Precision Phosphorus Management for Soybean

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Introduction

Soybean responds to phosphorus fertilization in the Midwest. Most correlation and calibration data suggests that soybean is less responsive than corn. Because of this, normal management in the Upper Midwest is to fertilize before the corn crop in a corn-soybean rotation for both the corn crop and following soybean crops. This saves the cost of one application and the logistical problem of fertilization with P after a corn harvest. This management works well in soils with a pH less than 7.4 and no free calcium or magnesium carbonate. The phosphorus fertilizer will not be tied up during the corn year leaving a residual amount large enough to cause a grain yield response in the soybean in low soil testing soils. In small plot research, phosphorus placement studies have indicated that normally a broadcast placement is best for soybeans. This is opposite of the best placement for corn is.

Little is known about site specific phosphorus application and management practices for soybean grown in glacial till landscapes. A study was initiated in spring 1996 in a soybean-corn rotation to determine the effect of landscape on phosphorus management for soybeans.

Materials and Methods

A study was started with two sites in South-Central Minnesota on soils derived from glacial till to answer question about the effect of phosphorus fertilizer application management on soybean in a soybean-corn rotation. Both sites were established in the spring of 1996 before planting. One site, located in Blue Earth County Minnesota, was planted to corn in 1996 and was planted to soybean in 1997. The other site located in McLeod County Minnesota was planted to soybean in 1996, corn in 1997, and will be soybean again in 1998. This research is in the early stages so only results from soybean crop in 1996 from the McLeod County site will be discussed.

The McLeod County site was 990 ft. by 480 ft. in size. Treatments were applied in strips in spring 1996 before chisel tillage and soybean planting by the cooperator farmer. The treatments included four phosphate rates of 0, 30, 60, and 90 lb/A and two application methods: broadcast incorporated and knifed to a depth of four to five inches at 30 inch spacings between knifes, Figure 1. Each treatment strip was six-30 inch rows wide with the center three rows harvested by a plot combine in 60 ft segments. Grain moisture was measured and the grain yields corrected to 13 % moisture.

Soil samples in a six-inch depth were taken in 60 foot segments in each check strip for Bray-P, Olsen-P, K, pH, and organic matter prior to planting spring 1996. This results in a grid cell pattern which is close to 60 X 60 foot . Each sample point represents a composite of nine cores. Using pH of the samples, the correct phosphorus soil testing procedure was used to categorize the phosphorus results into response categories of very low, low, medium, high, and very high. In Minnesota, Bray-P is used when the pH is less than 7.4 and Olsen-P is used for soils with a pH of 7.4 and greater. Table 1. shows the soil tests for each category.

Table 1. Bray-P and Olsen-P values for each soil test category in Minnesota.

Category	Phosphorus Soil Test Procedure Bray-P	Olsen-P
	--------- ppm ---------	
Very low	0 - 5	0 - 3
Low	6 - 10	4 - 7
Medium	11 - 15	8 - 11
High	16 - 20	12 - 15
Very high	21 +	16 +

For this study the average soil tests for the knife and broadcast treatment pairs were used in the grain yield response analysis. An elevation survey was also conducted to characterize the site.

Results and Discussion

Site characterization

Although this a small site, 11 acres, soil test values for the check strips varied considerably, Table 2.

Table 2. Mean, minimum, and maximum values for Bray-P, Olsen-P, K, pH, and organic matter in soil samples taken every 60 feet in the check strips, May 1996.

	Mean	Minimum	Maximum
Bray-P (ppm)	11.5	1	34
Olsen-P (ppm)	11.4	5	45
K (ppm)	136	85	252
pH	7.0	5.6	7.9
Organic matter (%)	5.2	2.3	9.9

These values are similar to others in experiments we have conducted in the past. Glacial till soils by the nature of their development are very mixed which results in considerable variability in soil properties.

At this site the spatial distribution of pH and elevation are related, Figures 2 and 3. The low portions of the landscape, northwest and southeast corners, tend to greater pH values. The Bray-P soil test distribution, Figure 4, ranges from 1 to 34 ppm. Bray-P values in the area where pH values are greater than 7.4 were in the 0 to 5 ppm range. The Olsen-P values were also low in these areas, Figure 5.

Grain yield response

The soil test categories corrected for pH ranged from low to high at this site, Figure 6. There were four segments with a low soil test, 21 segments with a medium soil test, and seven segments with high soil tests. The grain yield data was analyzed by soil test category. Previous research on similar landscapes indicates soil test phosphorus is a good predictor of corn grain yield response to phosphorus fertilizer application, Table 3.

