

SUGARBEET FACTORY SPENT LIME: ITS EFFECTS ON SOIL CHEMICAL PROPERTIES

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In last years research report it was reported that extracted calcium (Ca) and magnesium (Mg) was greater from soils where 20 ton A⁻¹ sugar beet factory spent lime was applied compared to the control (no spent lime applied) (Sims and Hoff, 2006). This was the case whether the Ca and Mg was extracted with ammonium acetate (NH₄OAc), which is the standard soil test method to determine soluble Ca and Mg (Reference Methods for Soil Analysis, 1992), or ammonium chloride (NH₄Cl), which is an unbuffered extractant used to determine soil cation exchange capacity (CEC) (Sumner and Miller, 1996). It was also reported that the calculation of CEC via the summation of extracted base cations (Ca, Mg, Potassium, and Sodium) greatly increased CEC estimates of soil treated with spent lime compared to the check (see CEC ratio column in Table 1).

Most of the CEC in the soils at both the Breckenridge and Hillsboro sites should be dominated by permanent CEC, caused by isomorphic substitution during the formation of the clay minerals. Therefore, it seemed plausible that increased CEC, as estimated by cation summation, where spent lime had been applied were artificially inflated. When soluble cations are determined with NH₄OAc in soil containing excess salts and carbonates, the extractant itself can solublize the salts and carbonates thus extracting more cations than would normally be the case (Suarez, 1996). The base cations extracted via this method are presumed to be primarily associated with the CEC of the soil. Thus CEC estimates determined by the summation of base cations extracted from soils containing excess salts and carbonates may inflate the CEC. Therefore, a portion of the CEC determined via cation summation on soils treated with 20 ton A⁻¹ spent lime may be the result of lime being dissolved and not an actual increased CEC. A more realistic determination of soluble cations requires that these excess cations be accounted for. Our objective was to determine if the summation CEC was indeed inflated where spent lime had been applied due to the dissolving of spent lime by the extractant.

Materials and Methods

Soils from the spent lime trial at Breckenridge and Hillsboro site (Sims et al, 2006) were extracted with NH₄Cl. The extract from this procedure was used to determine the base cations in the soils (Sims and Hoff, 2006) from which the Summation CEC was calculated. The extract was further analyzed to determine alkalinity (Lachat Instruments, 1997) and sulfate-sulfur (SO₄-S) (Lachat Instruments, 1991). Once alkalinity and SO₄-S was determined the results were converted to cmol (-) L⁻¹ (read centimoles of negative charge per liter). Further calculations to account for dilution and the amount of soil extracted converted the results as cmol(-) kg⁻¹ of soil. It is presumed the concentrations of anions (negative charge) are the result of dissolving salts or carbonates. Therefore, the concentration of anions is directly converted to a concentration of cations (charges must be equal in a solution). Spent lime contains Ca at 22 to 25 times the levels

of Mg (Sims et al., 2006), therefore, most of the anions measured in these samples are assumed to be associated with Ca.

Results and Discussion

Excess cations, as measured through alkalinity and $\text{SO}_4\text{-S}$, were observed in extracts from both the control plots soils and soils that had received 20 ton A^{-1} spent lime (Table 2). However, there were 5 times more excess cations where spent lime had been applied. The excess cations are assumed to be primarily Ca from the dissolving CaCO_3 or CaSO_4 in the soil rather than actual exchangeable Ca associated with the soils CEC. The amount of Ca extracted from these soils can be adjusted by subtracting the excess Ca from the total extracted Ca. If the adjusted Ca, instead of the unadjusted Ca, is used to calculate CEC in the summation method, then CECs are more similar between the control and limed soils than previously calculated (Table 2). Cations exchange capacity estimates are still greater where spent lime was applied, but the differences are must smaller than when CEC was estimated prior to making the Ca adjustment.

Some have suggested that the application of spent lime will increase the Ca:Mg ratio on the soil CEC, which is then credited with perceived soil improvements. If the original cation determination are used and assumed to be associated with the soil CEC, then 20 ton A^{-1} spent lime increased the Ca:Mg ratio from 1.8 to 2.6 at Hillsboro and from 1.1 to 2.1 at Breckenridge. But, if the adjusted Ca is used then the ratios are 1.6 at Hillsboro and 0.9 at Breckenridge regardless of whether spent lime as applied or not. This suggests that improvement in soil tilth and condition, perceived or otherwise, attributed to the application of spent lime is probably not associated with an increase in Ca:Mg ratio on the soil CEC.

References

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Table 1. Base cations and cation exchange capacity (CEC) in surface soils (0-3 inch depth) from two sugar factory spent lime trials and two rates of spent lime as determined in an unbuffered ammonium chloride extraction process (Reproduced from Sims and Hoff, 2006).

Element	Ca		Mg		K		Na		Sum of Cations [§]		Measured CEC		CEC Ratio Measured: Sum	
<u>tons A⁻¹ of Lime</u>	<u>0</u>	<u>20</u>	<u>0</u>	<u>20</u>	<u>0</u>	<u>20</u>	<u>0</u>	<u>20</u>	<u>0</u>	<u>20</u>	<u>0</u>	<u>20</u>	<u>0</u>	<u>20</u>
	----- cmols (+) kg ⁻¹ of soil -----													
Site														
Hillsboro	16.8	27.5	9.2	10.6	2.2	2.2	0.2	0.2	28.4	40.5	28.7	25.7	1.02	0.64
LSD _(0.05)	2.3		0.4		ns		ns				0.9			
Breckenridge	11.7	25.7	11.0	12.1	1.4	1.3	0.3	0.3	24.4	39.4	22.6	20.1	0.93	0.51
LSD _(0.05)	1.2		1.1		ns		ns				1.0			

§ CEC as determined by the sum of basic cations measured in the unbuffered ammonium chloride solution.

Table 2. Cation exchange capacity (CEC) and extracted calcium (Ca) in surface soils (0-3 inch depth) from two sugar factory spent lime trials and two rates of spent lime as determined in an unbuffered ammonium chloride extraction process

Element	Measured Ca		Excess Cations		Adjusted Ca [§]		Measured CEC		Summation CEC ^{§§}		Adjusted Summation ^{§§§} CEC		CEC Ratio Measured: Adjusted Sum	
<u>tons A⁻¹ of Lime</u>	<u>0</u>	<u>20</u>	<u>0</u>	<u>20</u>	<u>0</u>	<u>20</u>	<u>0</u>	<u>20</u>	<u>0</u>	<u>20</u>	<u>0</u>	<u>20</u>	<u>0</u>	<u>20</u>
	----- cmols (+) kg ⁻¹ of soil -----													
Site														
Hillsboro	16.8	27.5	2.0	10.0	14.8	17.5	28.7	25.7	28.3	40.4	26.3	30.4	1.09	0.85

LSD _(0.05)	2.3	1.6				0.9	2.4	1.3							
Breckenridge	11.7	25.7	2.5	13.6	9.2	12.1	22.6	20.1	24.3	39.3	21.8	25.7	1.04	0.78	
LSD _(0.05)	1.2		0.7				1.0		1.3		1.0				

§ cmols (+) kg⁻¹ of soil equivalent as derived from estimates of alkalinity and sulfate presumable from the dissolving of CaCO₃ and CaSO₄.

§§ CEC as determined by the sum of basic cations measured in the unbuffered ammonium chloride solution.

§§§ Adjusted Summation CEC is the result of Summation CEC minus the Alkalinity.