Effect of Precipitated Calcium Carbonate on Soil Characteristics And Sugarbeet Yield and Quality

MURALI K. DARAPUNENI[1,2], GARY W. HERGERT[1], ROBERT WILSON[1], ROBERT HARVESON[1], JEFF BRADSHAW[1] AND REX NIELSEN[1]
[1]University of Nebraska Panhandle Research and Extension Center, 4502 Avenue I, Scottsbluff, NE 69361 USA; [2]Agricultural Experiment Station & Science Center, New Mexico State University, 6502 Quay Rd. AM 5, Tucumcari, NM 88401

Introduction

Precipitated Calcium Carbonate (PCC) is a byproduct of the sugar purification process. Every year 95,000 tons of PCC is produced at three Western Sugar locations, Scottsbluff, NE., Torrington, WY., and Fort Morgan, CO. (Fig. 1) Research in MN and MI has shown positive results using PCC as a liming material, fertilizer source or soil amendment, and for control of Aphanomyces. Most of the soils in MN and MI are slightly acidic to neutral. This research focused on the effects of PCC application for alkaline soils.

Fig. 1. PCC from sugar factories

Objectives

Greenhouse Experiments
- Determine composition and variability of PCC materials from the 3 factory sites
- Determine herbicide sensitivity of Kochia collected from PCC piles
- Determine the response of the 3 major crops in the area to different rates of PCC to establish field trials
- Determine the effect of PCC on soil chemical and physical properties.

Field Experiments
- To determine the effect of PCC on:
  1) Yield and quality of sugarbeet, corn, and dry bean
  2) Soil characteristics (short term and long-term)
  3) Possible control of root aphids

Methods and Materials

Greenhouse Experiments

Biomass and soil studies:
- Collected 10 soil types within 40-km radius of three Western Sugar factories, where PCC might be used
- Collected PCC from the 3 factory sites
- Soil mixed with PCC at 4 rates: 0, 11, 22, 33, 44 Mg ha^{-1}, plus untreated control.
- Split-split plot design, 4 reps
- Sugarbeet, corn, and dry beans planted mid-February; grew for 7-8 weeks
- At the beginning and end of experiment, soils were analyzed for chemical properties
- Plant material was collected to determine drymatter for each soil at different PCC rates

Kochia- Herbicide Sensitivity Study:
- Design – Randomized Complete Block
- Kochia seed collected - Scottsbluff , Torrington, Ft. Morgan
- 3 herbicides- Roundup, atrazine, and dicamba at 6 rates
- Experiment was repeated twice

Greenhouse Root Aphid Study:
- Complete randomized design with 4 treatments (0, 9, 18, 27 Mg ha^{-1} PCC) and 10 replications
- Root aphid and root mass were evaluated by a visual rating.

Field Experiments

Sugarbeet Yield and Soil Quality Studies:
- 2012- 10 sites; 2013- 17 sites; 2014- 27 sites in Nebraska, Wyoming, and Colorado
- Latin-square design with 4 treatments (0, 9, 18, 27 Mg ha-1) and 4 replications
- Samples were collected before application of lime in the current year (0-122 cm) and after harvesting in the successive years (0-20 cm)
- Samples were analyzed for change in soil characteristics pH, soluble salts, CEC, N, P, K and other essential plant nutrients
- PROC MIXED was run in SAS®

Root Aphid Field Study:
- Split-plot design with 2 varieties (resistant and susceptible), 4 treatments (0, 9, 18, 27 Mg ha^{-1} of PCC), and 4 replications

Results and Discussion

Chemical composition of PCC
- The chemical characteristics of PCC collected from different locations are shown in the Table 1
- PCC provides some nitrogen and signicant phosphorus, sulfur, and iron

Location/ Nutrient	Scottsbluff, NE	Torrington, WY	Ft. Morgan, CO
	grams per each kilogram of PCC		
Total Nitrogen (N)	3.2	5.1	4.3
Phosphorus (P)	5.0	5.5	5.2
Potassium (K)	1.5	2.5	2.5
Magnesium (Mg)	7.5	9.5	8.5
Sulfur (S)	5.7	6.4	6.1
Zinc (Zn)	0.05	0.05	0.05
Iron (Fe)	1.2	1.8	1.6
pH	8.2	7.9	8.1

Table 1: Chemical composition of PCC

Greenhouse Experiments

Biomass and soil studies:
- There was no significant difference (P>0.05) in the dry matter production of sugarbeet, corn, or dry bean for different rates of PCC applications for most of the soils
- The application of different PCC rates had no significant effect (P>0.05) on the chemical characteristics of the soil (pH, CEC, soluble salts). The possible reason might be the lack of enough time for mineralization to release nutrients from the different rates of PCC applications. However, the change in Phosphorus content is under investigation.