Table 3. Distribution of corn grain yield responses over different soil test categories in Minnesota.

Soil Test Category	Probability for Corn Grain Yield Response
	%
Very low	•
Low	80
Medium	60
High	25
Very high	7

• = no data for this category. n = 33.

Phosphorus fertilizer increased soybean grain yields at the low and medium soil test levels at the 0.09 and 0.01, respectively, while no significant increase occurred at the high soil test categories ($P = 0.14$). The grain yield increase for soils in the low category, was 4.1 bushels A^{-1} at the 90 lb P_2O_5 A^{-1} rate. The method of application was not significant, 41.1 bushels A^{-1} for the broadcast treatments and 40.2 bushels A^{-1} for knifed phosphorus fertilizer treatments. At the medium soil test level, a significant increase of 2.6 bushels A^{-1} occurred ($P = 0.08$). The yield for broadcast treatments was 41.5 bushels A^{-1} while the knife treatments had a grain yield of 40.7 bushels A^{-1}. The difference in grain yield response was less for the medium testing soils than the low testing soils while the statistical significance was greater. This was caused by the difference in the number of cells with a low soil test (4) vs a medium soil test (21). This difference allows more precision in detecting small yield differences.

Table 4. Soybean grain yields by phosphorus soil test category as affected by phosphate rate and method of application at McLeod County site in 1996.

Phos. Rate	Low			Medium			High		
	Broadcast	Knife	Both	Broadcast	Knife	Both	Broadcast	Knife	Both
lb/A^{-1}	- - - - - - - - - - - -			- - - - bu/A^{-1} - - - -			- - - - - - - - - - - -		
0	38.9	32.0	38.0	39.4	39.9	39.7	40.5	40.8	40.6
30	40.3	38.6	39.6	40.4	39.4	39.9	40.3	38.9	39.7
60	42.0	39.8	40.9	41.3	40.7	41.0	39.6	38.1	38.9
90	41.2	43.3	42.1	42.8	41.9	42.3	42.0	39.4	40.7
	41.1	40.2		41.5	40.7		40.6	38.8	
Statistical Analysis									
Method			.63			.08			.02
Rate			.09			.01			.14
Rate & Method			.34			.96			.74
C.V.			6.8			7.0			5.8
n			4			21			7

In summary, soybeans does respond to phosphorus fertilization across the glacial till landscape in the phosphorus soil test categories of low and medium. These responses are greater in magnitude at the low soil test category than the medium category. The effect of fertilizer placement is not clear cut. There were small differences between the broadcast and knife application methods. The advantage was to broadcast applications. This did not occur with the placement on low testing soils.

