Silicon Dynamics in Soils Under Different Cropping Systems in Louisiana

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INTRODUCTION

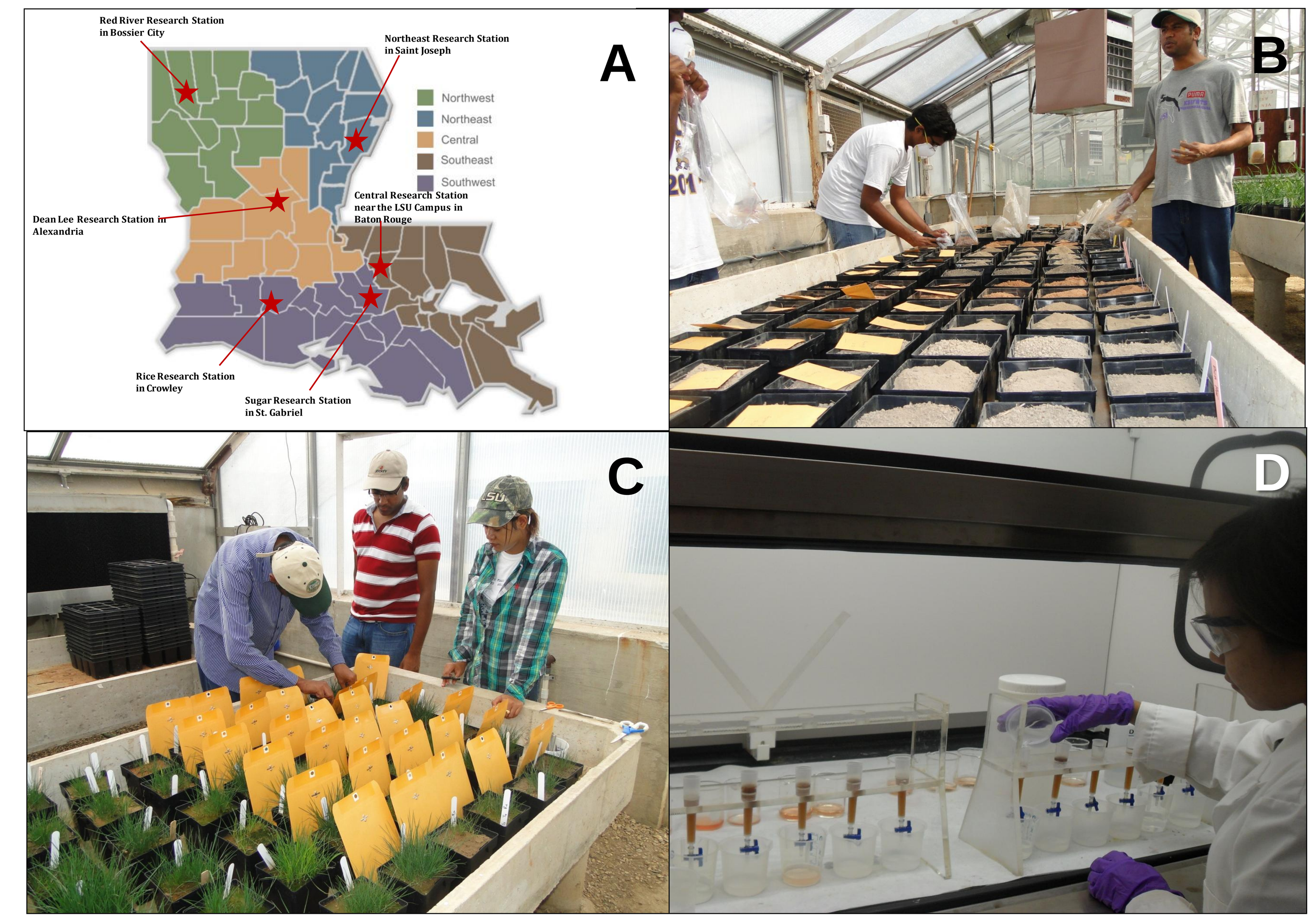
- Silicon (Si) is classified as a beneficial nutrient taken up by several plant species at levels even higher than nitrogen (N) and potassium (K).
- While Si is an abundant element on the Earth's crust, it is not always found in plant-available form. Plant-available Si is notably low in old (e.g. Ultisol) and organic (Histosols) soils thus application of Si-rich material such as $CaSiO_3$ is well-documented to be beneficial.
- Silicon can possibly be limiting as well in areas that have been continuously cultivated to crops especially to crops that are classified as Si-accumulator .
- The concentration of plant-available Si in the soil is controlled by several reactions, commonly influence by soil type and management practices.