Kochia- Herbicide Sensitivity Study:
- Kochia populations growing on PCC piles at Fort Morgan, Scottsbluff, and Torrington did not exhibit herbicide resistance and were controlled effectively with atrazine, Roundup, and dicamba.

Greenhouse Root Aphid Study:
- Although exact reasons were unknown, all rates of lime significantly reduced root aphid numbers as compared to an untreated control (Fig 2). The possible reasons might be the structural (crystalline) and chemical (Ca and S) nature of PCC. No significant differences were found between the tested rates of lime (P>0.05).
- Mean root area increased consistently in all rates of lime applications compared to control possibly due to soil textural modification by the PCC applications.

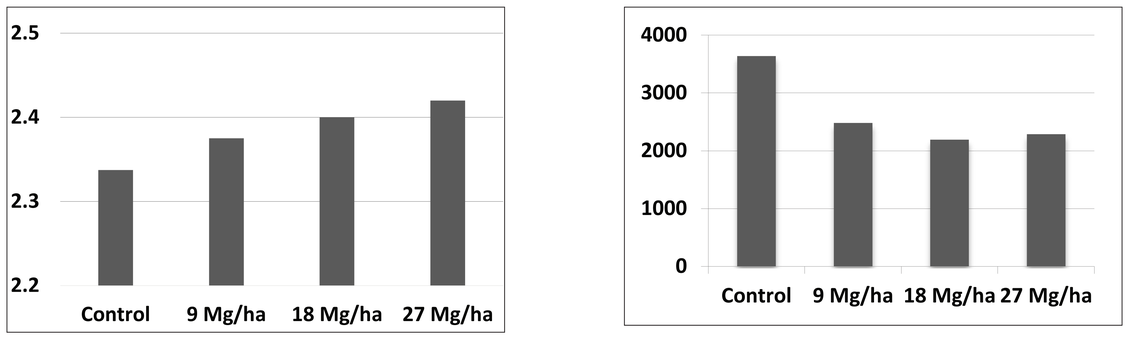

Fig. 2. Mean root area and root aphid populations for different rates of PCC applications

Field Experiments

Sugarbeet Yield and Soil Quality Studies:
- There is no significant difference (P>0.05) in the yield, sugar, and SLM parameters of sugarbeet for different rates of PCC applications for most of the soils during 2012-2014 (Table 2). In other words, no negative effects of PCC were observed in the sugarbeet yield and quality.
- pH did not change significantly (P>0.05) in most of the locations one year after PCC applications due to alkaline nature of the soils
- Olsen P content was significantly (P<0.05) increased with the rate applications in some of the soils due to the significant P supplemental nature of PCC
- Cation Exchage Capacity (CEC) was increased significantly (P<0.05) with the rate in all soils due to addition of Ca, Mg, and some Na ions onto soil colloids

Location	Yield (Ton/A)	Sugar (%)	SLM
Alliance, NE	NS*	NS	NS
N.E. Scottsbluff*, NE	NS	NS	NS
Scottsbluff, NE	NS	NS	NS
W. Torrington, WY	NS	NS	NS
N. Torrington, WY	NS	NS	NS
S. Torrington, WY	NS	NS	NS
Brush*, CO	NS	NS	NS
Brush, CO	NS	NS	NS
Yuma, CO	NS	NS	NS

Table 2: Effect of PCC on sugarbeet yield and quality
**No significance at 0.05 probability level*

Root Aphid Field Study:
- In the susceptible variety, a trend was observed, even though statistically not significant, to confirm the detrimental effect of PCC on root aphid populations.
- The yield increase due to aphid control as a result of PCC applications was not significant (P>0.05) due to later season Cercospora leaf spot incidence

Conclusions

- PCC has potential as an amendment for alkaline soils
- PCC has no negative effects on plant growth, yield, and quality of sugarbeet
- PCC is a good source of phosphorus and contains some nitrogen, sulfur, and iron
- PCC provides some control of sugarbeet root aphids

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