Acknowledgment

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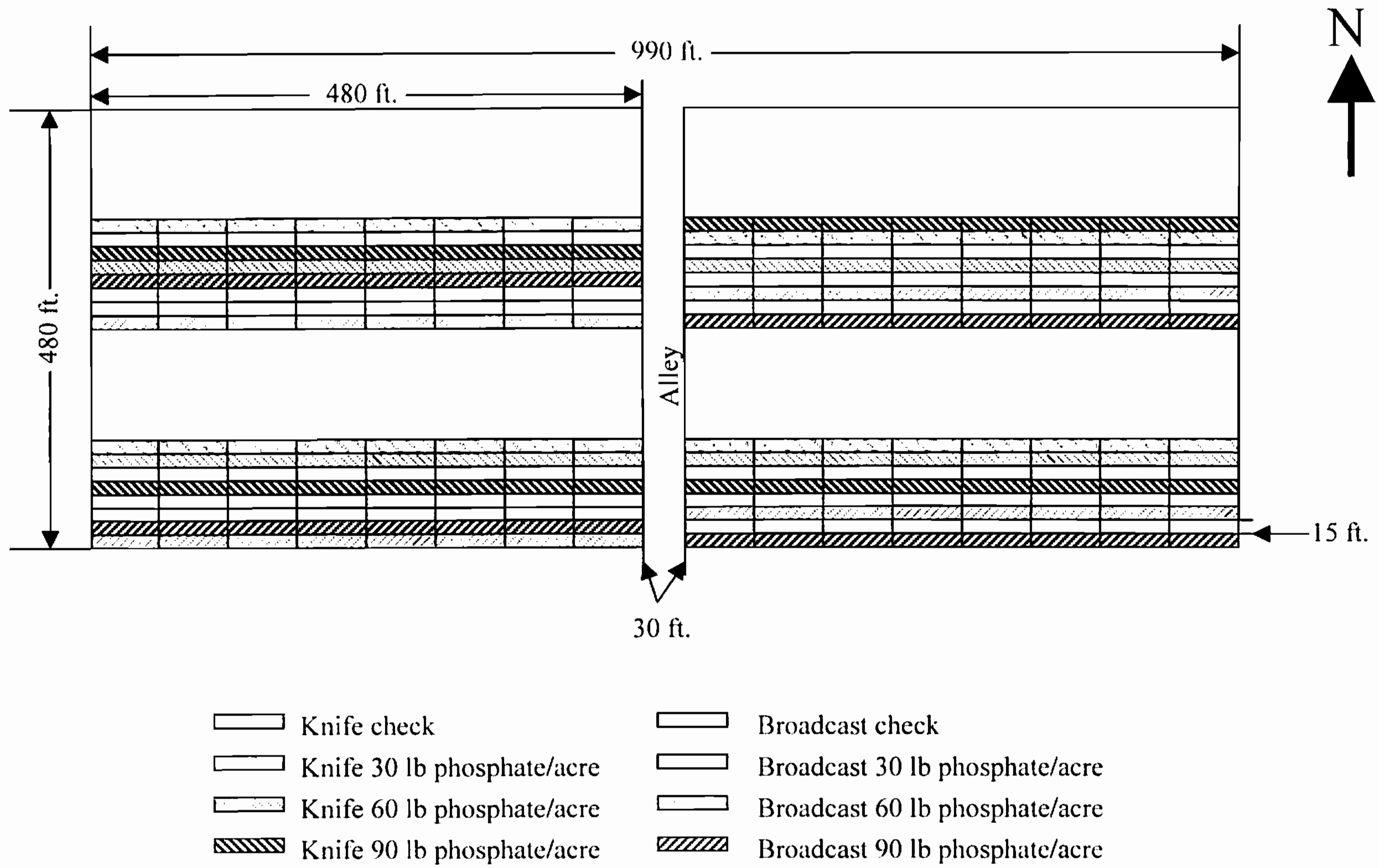

Figure 1. Plot layout with knife and broadcast treatment in McLeod County 1996.

