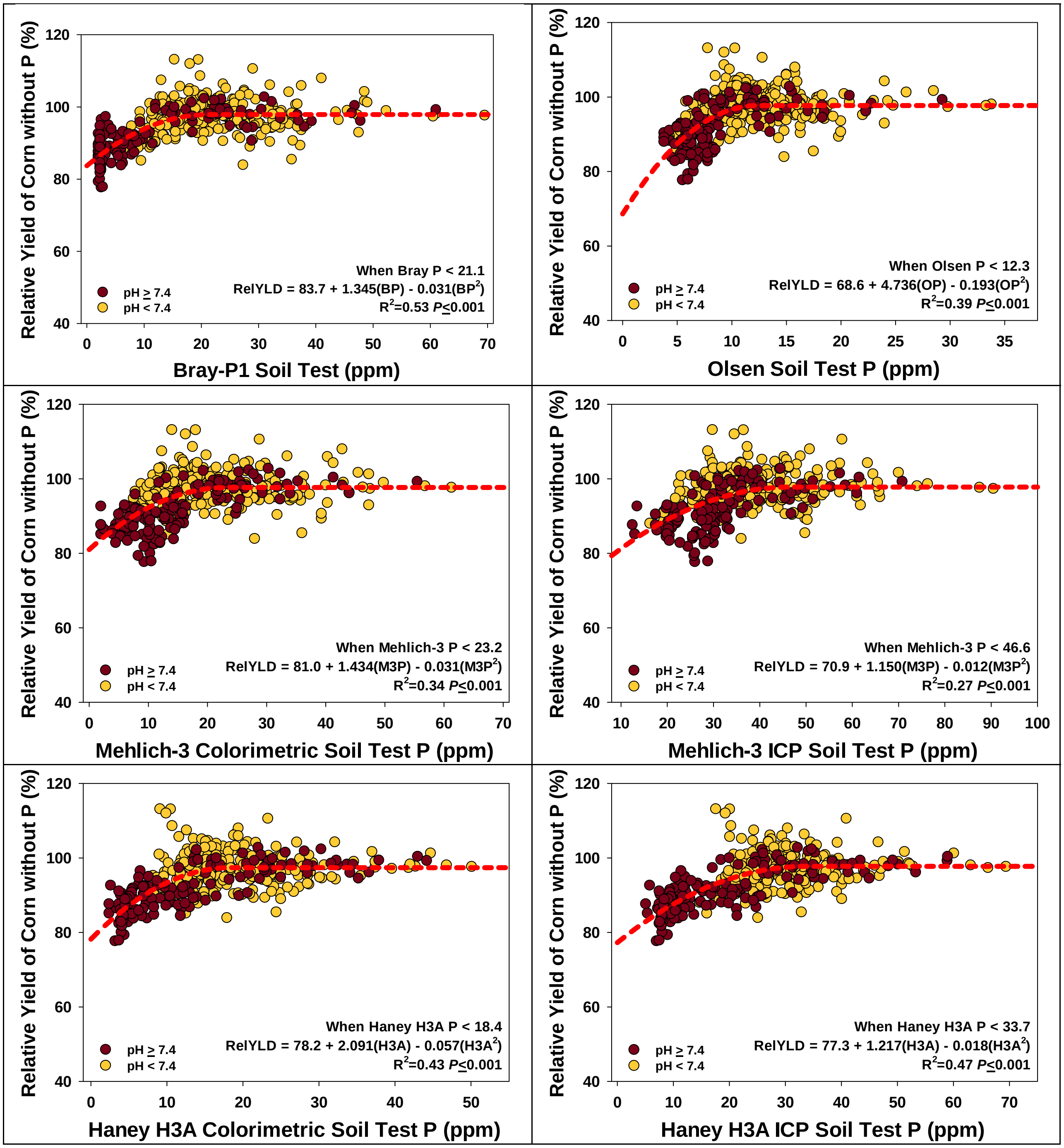

Figure 1. Critical Values for various soil test P methods derived from relative corn yield and soil test P and characterized by soil pH.

