A CASE FOR THE USE OF LIMESTONE IN NORTH DAKOTA

D.W Franzen
North Dakota State University, Fargo, ND

Abstract

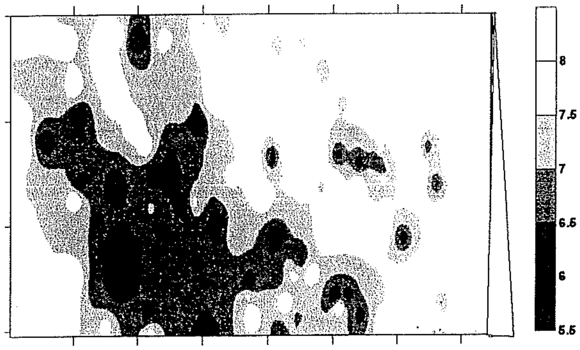
Farmers in North Dakota have long believed that nearly all of the cultivated land in the state was alkaline in pH. A recent survey of the state revealed that between 27% and 50% of the fields tested below pH 7, depending on landscape position, with about 17% of the state with pH less than 6.5. In site-specific studies in fields with dominant pH above 7, nearly all fields contained at least one area with pH below 7. Herbicide carryover studies have shown that areas of even slightly acid pH can result in significant reduction in yield to sensitive crops. Sugarbeet factory spent lime application to both acid and alkaline pH soils resulted in higher sugarbeet yields, apparently due to the increased ability of sugarbeet to resist the effect of *Aphanomycetes cochlioides* root rot. A study of poor sugarbeet growth also indicates response of sugarbeet to dolomite and spent lime applications.

Introduction

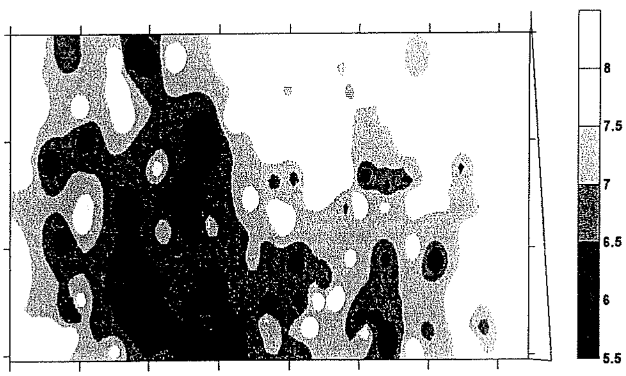
Until recently, there was little limestone applied to agricultural soils to amend pH in North Dakota. In a survey of soil samples received from North Dakota farms for the period 1982-1992, only 7% of fields tested below pH 6.5 based on a composite soil sample (Dahnke and Swenson, 1992). Within the survey publication, the statement "North Dakota does not have an acid soil problem," sums up the understanding that most farmers have regarding soil pH in the state. There are no limestone quarries in the state of North Dakota. However, the sugarbeet processing industry, with factories on both the Minnesota and North Dakota sides of the Red River use ground limestone in their processing and generate large amounts of "spent lime" which is usually piled or buried near the factory for want of any use. A series of research studies have shown some need for pH amendment and benefits of the use of limestone or spent lime for crop production in North Dakota.

Results and Discussion

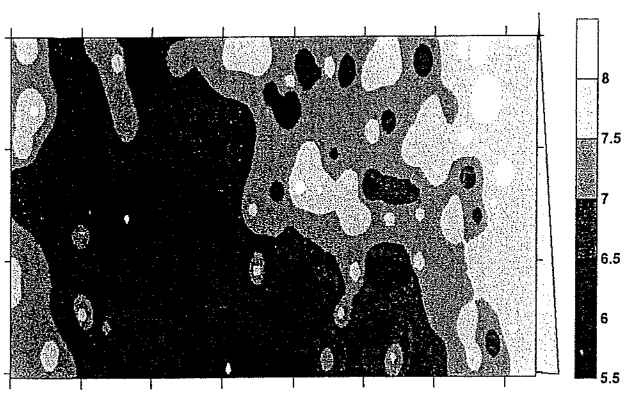
In 1998, a survey was conducted to determine certain soil nutrient levels by landscape position across North Dakota (Franzen, 1999). Three fields were sampled from each of the fifty-three counties in the state. Within each field, a 0-6 inch depth soil sample consisting of ten cores each were taken from an upland position, depression, and a slope. Results are shown in Figure 1. Relatively large areas of acid pH are generally found in the south-central counties and in the immediate counties adjacent to the Missouri River. 27% of upland areas, 35% of slopes and 50% of depressions were lower than pH 7.



