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The Relationship of Soil pH and Crop Yields in Northern Idaho

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Soils in northern Idaho have become increasingly acidified in the last 25 years. The acidification is due primarily to the long-term use of high rates of ammonium-based nitrogen fertilizers. A soil pH survey conducted in northern Idaho between 1982 and 1984 showed that only 6 percent of agricultural fields had soil pH values of 6.4 or greater (Table 1). Most of the region's soils would have fallen into this category 40 years ago. On the other end of the scale, 6 percent of the region's soils had pH values less than 5.0. Crops commonly grown in northern Idaho would probably not produce maximum yields in soils with pH values less than 5.0. In this survey, 77 percent of fields sampled had pH values between 5.0 and 5.9.

Table 1. The distribution of soil pH values in agricultural soils of northern Idaho.

Soil pH	Percent of fields
> 6.4	6
6.0 to 6.4	11
5.8 to 5.9	16
5.6 to 5.7	22
5.4 to 5.5	18
5.2 to 5.3	11
5.0 to 5.1	10
< 5.0	6

The soil pH values will undoubtedly decline still more with time, making a larger percentage of soils in the region too acid to produce maximum yields of most crops. For further information on the soil acidity problem in Idaho, see University of Idaho Current Information Series 629, *Implications of Acidification of Farmland in Northern Idaho*.

Research conducted from 1980 to 1986 in northern Idaho has shown that soil pH in silt loam soils declines about 0.1 unit for every 200 pounds of ammonium-based N applied to the soil. In terms of northern Idaho cropping systems, this means a drop of 0.1 pH unit for two winter wheat crops. In a cropping system where a winter wheat-legume rotation is followed, a pH drop of 0.1 unit would be expected in 4 years. In continuous winter wheat, the 0.1 unit drop would occur in 2 years.

Acidity in northern Idaho soils is usually confined to the plow layer of the soil profile. Soil pH usually increases below the plow depth. Acidity within the plow layer is relatively uniform under conventional tillage since annual tillage operations usually mix the soil in this layer. Under reduced tillage or no-till agriculture, however, soil acidification can become stratified, depending on the placement, rate and type of N fertilizer used.

Specific Crops

The relationship of soil pH to the potential yield of crops commonly grown in northern Idaho is shown in Table 2. In general, legume crops are most sensitive to acid soil conditions while cereal and grass crops are more tolerant to low soil pH.

Alfalfa — The minimum soil pH for maximum growth of alfalfa is 5.7. Alfalfa yields will decrease rapidly as field pH values decline. For further information, see University of Idaho Current Information Series 447, *Northern Idaho Fertilizer Guide: Alfalfa.*

Barley — The minimum pH value for maximum spring barley production in northern Idaho is 5.3. Research on spring barley has shown that yield declines sharply as the soil pH falls below 5.2 (Fig. 1).

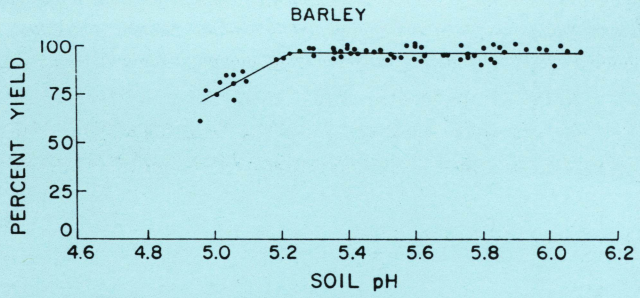

Fig. 1. The relationship of soil pH to the percentage yield of spring barley grown in northern Idaho.

Bluegrass Seed — Bluegrass is relatively tolerant to acid soil conditions. Yield declines in this seed crop have only been observed in fields with pH values less than 5.2. Little yield data are available on soils with pH values less than 5.0. Of the crops commonly grown in northern Idaho, bluegrass appears to be the most tolerant to very acid soil conditions.