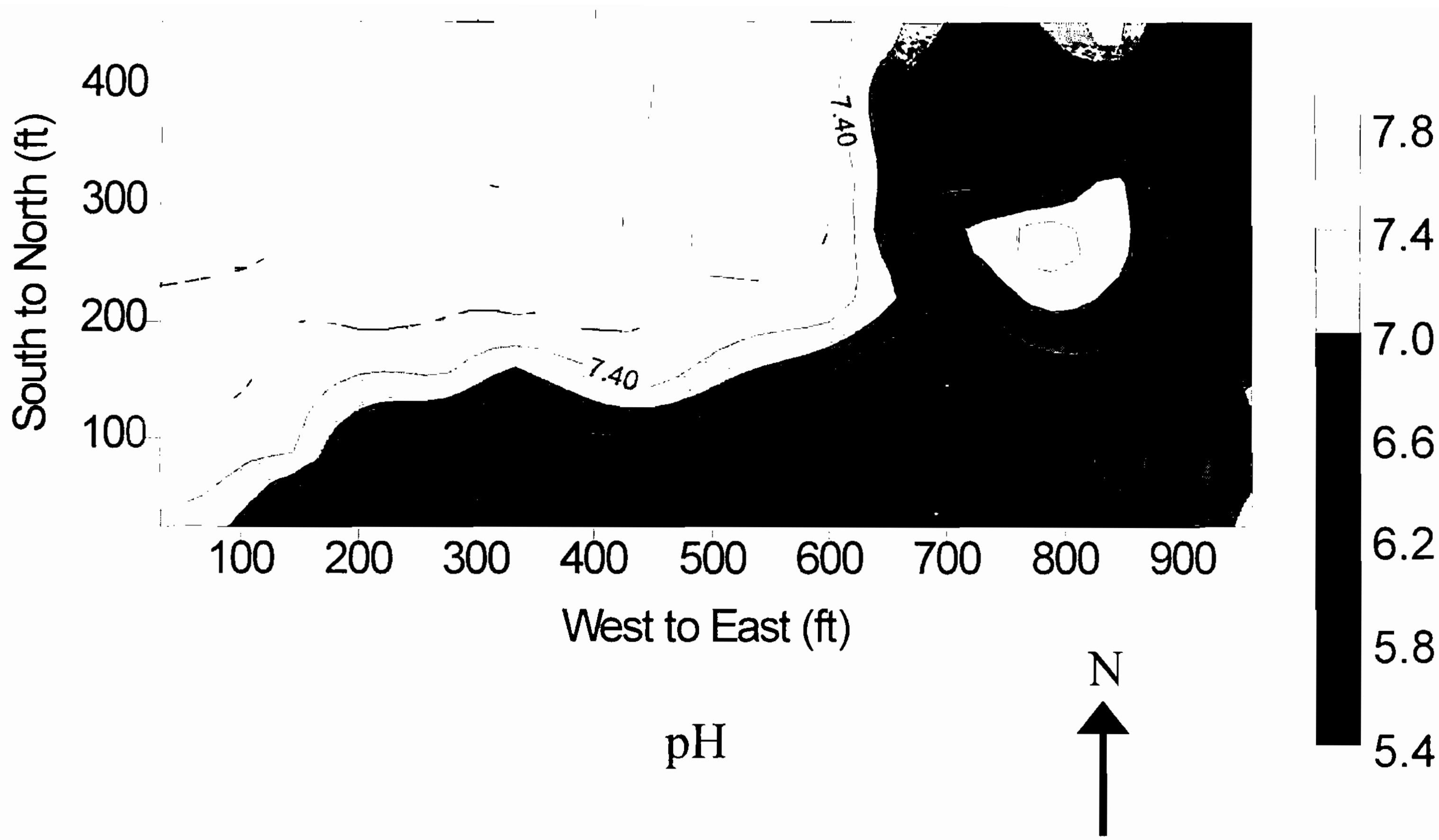

Figure 2. Spatial distribution of soil pH at McLeod County site May 1996.