OBJECTIVES

- To investigate the adsorption of Si onto soil particles of soils under different cropping systems in Louisiana.
- To evaluate the influence of silica ($CaSiO_3$) fertilization on ryegrass biomass accumulation, and concentration of extractable Si and plant-essential nutrients.

MATERIALS AND METHODS

- **Treatment structure and experimental design**: Five rates of $CaSiO_3$ slag (0, 1, 2, 4 and 8Mt ha^{-1} as AgrowSil®) and two check pots, with (2 Mt $CaCO_3$ ha^{-1}, calcium carbonate equivalent; 81%) and without lime were arranged in randomized complete block design with four replications.
- **Establishment:** Ryegrass seeds were sown on potted soil treated with different rates of $CaSiO_3$. Nitrogen, K, and P fertilizers were supplied at non-limiting rates. Source of bulk soils was from several locations in Louisiana under different crop production systems (Fig. 1 A).
- **Sampling time**: 30 and 60 days after sowing
- **Samples**: soil and biomass clippings
- **Analyses**: Si content of biomass clippings; Mehlich-3 extractable nutrients; extractable Si using different extraction procedures
- **Statistical analysis**: Analysis of variance on total biomass, total Si uptake, and acetic acid extractable Si as effected by different source and rate of calcium silicate slag.
- Silicon adsorption experiments were carried out on the soils in batch systems to determine adsorption isotherms (amount of Si adsorbed as a function of equilibrium solution Si concentration).



Figures 1A-D. Sites were the bulk soil samples were collected for the pot experiment (A); Treatment application to potted soils prior to seeding (B); Collection of biomass clippings (C); and Preparation of monosilicic acid by passing sodium orthosilicate through ion exchange resin (D).

RESULTS AND HIGHLIGHTS

Table 1. Significance of the effect of $CaSiO_3$ application on amount of biomass and total silicon content at 30 and 60 days after sowing (DAS).

Site	30 DAS		60 DAS		Total	
	Biomass	Uptake	Biomass	Uptake	Biomass	Uptake
St. Joseph	ns	<0.01	<0.10	<0.10	<0.05	ns
Dean Lee	ns	ns	ns	ns	ns	ns
Ben Hur	<0.10	ns	ns	ns	ns	ns
Bossier	<0.10	ns	ns	<0.01	ns	ns
St. Gabriel	ns	<0.05	ns	ns	ns	ns
Crowley	<0.10	ns	<0.001	ns	<0.001	ns
Monroe	<0.001	ns	ns	ns	ns	ns

