CORRELATION OF BRAY, OLSEN AND MEHLICH 3 SOIL TESTS WITH CORN GRAIN YIELD

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INTRODUCTION

In the past, the Bray P1 soil test was the most common extractant used to assess the soils relative ability to supply P to growing crops in much of the eastern Great Plains and Midwest. The Olsen P soil test is often used in much of the western Great Plains. In recent years, several states/laboratories, including Kansas State University, have adopted the Mehlich 3 extractant for routine use. The ability to extract multiple elements with a single extractant and its reported utility on both neutral and calcareous soils are major advantages of the Mehlich-3 extractant. The main disadvantage of the Mehlich-3 extractant is a lack of data correlating soil test values with crop response. While there have been efforts to correlate the Mehlich-3 extractant analytical results with Bray and Olsen P analytical values, little effort has been directed at directly correlating the Mehlich-3 extractant with crop response.

In addition, there are two common methods of Mehlich-3 determination – a colorimetric procedure and inductively coupled plasma (ICP) analysis. A major advantage of the ICP procedure is the ability to simultaneously determine multiple soil test nutrients from the single extract. As a result, laboratories adopting ICP determinations often report greater cost efficiencies than with single nutrient, colorimetric determinations. Little data from the Great Plains has looked at the relationship of these two methods of determination.

The objectives of this work were to 1) determine the relationships among the Bray P1, Olsen P, Mehich-3 Colorimetric (M-3 Col) and Mehich-3 ICP (M3-ICP) tests, 2) to correlate each of these tests to corn grain yield and P content and 3) evaluate several models for determining the critical soil test value for each extractant/procedure.

MATERIALS AND METHODS

Field studies were established across the state of Kansas as part of a larger project. Several randomized complete block studies were conducted each year from 2002 through 2005. Most of these studies included 5-6 replications and P application rates of 0, 20, 40, 80 and 120 pounds of P_2O_5/A. Locations included Cherokee (2), Stevens, Greeley (2) and Republic Counties in Kansas and Dekalb County, MO. Additionally, a longer term strip treatment study was established in Shawnee county. This study included 0, 20, 40, 80 and 120 pounds of P_2O_5/acre application strips and 15 sampling tiers within each one-half mile long strip. Other than P application, all other cultural practices at each of these locations were determined by the farmer-cooperator.

Soil samples from individual plots/sampling locations consisted of compositing 12-15 individual cores from the surface 6-7 inches into a single sample. Bray P1 and Olsen P determinations were conducted at the Kansas State University soil testing laboratory while Servi-Tech Laboratories performed M3-Col and M3-ICP determinations from the same prepared soil samples. Over 1,600 individual soil samples were used for correlations among soil test extractants/methods.

Correlation of each soil test/procedure to grain yield and grain P content utilized the individual check plots of each replication for each of the RCB studies. Because of the large number of harvest/sampling locations at the Shawnee county location, this location was not included in correlating each soil test to crop response. Yield sufficiency was calculated by dividing the check plot yield by the highest yielding P treatment in each individual replication. Individual plots and replications were used in order to collect data from as wide a range of soil test values as possible.

Regression analysis was used to evaluate the relationships among each soil test extractant/procedure and crop grain yield and P content. The models used included the Mitcherlich equation, a quadratic-plateau equation and a modified Mitcherlich equation.

Mitcherlich

$$Y = c - (b^* \exp (PST \times c))$$

Quadratic-Plateau

$$Y = a + (b \times PST) + (c \times PST \times PST)$$

Modified Mitcherlich

$$Y = 1 - \exp (a \times PST)$$

The lowest total error sum of squares (ESS) was used to determine the best-fit model for a particular extractant, and the coefficient of determination (R^2) was subsequently determined. For comparison purposes, the total ESS is presented in Table 1 as a normalized value since there were not an equal number of observations for each soil test extractant/procedure. The soil test critical value was determined by estimating the soil test at the 95% sufficiency level for each model and each extractant/procedure. For grain P content, only the quadratic-plateau model was used to correlate soil test values and grain P content.