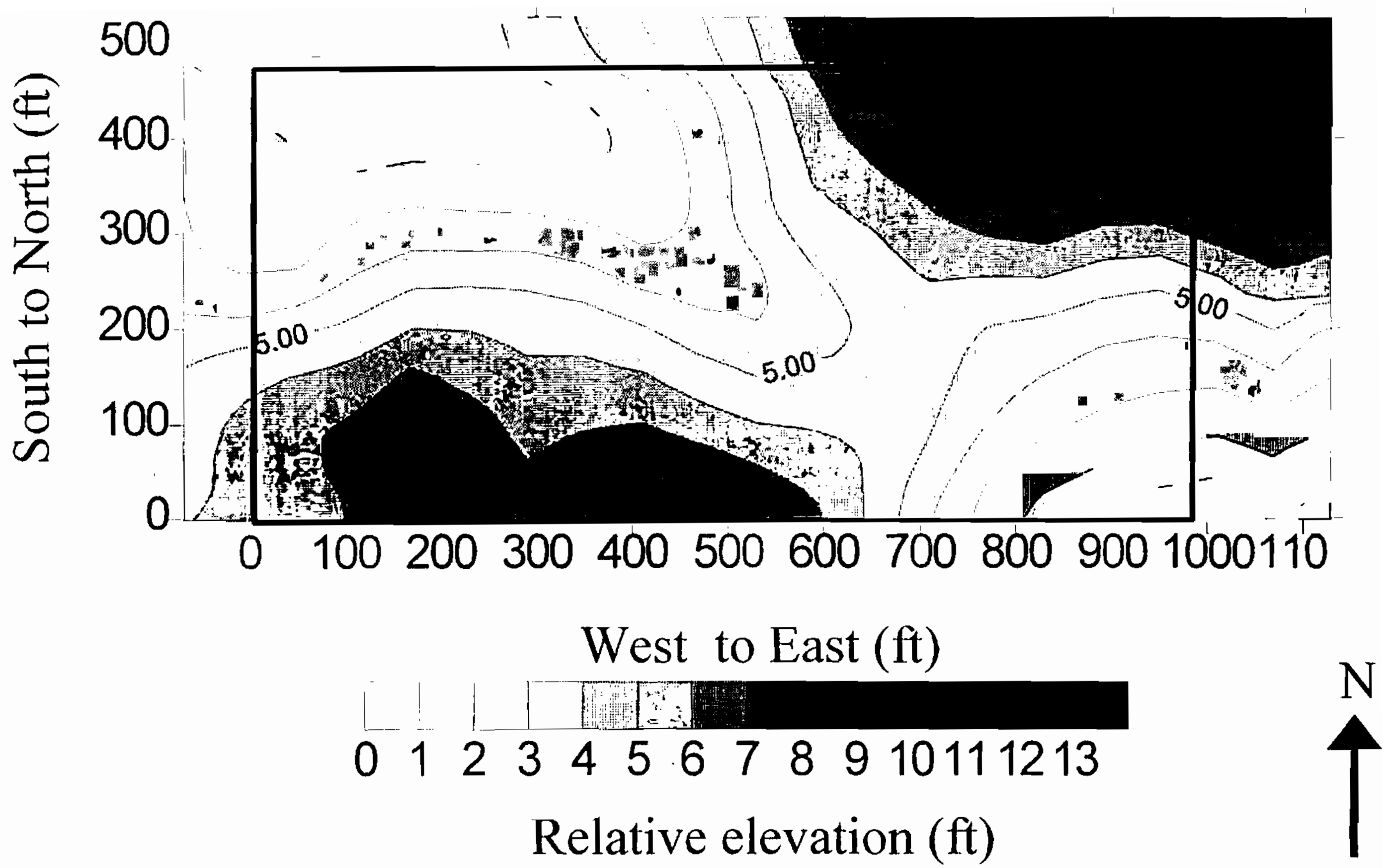

Figure 3. Relative elevation at the McLeod County site.