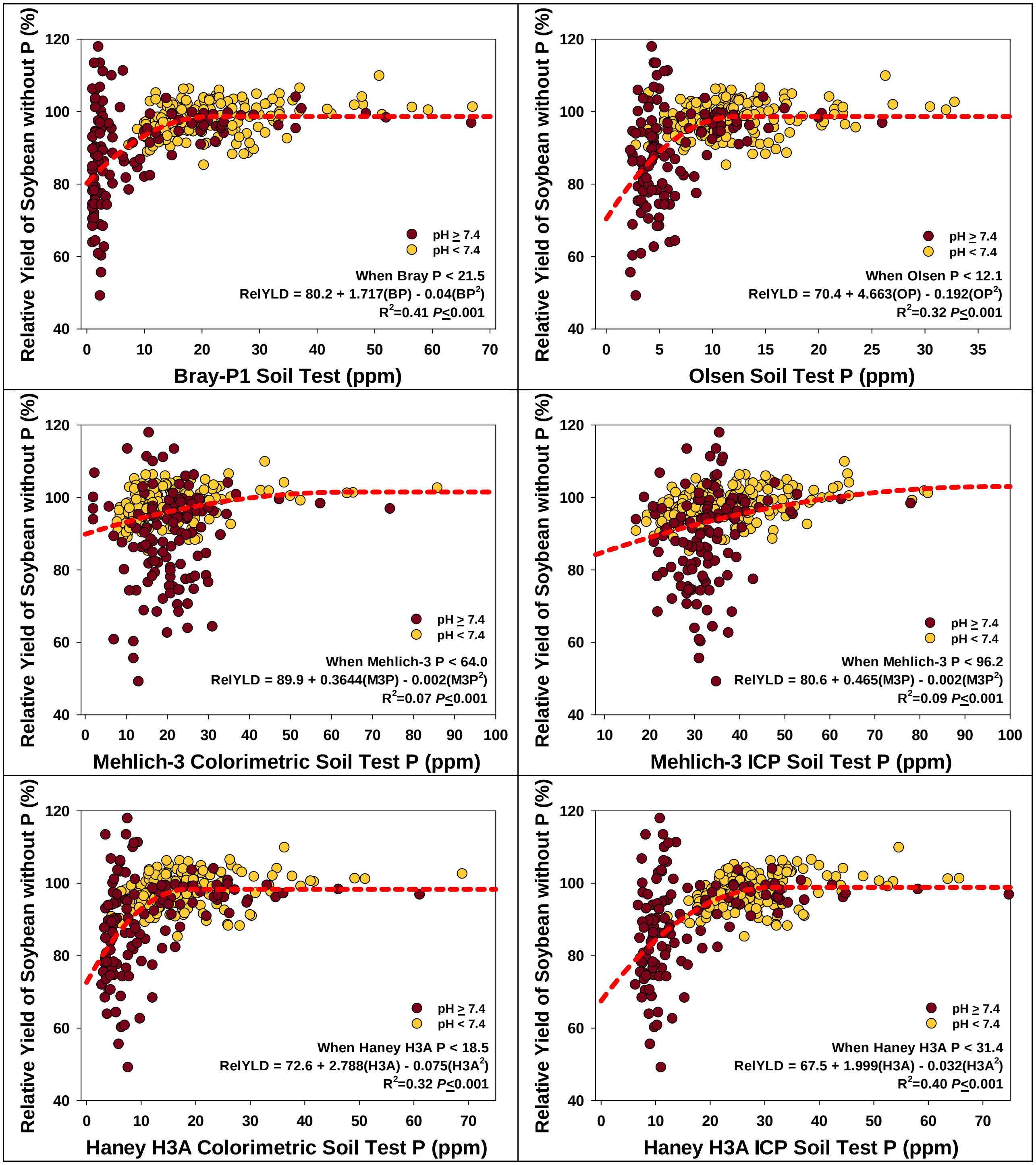

Figure 2. Critical Values for various soil test P methods derived from relative soybean yield and soil test P and characterized by soil pH.