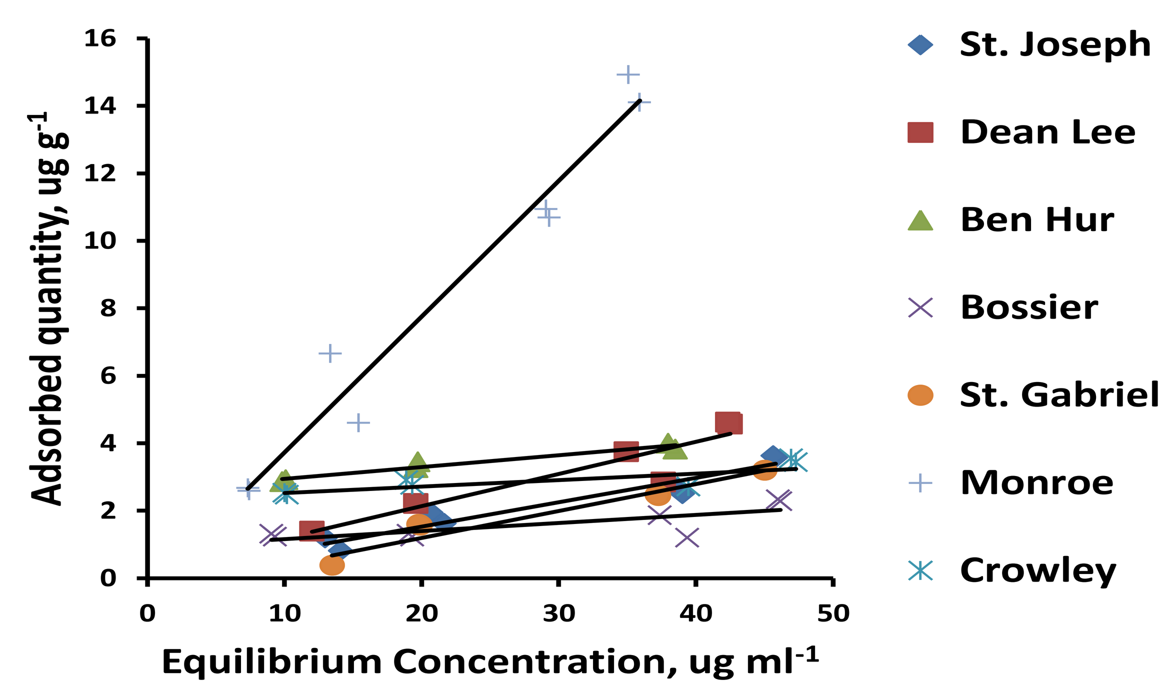


Figure 2. Silicon adsorption isotherms of selected agricultural soils of Louisiana.

Table 2. Coefficient of determination (r^2) of silicate adsorption data for soils fitted with the Freundlich and Langmuir equations in six different soils of Louisiana.

Site	Soil pH	% OM	Soil Texture	Linear Freundlich Equation logx/m=1/nlogC + logK	r^2	Langmuir Equation c/q=(1/b)c+1/ab	r^2
St. Joseph	6.72	1.768	Silt loam	y = 0.9652x - 1.0748	0.901	y = 0.0081x + 13.242	0.002
Dean Lee	7.28	1.496	Silt loam	y = 0.8673x - 0.7910	0.908	y = 0.051x + 8.1495	0.143
Ben Hur	5.23	3.032	Silt loam	y = 0.2021x + 0.2257	0.815	y = 0.233x + 1.7622	0.965
Bossier	6.73	0.273	Very fine sandy loam	y = 0.2936x - 0.2178	0.480	y = 0.4129x + 5.5716	0.623
St. Gabriel	6.91	0.994	Silt loam	y = 1.5879x - 2.0761	0.867	y = -0.4782x + 33.2	0.414
Crowley	7.34	1.496	Silt loam	y = 0.1504x + 0.2479	0.547	y = 0.2865x + 1.4131	0.929
Monroe	6.15	2.829	Silt clay loam	y = 0.0459x + 0.2479	0.958	y =-5.2792x+22.418	0.174

ACKNOWLEDGEMENTS

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- Across the soils tested, the amount of Si extracted increased with increasing AgrowSil application rates (data not shown). However, these increases were not consistently reflected from the amount of biomass and Si uptake of ryegrass (Table 1). Apart from soil pH and extractable Ca which increased with increasing AgrowSil application rates, the extractable Mg, Cu, Zn, Fe, and other micronutrients were not altered (data not shown).
- Increased in the amount of biomass or Si uptake was observed from all the soils except the one from Dean Lee. In addition, these significant responses were not consistently observed at the two sampling times. It was generally observed that the application of AgrowSil at 2 Mt ha^{-1} was more effective than the higher rates (4 and 8 M ha^{-1}) in increasing the biomass production and Si uptake.
- There was considerable difference in the Si adsorption and supplying capacity amongst the soils tested (Fig. 2). This could be attributed to the relation between the chemical nature of monosilicic acid and the physicochemical properties of the soil. The silicate adsorption data of the investigated soils showed a better fit to the Freundlich equations (Table 2). The adsorption studies by Batch method showed that the adsorbed silicate increased with increasing equilibrium silicate concentration (Ci) for all of the tested soil samples. These results are consistent with the adsorption isotherm where the soil from Bossier site had the least amount of monosilicic acid adsorbed. Perhaps this is also explains that while the extractable Si in soil at 60 days of seeding was noted to be the lowest, the Si uptake was not reduced compared with all the other soils investigated. Therefore while some soils may benefit from Si fertilization markedly others may not.