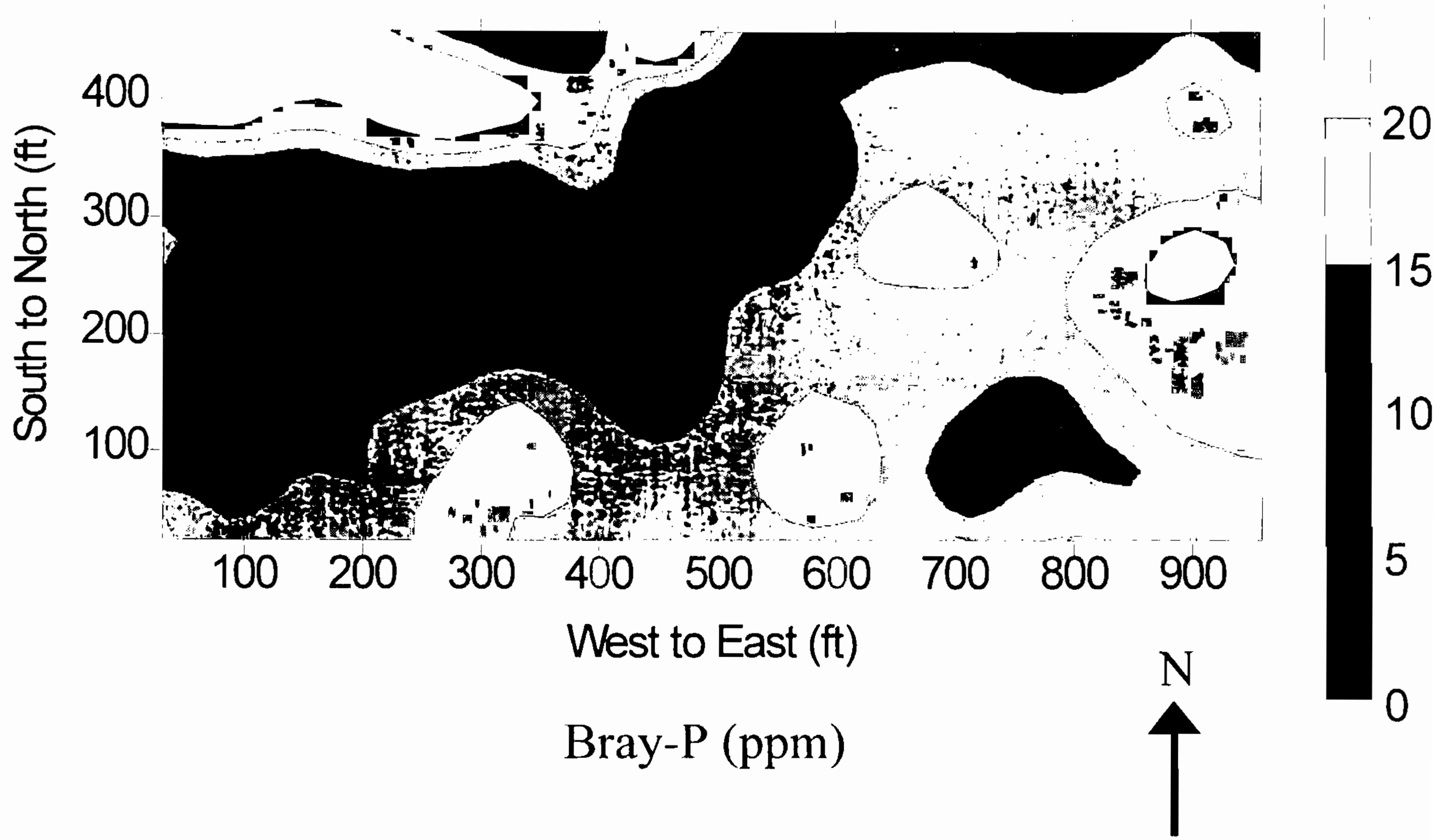

Figure 4. Spatial distribution of Bray-P values at McLeod County site, May 1996.