RESULTS AND DISCUSSION

All soil tests were highly correlated to one another when calcareous soils were excluded. For calcareous soils the Bray P1 extractant frequently, but not always, extracted relatively less soil P than any other extractant/method than on non-calcareous soils. As a result, all presented correlations pertaining to the Bray P1 extractant excluded calcareous soils (Fig. 1, 2 and 3). On non-calcareous soils, the Bray P1 extractant was very highly correlated to the Mehlich-3 extractant, regardless of the method of determination (M3-Col, R^2 = 0.90 and M3-ICP, R^2 = 0.92). While the Bray P1 was highly correlated to the Olsen P test, the strength of the correlation was considerably weaker (R^2 = 0.80).

The M3-Col test extracted about 11% more P than did the Bray P1 while the M3-ICP procedure extracted even more. The M3-ICP determination extracted more than 22% more P than the Bray P extractant. The Olsen test extracted just slightly less than 50% of the P extracted by the Bray P1 test.

M3-Col = (1.11 x Bray P) M3-ICP = (1.22 x Bray P) + 4

Olsen P = (0.49 x Bray P) M3-ICP = (M3-Col x 1.10) + 4

Table 1. Correlation, Error and Critical Soil Test Values Of Soil Tests To Corn Grain Yield

Model	Bray P1 (n=38)		M3-Col (n=38)		M3-ICP (n=26)		Olsen (n=38)	
	NESS[1] / R^2	Critical Value (ppm)	NESS / R^2	Critical Value (ppm)	NESS / R^2	Critical Value (ppm)	NESS / R^2	Critical Value (ppm)
Quadratic-Plateau	2.56 0.43	22.8	2.39 0.41	24.6	2.74 0.50	33.2	2.84 0.28	14.9[2]
Mitcherlich	2.35 0.41	27.0	2.27 0.43	31.7	2.53 0.54	38.0	2.84 0.29	18.5[2]
Modified Mitcherlich	2.47 0.38	18.4	2.59 0.44	24.2	2.57 0.53	42.5	3.64 0.27	8.7

[1] NESS = Normalized Error Sum Of Squares; NESS = (Total ESS/n) x 100
[2] Estimated critical value is outside the range of data in the data set

In general, the M3-ICP procedure was more highly correlated with corn grain yield than were any of the other extractants. Interestingly, the Olsen test resulted in the lowest correlations and the highest ESS of any of the studied tests. Additionally, the estimated critical Olsen P soil test value was outside the range of values measured in this study. The Bray P1 and M3-Col performed similarly. The Mitcherlich model for determining critical soil test values would seem to provide the least amount of error as compared to either of the other two models, but also resulted in the overall highest critical soil test values. The quadratic-plateau model resulted in intermediate error and critical soil test values.

Grain P contents were highly correlated to P soil test for all of the extractants/procedures (Figure 8-11). Using the previously estimated critical P soil test values for the Mitcherlich and quadratic-plateau models, grain P contents at the identified critical P soil test values were generally in the range of 0.31-0.33 lbs P_2O_5 per bushel of corn grain for the Bray P1 and Mehlich 3 extractants. Grain P content continued to increase at the highest Olsen P soil test values measured.

SUMMARY

In summary, it seems that 1) the Bray P1, M3-Col and M3-ICP P soil test extractants should perform equally well; 2) Different interpretations need to be used for each of these extractants/procedures. The Mehlich 3 colorimetric and ICP determinations should be treated as two different P soil tests, 3) The Olsen test did not perform as well in this study as was expected. Perhaps this is due to fact that the majority of the soils utilized were not alkaline or calcareous, 4) The Mehlich 3 extractant performs equally well on neutral-acidic soils and calcareous soils, 5) There does not seem to be a down side to switching from the traditional Bray P1 extractant to the Mehlich 3 extractant and 6) It may be possible to use corn grain P content to evaluate P management programs.