Lentils — The minimum pH value for maximum lentil production in northern Idaho is 5.65 (Fig. 2). The relationship between soil pH and yield is strong. Differences in pH tolerance among lentil varieties are not expected because, even though lentils do have a fairly wide genetic diversity, all evolution occurred in areas with high pH soils. Soil pH may affect lentils indirectly. Soil pH values less than 5.65 adversely affect *Rhizobium leguminosarum*. This may result in less nodulation which in turn adversely affects the nitrogen nutrition of the lentil plants. This observation has been made for other legumes.

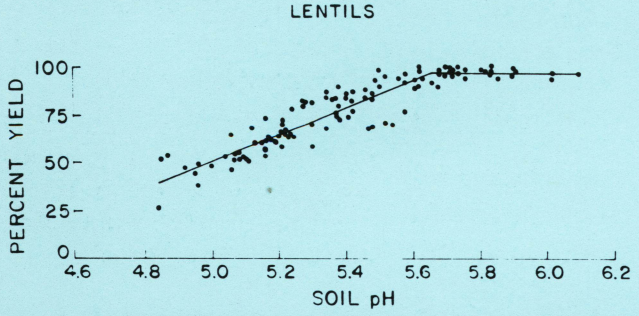

Fig. 2. The relationship of soil pH to the percentage yield of lentils grown in northern Idaho.

About 52 percent of agricultural soils in northern Idaho have surface (12 inch) pH values less than 5.65. Consequently, over half of the 40,000 acres annually planted to lentils in northern Idaho have pH values too low to produce maximum yields. Data plotted in Fig. 2 indicate that lentil yield will be only 79, 65 and 50 percent of maximum yield potential at soil pH values of 5.4, 5.2 and 5.0, respectively.

Peas — The minimum acceptable pH value for maximum spring pea yields was 5.52 (Fig. 3). At soil pH values of 5.3, 5.1 and 4.9, spring pea yields would be only 77, 59 and 42 percent, respectively, of maximum yield potential. About 42 percent of the 60,000 acres annually planted to spring peas in northern Idaho have pH values less than the minimum acceptable value for 100 percent (maximum) yield.

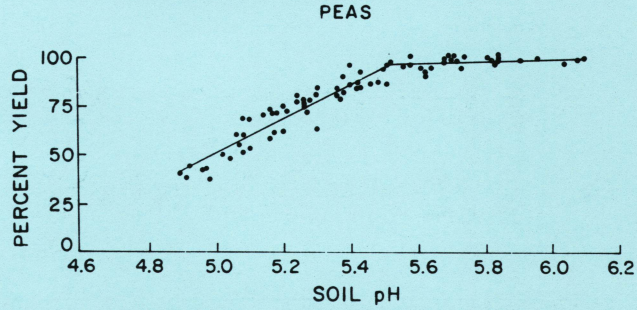

Fig. 3. The relationship of soil pH to the percentage yield of spring peas grown in northern Idaho.

As is true with lentils, pea varieties show little difference in their response to decreasing soil pH. Since peas evolved in neutral to alkaline soils, they logically would be similar in tolerance to pH. Growers within the region have known for several years that low soil pH values reduced both spring pea and lentil yields. The low economic value of peas and lentils relative to the cereal crop in the rotation has prevented corrective action, however. Spring peas, like lentils, are legumes nodulated by *R. leguminosarum*. Low soil pH apparently affects the pea plant indirectly by inhibiting N_2 fixation and causing inadequate N nutrition of the pea plants. Research conducted near Cavendish in Clearwater County showed that populations of nodulating bacteria are severely reduced under acid soil conditions.

Wheat — A strong relationship between soil pH and winter wheat yields was observed in field research conducted in northern Idaho (Fig. 4). The three winter wheat varieties used in these studies reacted differently to a range of acid soils. Consequently, each variety must be considered separately in terms of tolerance to

Table 2. The relationship of soil pH on the percentage maximum yield of crops grown in northern Idaho.

Crop	Soil pH									
	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7
	(% of maximum yield)									
Alfalfa	-	-	-	-	-	-	70	80	90	100
Barley	54	64	74	83	93	100	100	100	100	100
Bluegrass	-	-	90	90	100	100	100	100	100	100
Lentils	36	43	50	57	65	72	79	86	93	100
Peas	33	42	51	59	68	77	86	94	100	100
Wheat	34-76	47-81	57-86	67-90	76-100	95-100	100	100	100	100

soil acidity. The wheat varieties studied originated in different states and different soil pH environments, unlike the peas and lentils.