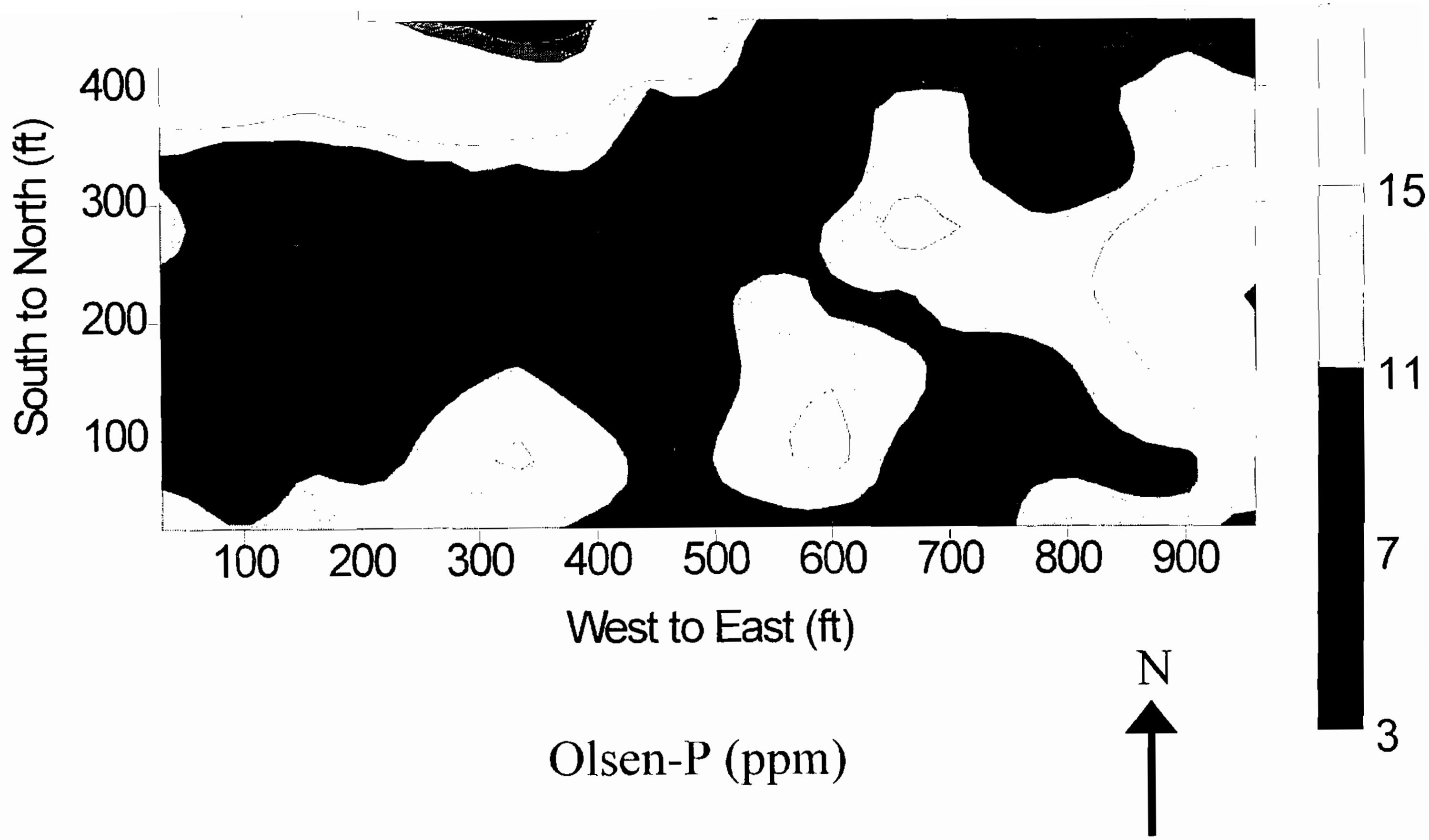

Figure 5. Spatial distribution of Olsen-P values at McLeod County site, May 1996.

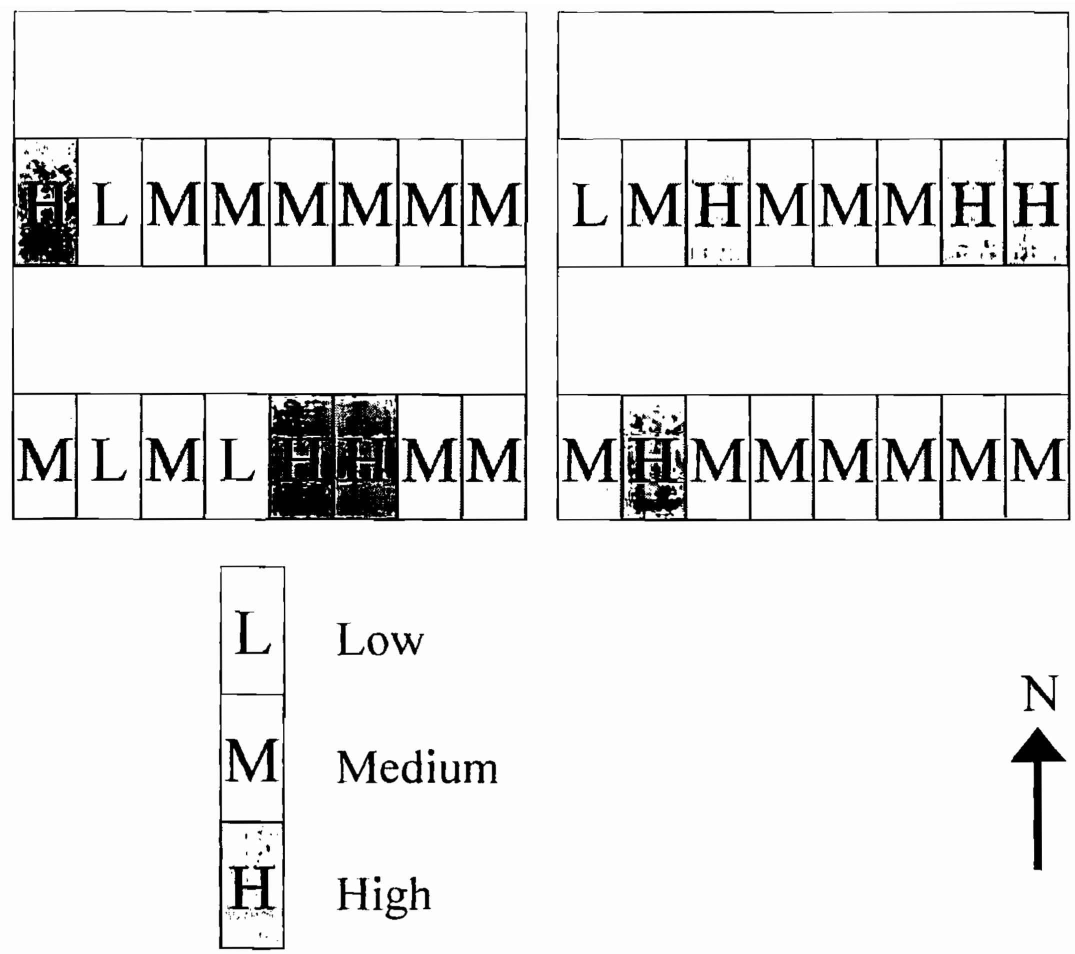

Figure 6. Phosphorus soil test categories adjusted for pH at McLeod County site, May 1996

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