Upland positions



Sloping positions



Depressions

Figure 1. Soil pH survey, by landscape position.

Site-specific studies on several North Dakota fields have found low pH areas in most of the data sets (Table 1).

Table 1. Listing of site-specific study fields and range of pH found in each.

Site	pH range
Colfax	6.9-8.5
Gardner	6.9-8.1
Hunter	6.5-8.5
Mandan	5.5-7.6
Valley City	4.9-7.8

From this small sampling of fields, it is possible to postulate that many fields within the state which have tested high in pH using composite testing may have areas within them of significant size with acid pH.

There is some disagreement regarding the need for lime to amend various crops in the Midwest, as illustrated in Table 2. Doll (1964) considered a pH of 5.5 acceptable for wheat, but others considered 6.0 as a minimum pH standard in the North Central states.

Table 2. Comparison of opinions on acceptable and minimum pH for various crops.

Crop	Acceptable pH ranges (Doll, 1964)	Minimum pH, various authors, from Pearson and Adams, 1967.
Alfalfa	6.3-7.8	6.5-6.8
Soybeans	6.0-7.0	6.0-6.8
Corn	5.5-7.5	6.0-6.8
Wheat	5.5-7.0	6.0-6.8
Sugarbeets	6.0-7.5	6.0-6.8
Rotations with legumes	6.0-7.5	6.5-6.8
Potatoes	5.2-6.5	5.1-6.5

In North Dakota, there is a movement to reduce acres of wheat and rotate instead to field peas, soybeans, canola and other crops with higher pH requirements. Also, there is a very significant acreage of alfalfa in the areas of the state lowest in pH. Certainly the requirements of alfalfa in these areas need to be investigated.

Of interest in the east, in the area of sugarbeet production, one of the implications of low pH inclusions is the carryover of herbicides. Franzen and Zollinger (1997) have reviewed the effects of low pH on increased carryover of several groups of herbicides, including isoxazolidinones, imidazolinones and triazolopyrimidine sulfonanilides.

The degree of importance of liming sugarbeets with respect to alleviating carryover concerns from imidazolinones is illustrated in Table 3.

Table 3. Response of sugarbeets to spent lime treatments applied in 1996 with cropping in 1997 and 1998 (Bresnahan et al., 1999)

Herbicide	Lime, t/a	pH	Root yield,t/a		Extractable sucrose,lb/a	
			1997	1998	1997	1998
Control	0	5.7	14.3	21.4	3500	7076
	3	6.8	22.7	23.1	6100	7904
	10	7.7	21.4	29.3	5900	9588
Pursuit	0	5.7	0	7.7	0	2276
	3	6.8	0	21.0	0	6914
	10	7.7	0	25.3	0	8270
Raptor	0	5.7	12.9	22.8	3100	7540
	3	6.8	16.5	23.0	4300	7687
	10	7.7	20.1	25.1	5200	8036
LSD (0.1)			1.8	4.9	900	1809

Of additional interest in Table 3 is the increase in sugarbeet yield with lime application in the first year at both rates of spent lime and the second residual year with the 10 t/a application rate. This increase in yield not due to herbicide carryover was investigated further with respect to disease tolerance (Table 4.) At a low pH site, liming increased pH, decreased root rot and increased both root yield and extractable sugar yield.

Table 4. Effect of spent lime on soil pH, root yield and sucrose content. Lime applied 1999, sugarbeets grown in 2001 (Bresnahan et al., 2002).

Spent lime, t/a	Soil pH	Root rot rating*	Root yield, t/a	Extractable sucrose, lb/a
0	5.9	2.7	6.7	1310
3	6.7	2.2	12.6	2434
10	7.7	1.8	16.0	3036
LSD (0.05)		0.4	5.4	1055

* root rot rating 0- no damage, 7- dead.

The study was duplicated on a high pH site with yield increases seen at the 10 t/a spent lime rate (Table 5).

