FARMING PRACTICE
IL AMENDMENT WITH LIME AND GYPSUM

IMPACT: SOIL PHYSICO-CHEMICAL QUALITY

Reference 5

Li Y.; Cui S.; Chang S.X., Zhang Q. 2019 Liming effects on soil pH and crop yield depend on lime material type, application method and rate, and crop species: a global meta-analysis. Journal of Soils and Sediments 19(4) J Soils Sediments 19:1393–406 10.1007/s11368-018-2120-2

Background and objective

Acid soils are considered soils with a pH < 5.5 in their surface horizons (0–20 cm). About 3950 million hectares of land area has been estimated to be affected by acidity, occupying nearly 30% of the global land surface and accounting for approximately 50% of the global arable land area. Soil acidity is one of the most yield-limiting factors that affect crop productivity. Quantify the effects of liming on (1) the yield of various row crop and forage species, (2) soil chemical properties (pH and cation exchange capacity (CEC)) and nutrient status, as well as (3) the effect of different liming rates, methods, and liming materials on soil pH.

Search strategy and selection criteria

Published journal articles from 1980 to 2017 were searched using the ISI Web of Science (http://apps.webofknowledge.com/) and China Knowledge Resource Integrated Database (http://www.cnki.net/) using the topic "soil amendment" or lime or amelioration and topic "acid soil" or "soil acidification." 1) Paired observations between a no-liming control and a liming treatment under identical experimental conditions were included. If an individual study used more than one level or material type of lime application at the same site, measurements of different application rates or liming materials were separately paired with no-liming control. 2) The mean and standard deviation (or standard error) of the achieved yield (either grain yield or biomass), soil pH value, and at least two replications were provided either as part of the experimental design or in figure captions. 3) Liming management practices were included as treatments, while other essential agronomic practices such as cropping intensity, fertilizer management, and irrigation were similar.

Data and analysis

To derive the overall response effect of the treatment group relative to the control group, the weighted response ratio (RR++) between treatment and control was calculated. The meta-analysis was performed using the using the restricted maximum likelihood estimator (RMLE) estimation in the rma.unl model for "metafor" package of the R statistical software (version 3.4.2). For each group (crop species, liming material, experimental condition, liming duration, soil texture, liming practice, and land use type), the mean effect size (RR) and its 95% confidence interval (CI) were calculated with bias-correction generated via bootstrapping.

Number of papers	Population	Intervention	Comparator	Outcome	Quality score
175	Field-studies, laboratory incubation or greenhouse pot studies	Liming treatment, including dolomite ($CaMg(CO_3)_2$), calcium hydroxide ($Ca(OH)_2$), calcium carbonate ($CaCO_3$), and calcium oxide (CaO)	No-liming control under identical experimental conditions	Metric: Soil pH, Cation exchange capacity (CEC), soil nutrients; Effect size: Logarithm of ratio of the considered metrics in the intervention to the considered metrics in the control	0.8125

Results

- Regardless of environmental and experimental conditions, application of lime always significantly increased soil pH. Regardless of liming materials, the increasing application rate of lime improved soil pH.
- Both in field and pot conditions, lime application significantly increased soil exchangeable Ca and Mg concentrations. Lime application significantly increased soil available nitrogen (AN) and available phosphorus (AP) in field conditions by 7% (95% CI 0.01 to 0.13) and 9.3% (95% CI 0.04 to 0.14), respectively.
- Liming significantly increased soil CEC in field conditions by 14.4% (95% CI 0.05 to 0.22)

Factors influencing effect sizes

- Liming rate : Liming rate was the most important factor for changes in the response ratio of soil pH in field-based experiments, followed by initial SOM, initial soil pH, and liming methods
- Scale of experiment : The effect of liming on soil pH was more pronounced in pot conditions than in field conditions by 36%
- Time scale : The effect size of liming on soil pH decreased from < 3- to 3–6-year studies.
- Soil organic matter : Soil organic matter (SOM) < 10 g kg^{-1} had a significantly higher effect than SOM > 30 g kg^{-1}.
- Soil texture : The liming effect size in sandy soil was 32% higher than in clayey soils.

Conclusion

To effectively neutralize soil acidity, the optimum liming duration, rate, and material type were < 3 years, 3–6 Mg ha^{-1}, and $Ca(OH)_2$, respectively. Liming significantly ameliorated soil Al^{3+}, increased basic cations (Ca^{2+} and Mg^{2+}), neutralized soil pH across different cropping systems, and improved the soil nutrient status (increasing exchangeable nitrogen, potassium, and phosphorous).