Fig. 1. Correlation of Bray P and Mehlich 3 - Colorimetric

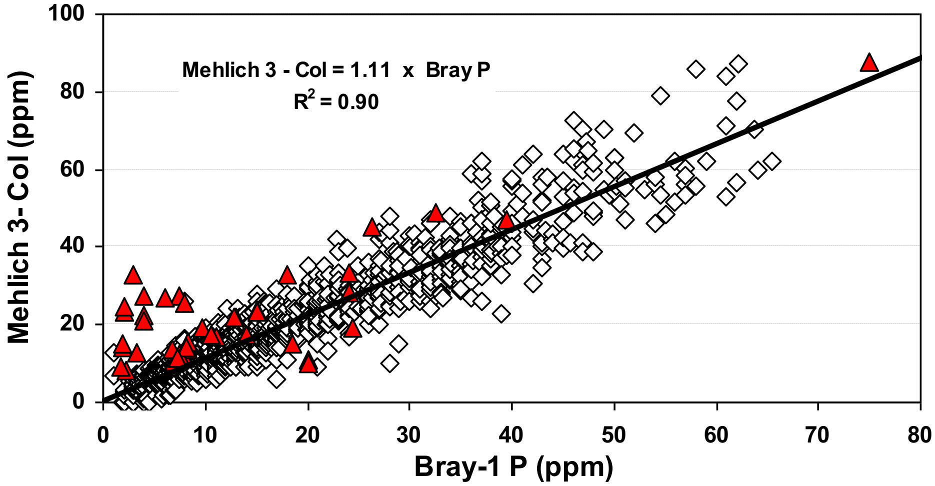

Fig. 2. Correlation of Bray P and Olsen P

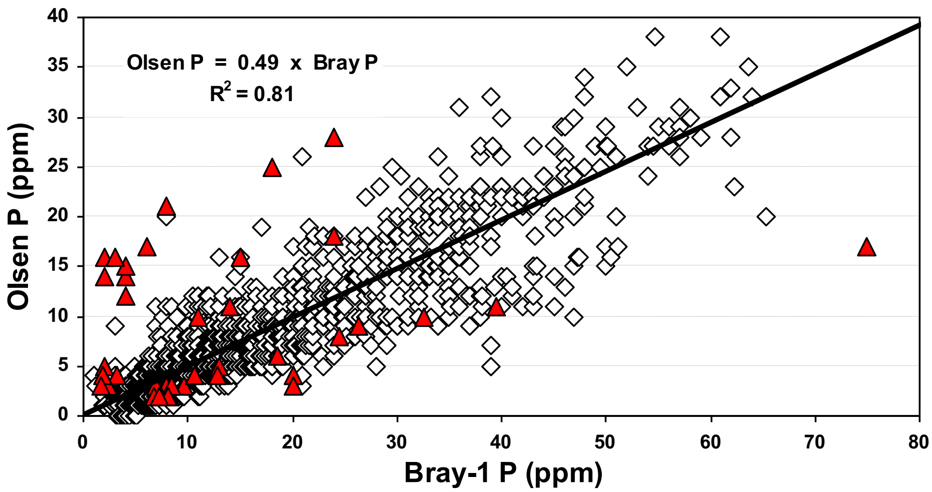

Fig. 3. Correlation of Bray P and Mehlich 3 - ICP

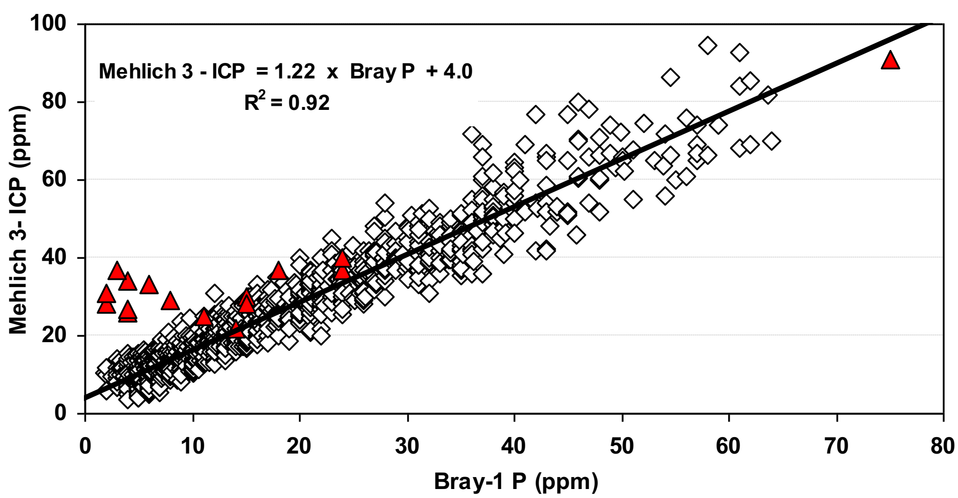

Fig. 4. Corn Yield Relation To Bray P1 Soil Test

KSU, 2002-2005