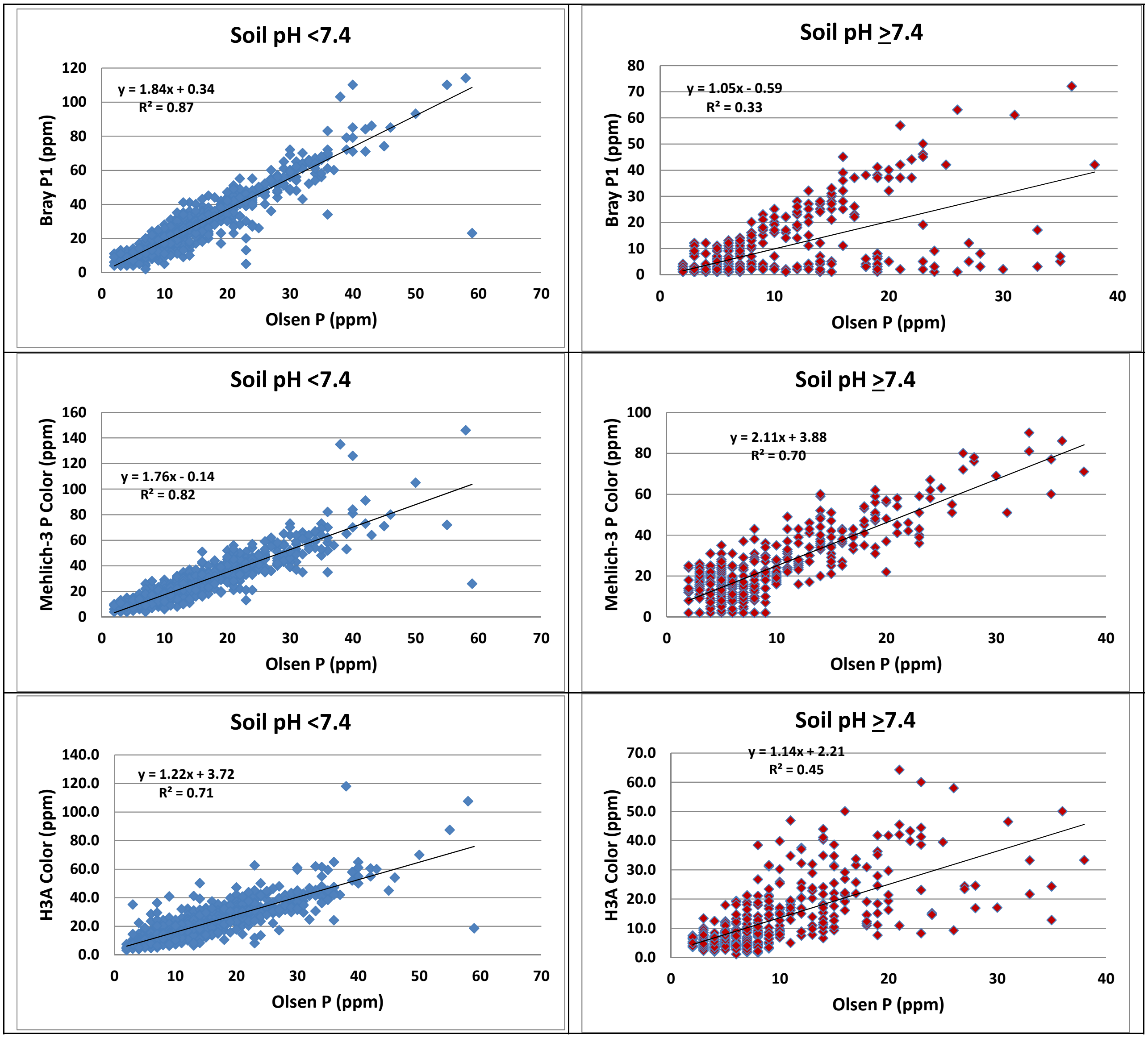

Figure 3. Comparison between the Olsen soil P test and the Bray-P1, Mehlich-III, or Haney H3A colorimetric tests summarized based on soil pH greater than or equal to 7.4 and less than 7.4.

