Prediction of corn and soybean grain yield response to P in Minnesota using the Haney H3A and Mehlich-III tests

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Background

In Minnesota, the Bray-P1 soil test is suggested for use for corn and soybean production for soils with pH<7.4 and the Olsen test is suggested when soil pH is 7.4 or greater. Other soil tests are available for use but have not been correlated and calibrated to corn and soybean yield response in Minnesota.

Objectives

- Determine if the Haney H3A and Mehlich-III tests (analyzed colorimetrically or by ICP) correlate to corn (*Zea mays* L.) and soybean (*Glycine max* var. Merr.) grain yield response.
- Compare the amount of P extracted among the Bray-P1, Olsen P, Mehlich-III, and Haney H3A soil P test methods for acid and alkaline soils.

Methods

STRIP TRAILS

- Strip trails were conducted at 10 locations (Table 1) throughout Minnesota.
- Strips were treated with 0 or 98 kg P ha^{-1} and replicated three to four times in each field.
- Soil samples (0-15 cm depth) and yield were collected every 12m along each paired strip. Relative grain yield represents the percent yield produced by the 0 P plot versus the bordering plot where P was applied.

SOIL TEST P ANALYSIS

- Bray-P1, Olsen P, Mehlich-III and Haney H3A P were measured colorimetrically,
- Mehlich-III and Haney H3A P were also measured with inductively coupled plasma spectrometry (ICP).

STATISTIC ANALYSIS - SAS

- Critical values were determined using a quadratic plateau model in PROC NLIN
- Correlation among the individual soil tests was conducted using PROC CORR and PROC REG

Table 1. Summary crop (corn, Cn; Soybean, Sb), pH, calcium carbonate equivalency (CCE) and soil test P taken prior to fertilizer application. Soil test P summary includes average (AVG) and standard deviation (SD) from 63-64 sampling areas within each location.

Site	Crop	pH	CCE (g kg^{-1})	Bray-P1		Olsen-P		M3P-C		M3P-ICP		H3A-C		H3A-ICP	
				mg P kg^{-1}											
				AVG	SD	AVG	SD	AVG	SD	AVG	SD	AVG	SD	AVG	SD
1	Cn	8.2	124	2.9	2.2	7.1	2.7	11.3	6.3	30.1	8.8	5.7	3.1	10.0	3.6
2	Sb	8.2	34	4.5	3.7	4.8	2.3	13.8	6.9	31.9	7.3	8.8	4.1	12.4	4.7
3	Sb	7.2	0	20.3	10.8	11.2	5.7	18.4	8.8	42.5	9.9	16.6	7.9	31.5	9.8
4	Cn	6.1	0	16.9	7.0	12.5	4.2	15.3	6.0	31.7	8.2	13.7	6.5	25.8	7.2
5	Cn	4.9	54	5.6	3.2	6.4	1.2	6.1	2.5	20.5	4.4	10.0	5.2	17.3	8.1
6	Cn	7.0	17	13.7	8.5	7.5	4.1	15.8	4.7	31.6	7.3	16.5	8.4	22.3	9.7
7	Cn	7.5	4	23.0	12.3	12.1	5.4	20.0	10.6	38.0	13.0	20.2	10.2	32.8	12.5
8	Sb	7.0	4	15.3	5.4	9.0	3.3	13.6	5.9	28.8	8.2	15.2	5.5	23.8	5.6
9	Sb	7.1	8	24.5	14.1	13.8	6.8	25.2	11.3	37.0	12.6	25.3	11.2	32.7	12.6
10	Cn	7.2	1	34.3	15.6	14.8	6.7	33.7	18.3	54.8	23.2	24.9	15.3	34.7	17.8

Results

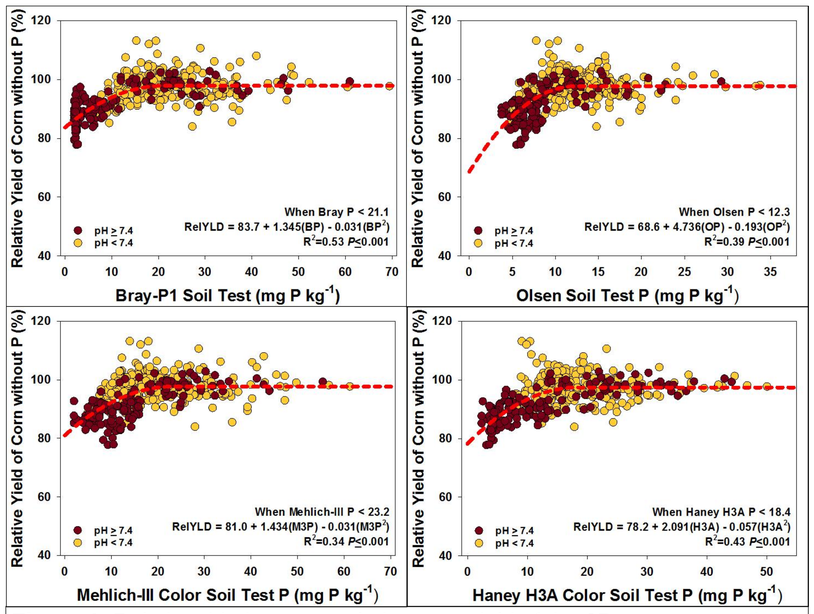

Figure 1. Relationship between relative corn yield of the 0P treatment and selected soil test P methods characterized by soil pH.