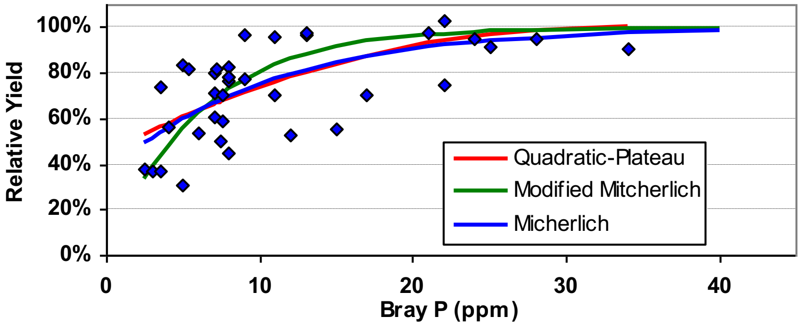

Fig. 5. Corn Yield Relation To Mehlich-3 Col Soil P

KSU, 2002-2005

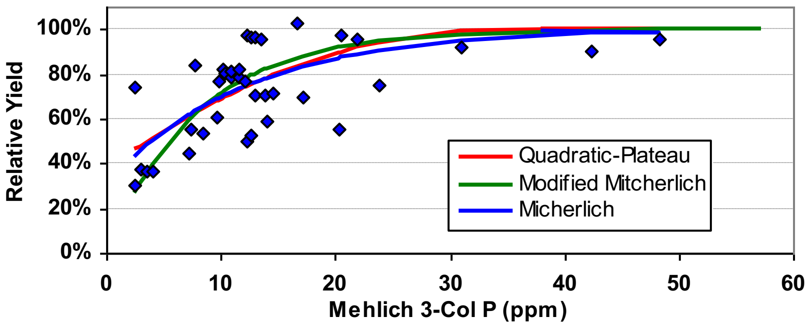

Fig. 6. Corn Yield Relation To Mehlich-3ICP Soil P

KSU, 2002-2005

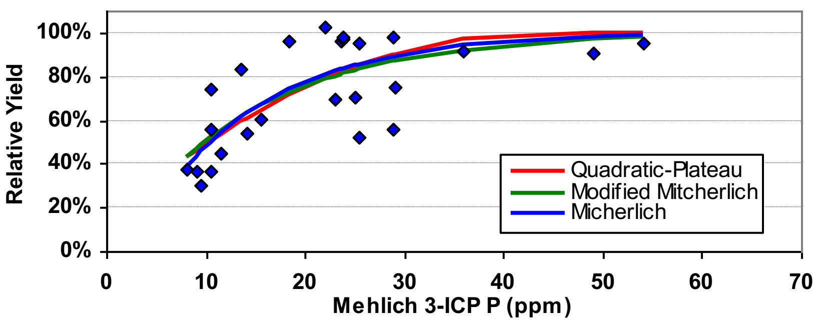

Fig. 7. Corn Yield Relation To Olsen Soil P

KSU, 2002-2005

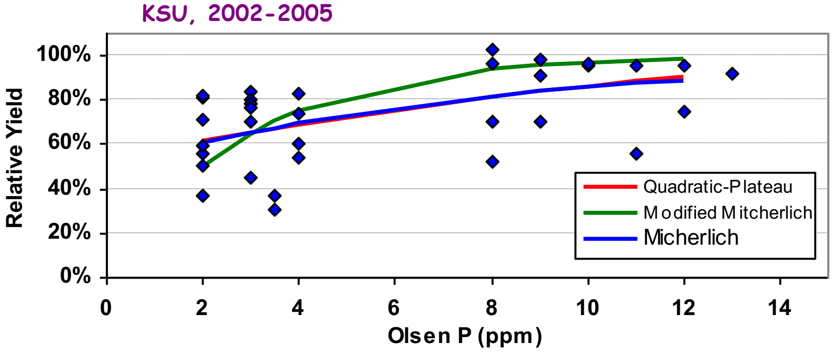