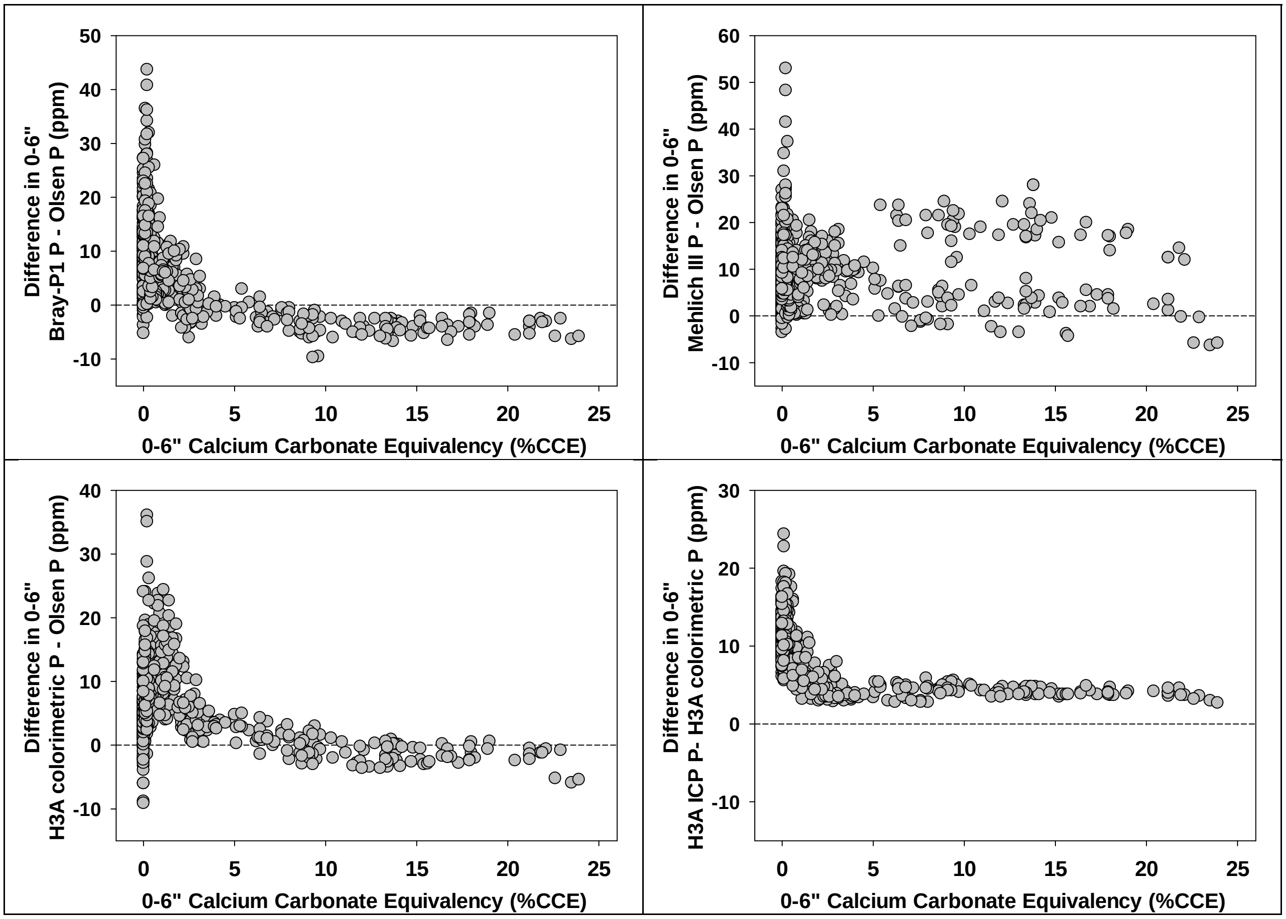

Figure 4. Difference between the Bray-P1, Mehlich-III, and H3A colorimetric P tests minus the Olsen P test and the difference between P measured by ICP and color for the H3A test versus Calcium Carbonate content in Minnesota Soil.

PROCEEDINGS OF THE

46th
NORTH CENTRAL
EXTENSION-INDUSTRY
SOIL FERTILITY CONFERENCE

Volume 32

November 2-3, 2016
Holiday Inn Airport
Des Moines, IA

PROGRAM CHAIR:

Dorivar Ruiz Diaz
Kansas State University
Manhattan, KS 66506
(785) 532-7213
ruizdiaz@ksu.edu

PUBLISHED BY:

International Plant Nutrition Institute
2301 Research Park Way, Suite 126
Brookings, SD 57006
(605) 692-6280
Web page**: www.IPNI.net**

ON-LINE PROCEEDINGS:

http://extension.agron.iastate.edu/NCE/