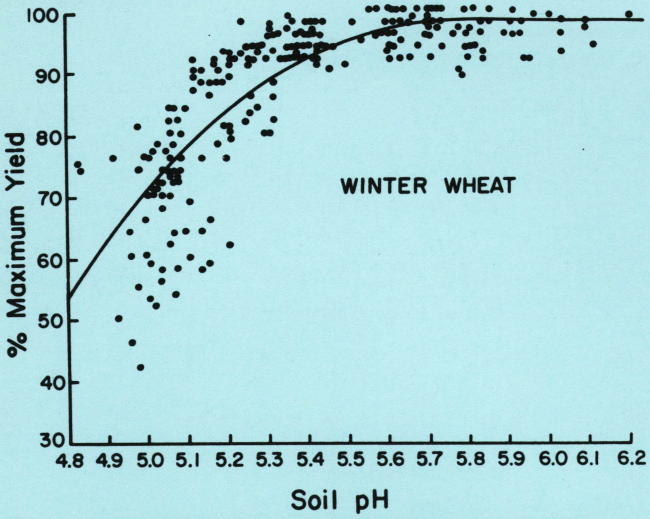

Fig. 4. The relationship of soil pH to the percentage yield of winter wheat grown in northern Idaho.

Minimum pH values for maximum winter wheat yields range between 5.1 and 5.4, depending on variety (Table 2). A pH value of 5.19 is the minimum acceptable pH value for maximum Daws winter wheat production in northern Idaho (Table 3). Approximately 16 percent of the agricultural soils of northern Idaho are below pH 5.2. Thus, 48,000 of the 300,000 acres in northern Idaho annually planted to winter wheat have pH values too low to produce maximum yield of Daws. Hill 81 and Stephens have much higher minimum soil pH values, 5.31 and 5.37, respectively, for maximum yield. About 27 percent of northern Idaho agricultural soils have less than the minimum acceptable pH value for Hill 81, and about 30 percent have less than the minimum acceptable pH value for Stephens.

Table 3. The relationship of soil pH to the percent maximum yield of three winter wheat varieties in northern Idaho.

	Soil pH						
Variety	**4.8**	**4.9**	**5.0**	**5.1**	**5.2**	**5.3**	**5.4**
	(% of maximum yield)						
Daws	34	49	64	79	100	100	100
Hill 81	76	81	86	90	95	99	100
Stephens	38	47	57	67	76	96	100

Differences in pH tolerance among wheat varieties enable a grower to select the variety most suited to the soil pH of a particular field. This is not a factor when soil pH is above 5.4, but variety differences do occur between pH values of 5.2 and 5.4 and usually (especially between pH 5.2 and 5.3) Daws appears to be the best variety. Daws is not the best variety choice at pH levels below 5.2 (Table 3). At pH of 5.0, Hill 81 offers the highest percent maximum yield. At pH value of 4.8, Daws is the poorest choice of the three winter wheat varieties evaluated.

One additional factor to note is that Hill 81, Daws and Stephens have different yield potentials. Under certain environmental conditions, 67 percent yield of Stephens wheat may be greater than 85 percent of Daws. Local environmental conditions determine the yield potential of each wheat variety. Even though a liming program is the ultimate solution for acid soils in northern Idaho, varietal differences in tolerance to acid conditions provide a useful, if only temporary, management tool.

Liming

Since the soil acidity present in northern Idaho soils developed over a long period of time as a consequence of ammonium-based N fertilizers, simple, cheap techniques to neutralize soil acidity will not work. The only way to correct a soil acidity problem is to apply some type of lime material. At least 80 percent of the soil in northern Idaho will someday require lime to produce maximum crop yields. For additional information on liming materials, consult University of Idaho Current Information Series 787, *Liming Materials.*

Economics

Since the use of liming materials means added production costs, a crop yield loss from soil acidity of less than 20 percent may not be economical to correct. Crop prices, as well as lime material costs, will impact future crop yields produced in northern Idaho.

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