Fig. 8. Corn Grain P Content vs. Bray Soil P
KSU, 2002-2005

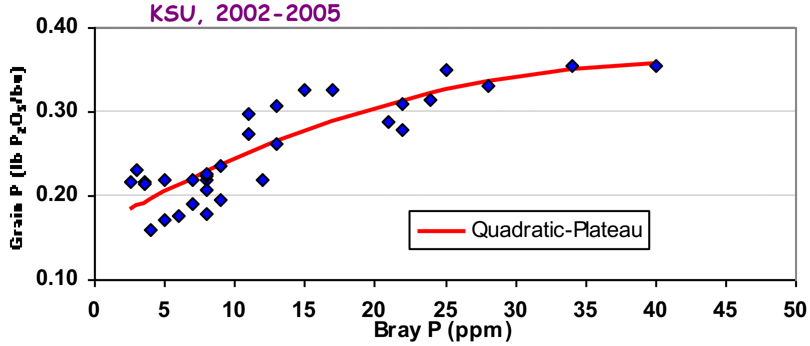

Fig. 9. Corn Grain P Content vs. Mehlich 3-Col Soil P
KSU, 2002-2005

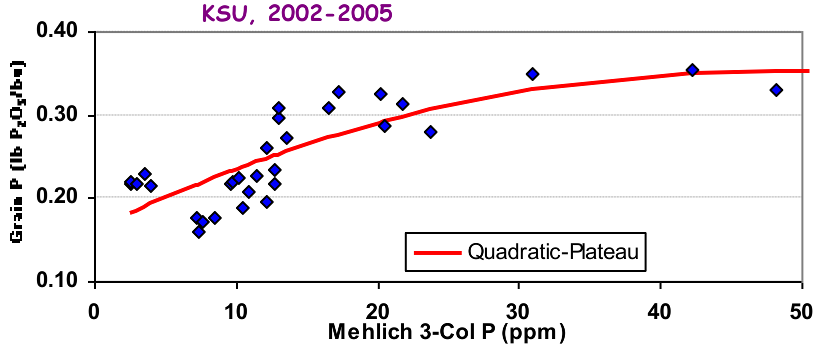

Fig. 10. Corn Grain P Content vs. Mehlich 3-ICP Soil P
KSU, 2002-2005

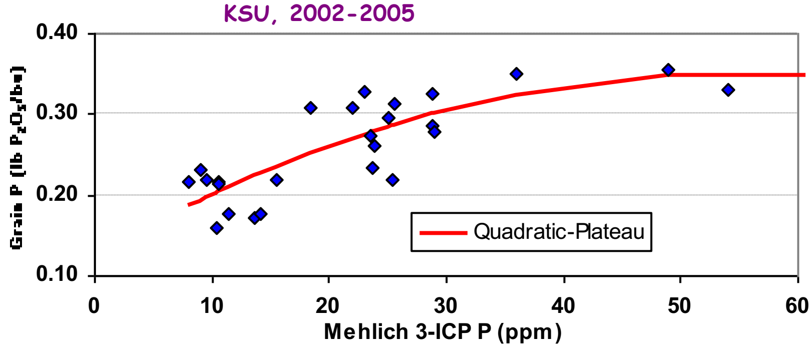

Fig. 11. Corn Grain P Content vs. Olsen Soil P
KSU, 2002-2005