Table 5. Effect of spent lime on soil pH, root yield and sucrose content at a high pH site. Lime applied 1999, sugarbeets grown in 2001 (Bresnahan et al., 2002).

Spent lime, t/a	Soil pH	Root rot rating	Root yield, t/a	Extractable sucrose, lb/a
0	7.8	3.1	14.7	7899
3	8.1	3.1	14.9	8509
10	8.2	2.4	18.3	10479
LSD (0.05)		0.9	3.1	1053

Areas of generally poor sugarbeet growth have been examined in the Red River Valley. Transects from good to poor sugarbeets indicated that the poor growth may be related to soil Mg levels. These areas occur in both high pH (pH8) and lower pH (pH 5.2-6.5) areas. The only commonality is relatively low soil and plant Mg content (Franzen et al., 2001). Treatments were applied last fall (spent lime and dolomite) and this spring (K-Mag, magnesium sulfate, boron) to sugarbeets in an areas of historically poor beet growth. Results from 6-leaf plant weight show responses to dolomite, K-Mag, magnesium sulfate, and spent lime (Table 6). Shortly after sampling for early dry matter content, a heavy rain triggered infection in the field by *Rhizoctonia* and *Aphanomycetes*. Stand reduction due to disease was measured July 23 and all treatments showed some indication of helping the beets withstand disease.

Table 6. Response of sugarbeets to treatments in poor sugarbeet growing areas, Galchutt site, 2002. Franzen, unpublished data.

Treatment	Dry matter, 10 6-leaf beets 6/17	Stand Reduction due to root rot diseases 7/23
Check	15.4 b	22.0 a
2 t/a Dolomite	18.6 ab	6.6 b
4 t/a Dolomite	14.1 b	7.2 b
2 t/a Spent lime	21.1 a	5.8 b
100 lb/a Mg as K-Mag	22.2 a	11.6 ab
100 lb/a Mg as Mg Sulfate	23.7 a	6.5 b
2 lb/a B	15.5 b	6.5 b
50 lb/a Mg as K-Mag	25.0 a	7.8 b
LSD	$P<0.10$ 7.2	$P < 0.05$ 13.3

Conclusions

Significant areas of acidic soils are present in North Dakota. Depending on the crop rotation, these areas may need lime amendments. Sugarbeet spent lime appears to beneficial to sugarbeets in certain circumstances at low and high pH. Low pH areas should be identified using site-specific methods and amended. Other areas may also benefit from application of lime if *Aphanomycetes* is present even if soil pH levels are over 8.0.

References

Bresnahan, G.A, A.G. Dexter, and W.C. Koskinen. 1999. The effect of soil pH on sugarbeet yield and herbicide degradation. p. 82-91. *In* 1998 Sugarbeet Research and Extension Reports. Vol. 29. Sugarbeet Research and Education Board of Minnesota and North Dakota. Fargo, ND.

Bresnahan, G.A., A.G. Dexter, C.E. Windels, J.R. Brantner, and J.L. Luecke. 2002. Influence of soil pH on *Aphanomycetes cochlioides* in sugarbeet. p. 264-268. *In* 2001 Sugarbeet Research and Extension Reports. Vol. 32. Sugarbeet Research and Education Board of Minnesota and North Dakota. Fargo, ND.

Dahnke, W.C. and L.J. Swenson. 1992. Summary of Soil Fertility Levels for North Dakota: 1982-1991. NDSU Exp. Sta. Bull. No. 525.

Doll, E.C. 1964. Lime for Michigan soils. Mich. Agr. Exp. Sta. Ext. Bull. 471.

Franzen, D.W. and R.K. Zollinger. 1997. Interaction of soil applied herbicides with soil pH. p. 14-23. *In* Proceedings of the North Central Extension Industry Soil Fertility Conference, G. Hergert, ed., Nov. 19-20, 1997, St. Louis, MO. Potash & Phosphate Institute, Brookings, SD.

Franzen, D.W. 1999. North Dakota survey of soil copper, pH, zinc and boron levels. NDSU Ext. Report 52.

Woodruff, C.M. 1967. Crop response to lime in the Midwestern United States. p.207-231. *In* Soil Acidity and Liming, R.W. Pearson and R. Adams, ed. Agronomy Monograph 12, ASA, Madison, WI.