Polyhalite Solubility and Transport in Acid Soils and Mineral Uptake by Plants as a Source of Calcium

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Background

Ca, as a necessary and macro element in plants, plays an important role in metabolic processes, e.g. strengthen cell wall structure, helps plant against heat and diseases stresses, improves fruit quality.

In low pH soils, e.g. acid soils, Ca deficiency can occur in plants due to Ca^{2+} leaching or lower Ca content in acid soils, may be as a consequence of H^+ replacing Ca^{2+} on cation-binding sites in acid soils. Ca deficiency greatly lower the appearance of fruit or vegetables quality, and reduce economic return.

Ca fertilizers application could increase soil pH, then improve the availability of Ca in soils. Ca sources including gypsum, lime, calcium carbonate for soil application. A new natural fertilizer – polyhalite ($K_2Ca_2Mg(SO_4)_4 \cdot 2(H_2O)$), including Ca (12%), Mg (3.6%), K (12%) and S (19.2%), was recently used in agricultural production and proved to be a better fertilizer. However, it is not clear whether would be an option as Ca fertilizer in vegetables production.

Fig. 1 Ca deficiency in lettuce

Objectives

(1) The solubility and transport of polyhalite in acid soils;
(2) The effect of polyhalite as Ca sources on lettuce growth and nutrients uptake.

Materials and Methods

A pot experiment was conducted in greenhouse in China Agricultural University with 47 growing days from 10 September to 26-27 October. Acid soils were used in current experiment from Fuzhou, Fujian in southeast of China. The soil properties were pH 5.45, available P and K 57 and 106 mg/kg, exchangeable Ca and Mg 684 and 59 mg/kg. Pot with 10 L volume (27 cm height and 25 cm diameter) was used in the experiment and filled with about 8 L soil (11.0 kg in weight), a tube was connected to the bottom of growing pot to collect soil leachates by each 8 days after crop transplanting.

Lettuce (Boston lettuce) was used in the experiment, Ca fertilizers including $CaCl_2$ (abbreviated as CC), gypsum (GS) and polyhalite (PS) were used as Ca sources, and five levels of Ca application designed (0, 20, 40, 80 and 160 kg Ca/ha), so there were 13 treatments and repeated 5 times for each treatment. Ca fertilizer was applied at top 0-5 cm soil and mixed evenly.

Crop (only aboveground part) fresh weight, dry matter and nutrients concentration (N, P, K, Ca, Mg and S) were measured at final harvest, and NO3-, NH4+, P, K, Ca, Mg and S were measured in soil leachates, in order to calculate soil nutrient loss in leachates.

Results

1, Fresh weight (g per pot)

Ca fertilizers and application levels neither has effect on lettuce fresh weight by using two-way ANOVA analysis. However, there is a positive effect of Ca fertilizer application on crop growth under one-way ANOVA, except for 160 kg Ca per ha in gypsum treatment.

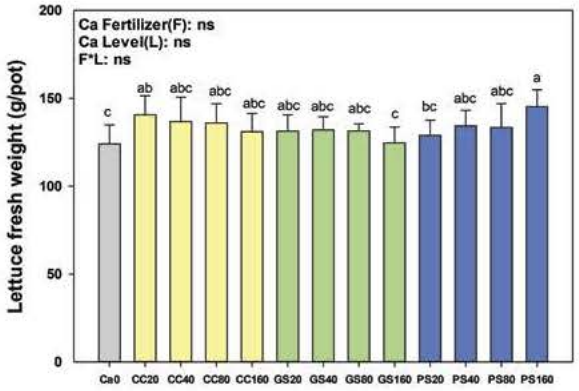

Fig. 2 Ca fertilizers and application rates effect on lettuce growth

2, Nutrient loss in soil leachates (mg Ca per pot)

Compared with $CaCl_2$, gypsum and polyhalite have a lower nutrient (Ca) loss in soil leachates, and similar Ca loss in soil leachates were found between gypsum and polyhalite.

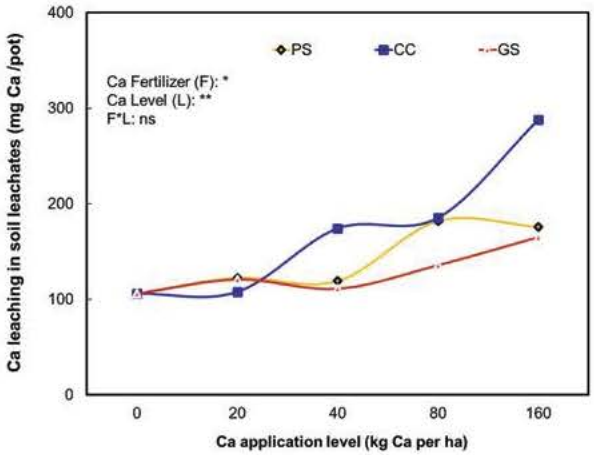

Fig. 3 Ca fertilizers and application rates effect on Ca leaching

3, Nutrient uptake by lettuce (mg Ca per pot)

For lettuce Ca uptake, both experimental factors (fertilizer and application rate) have no significant effect on lettuce Ca uptake.

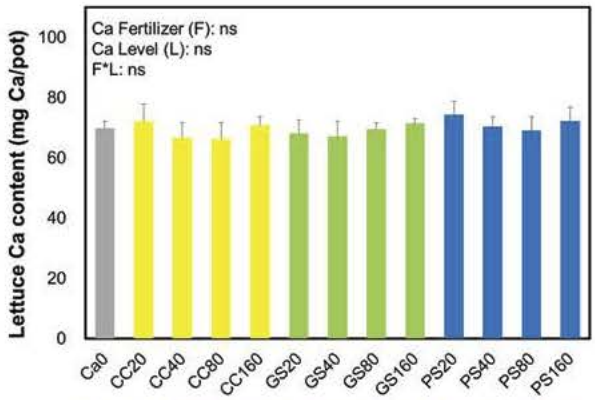

Fig. 4 Ca fertilizers and application rates effect on Ca uptake

Conclusions

- For crop growth and Ca uptake by lettuce aboveground, neither $CaCl_2$, gypsum nor polyhalite had no significant effect.
- Polyhalite as a natural fertilizer, had similar leaching characters when compared to gypsum in current study.
- Polyhalite, one in four fertilizer (including K, Ca, Mg and S), could be an option for Ca source used in lettuce growing field or other vegetables production in acid soils or potential Ca deficiency conditions, as an lower nutrient release fertilizer.

Acknowledgments

We greatly appreciate Dr. Hillel Magen and Dr. Menachem Assaraf giving the comments on the design of current study.