Table 3. Soil Test P correlation coefficients according to soil pH.
**pH < 7.4 Correlation values above 0.06 are significant at P<0.05. (n=923)*
**pH ≥ 7.4 Correlation values above 0.09 are significant at P<0.05. (n=413)*

	M3–C	M3–ICP	H3A–ICP	H3A–C	Olsen P
Bray P	0.96	0.90	0.87	0.87	0.93
	0.41	0.54	0.88	0.86	0.58
M3–C		0.90	0.87	0.87	0.90
		0.90	0.55	0.56	0.83
M3–ICP			0.89	0.84	0.84
			0.67	0.67	0.83
H3A–ICP		*pH < 7.4*		0.96	0.85
		pH ≥ 7.4		0.98	0.67
H3A-C					0.84
					0.67

Table 2. Critical soil test P levels and model R^2 for various soil test methods summarized for corn and soybean data. The critical level is defined as the soil test at 95% of maximum grain yield.

	Corn		Soybean	
	mg P kg^{-1}	R^2	mg P kg^{-1}	R^2
Bray-P1	12	0.53	12	0.41
Olsen P	9	0.39	8	0.32
M3-C	14	0.34	17	0.07
M3-ICP	32	0.27	39	0.09
H3A–C	12	0.43	12	0.32
H3A-ICP	22	0.47	21	0.40

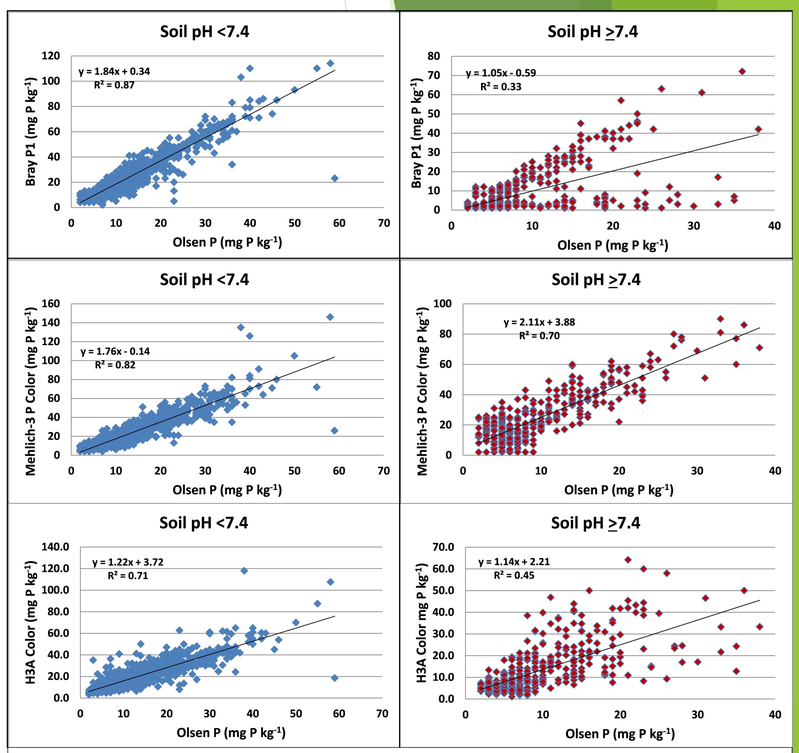

Figure 2. Comparison between Olsen soil P test and the Bray-P1, Haney H3A, or Mehlich-III colorimetric tests based on soil pH ≥7.4 and pH < 7.4.

Discussion

- Critical values are lowest for the Olsen P test followed by the Bray-P1 and Haney H3A (colorimetric), which are similar to each other for both crops. The Mehlich-III colorimetric critical values are slightly higher, followed by the Haney H3A ICP and Mehlich-III ICP, which resulted in the greatest critical levels of all tests (Table 2).
- The Mehlich-III colorimetric and ICP test were poorly correlated to soybean grain yield (Table 2).
- The Bray-P1 test resulted in the greatest correlation with corn and soybean grain yield response (Table 2).
- Correlation among all soil tests was greatest when soil pH was <7.4 (Table 3).
- Analysis by ICP resulted in greater amount of P analyzed due to organic P extracted.
- The Haney H3A and Bray-P1 correlated to each other, but were poorly correlated to the Olsen P on high pH soils (Figure 2). The Mehlich-III test correlated similarly to the Olsen regardless of soil pH.
- The amount of P extracted by the Bray-P1 and Haney H3A (colorimetric) equaled the Olsen P test when CCE approached 25 g kg^{-1} and 50 g kg^{-1}, respectively (data not shown). The Mehlich-III (colorimetric and ICP) test was affected by carbonates but never resulted in less P extracted than the Olsen test.

Conclusion

The Haney H3A and Mehlich-III soil P tests can be calibrated for use in Minnesota for corn and soybean. None of the test methods studied provide an advantage in assessing soil P status in soils. In high pH soils where free carbonates may be present, the Olsen P test is preferred to avoid an underestimation of available P.

UNIVERSITY OF MINNESOTA EXTENSION

Thank you to the Minnesota Agricultural Fertilizer Research and Education Council (AFREC) and the Minnesota Clean Water Legacy Amendment Fund for providing support for this research.