Biomass and Silicon Uptake of Wheat in Response to Different Levels of Plant-Available Silicon

Narayanaswamy, C. [1], B. Tubaña[1], S. Chanda[1], and L. Datnoff[2]

[1]School of Plant, Environmental, and Soil Sciences, Louisiana State University Agricultural Center
[2]Department of Plant Pathology and Crop Physiology, Louisiana State University Agricultural Center

Introduction

While silicon (Si) is one of the most abundant elements found in the Earth's crust, it is mostly inert and slightly soluble. Continuous crop cultivations tends to remove large quantities of Si from soil. For crops like rice and sugarcane, Si fertilization has become beneficial to attain high yields through increased resistance to both abiotic and biotic stress. Although there is a vast information available in rice and sugarcane, Si fertilization in wheat is understudied.

Objective

To evaluate wheat biomass production and Si uptake in response to varying levels of soil Si extracted by different solutions.

Materials and Methods

- Twelve selected soils from Indiana, Mississippi, Ohio, Alabama, Michigan and Louisiana were collected in bulk, air-dried, and processed to pass 2 mm sieve (Fig. 1A).
- Processed soils with an approximate weight of 2 kg were placed in pots (Fig. 1B).
- Different rates of calcium silicate ($CaSiO_3$) slag (0, 1, 2, 4, 6, and 8 MT ha^{-1}) were applied; a control and two rates of calcium carbonate (1 and 2 MT ha^{-1}) were also included in the treatment structure. Treatments were replicated four times and arranged in a randomized complete block design.
- Four wheat seeds were sown and thinned down to two seedlings per plot. Optimal moisture and nutrients (N, P, K and Zn) were maintained.
- Wheat biomass samples were collected at maximum tillering; soil samples were collected from each pot. Silicon content in soil and biomass was determined.

Figure 1. Bulk soil sample processing (A), potting (B). Pots were watered to maintain optimal moisture (C), whereas pots were thinned leaving two seedlings three weeks after sowing (D).

Results and Conclusions

Table 1. Texture, pH, organic matter content, and acetic acid extractable silicon of soils collected from different locations.

Location	State	pH	Texture	OM %	Si mg kg^{-1}
Crawfordsville	IN	6.4	Silt loam	5.0	54
Butler	IN	6.7	Silt loam	2.7	59
Portage	IN	5.0	Fine sandy loam	3.6	36
Millford	MI	7.1	Sandy loam	1.3	53
Highland	MI	5.1	Sandy loam	1.3	22
Saginaw	MI	7.4	Fine sandy loam	2.3	76
St. Gabriel	LA	6.9	Silt loam	1.0	73
Bossier	LA	6.7	Very fine sandy loam	0.3	44
Crowley	LA	7.3	Silt loam	1.5	103
Butler Paulding	OH	7.1	Silt loam	3.2	106
Hillsboro	AL	7.0	Silt loam	1.3	68
Columbus	MS	7.4	Silty clay	2.4	165

- Wheat grown on soils with initially low acetic acid extractable Si with either high organic matter or low soil pH responded to increasing rates of $CaSiO_3$ slag. Table 1 show the pH, organic matter content, and acetic acid extractable Si of soils collected from different locations in Indiana, Mississippi, Alabama, Michigan, Ohio, and Louisiana.
- Generally, extractable Si increased with increasing $CaSiO_3$ rate however, reduction in biomass production was observed if $CaSiO_3$ was applied at rates > 4 MT ha^{-1}. The relationship between wheat Si uptake and acetic acid extractable Si shows similar pattern (Fig. 2). The reduction in biomass yield may have resulted from the negative effect of high pH brought about by high application rates of $CaSiO_3$ on the solubility of several plant essential nutrients.
- The relationships between wheat Si uptake and soil Si extracted by different solutions generally show an increasing trend; these solutions included 0.5 M NH_4 acetate, deionized water, and 0.1 M $CaCl_2$. On the other hand, 0.5 M acetic acid, 1 M sodium acetate and 0.1 M citric acid- extractable Si initially show a linear relationship with wheat Si uptake then plateau at 127, 138, and 205 mg Si kg^{-1}, respectively (Fig. 3).
- Wheat biomass production positively responded to application of $CaSiO_3$ at increasing rate but only up to 4 Mt ha^{-1}. The benefit of $CaSiO_3$ slag application to crops requiring large Si supply can be offset by the change in soil pH which eventually affect the solubility of essential nutrients.

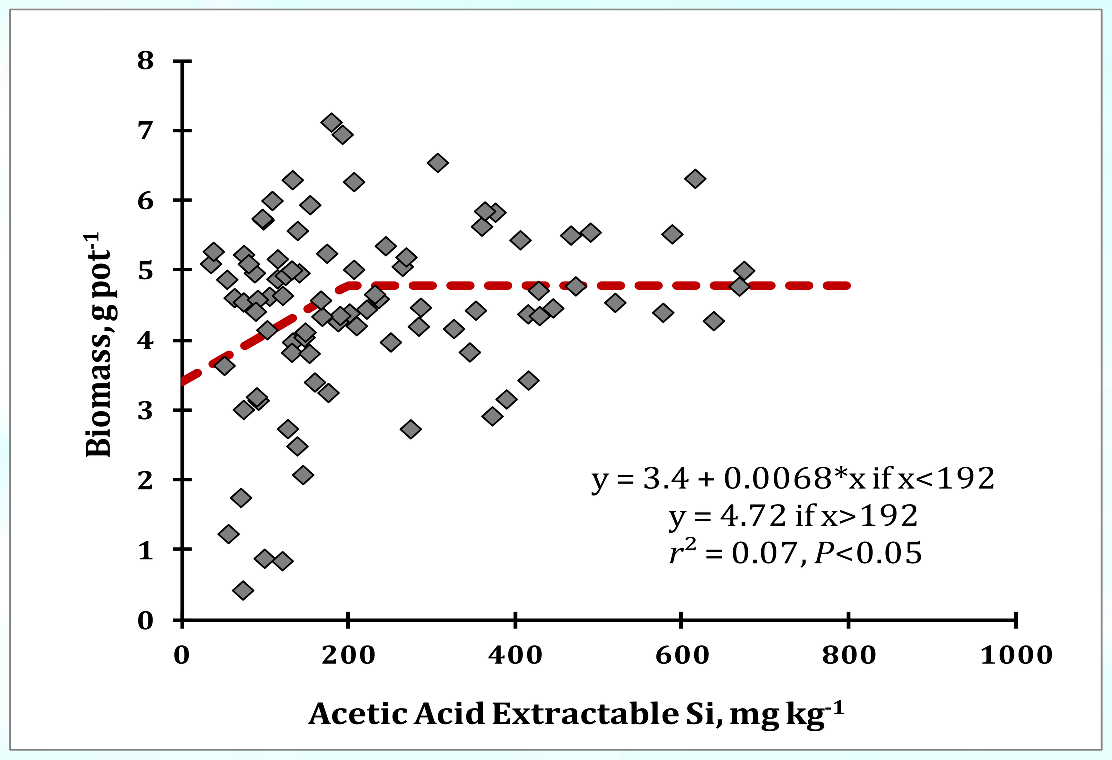

Figure 2. Relationship between wheat biomass and acetic acid extractable silicon.

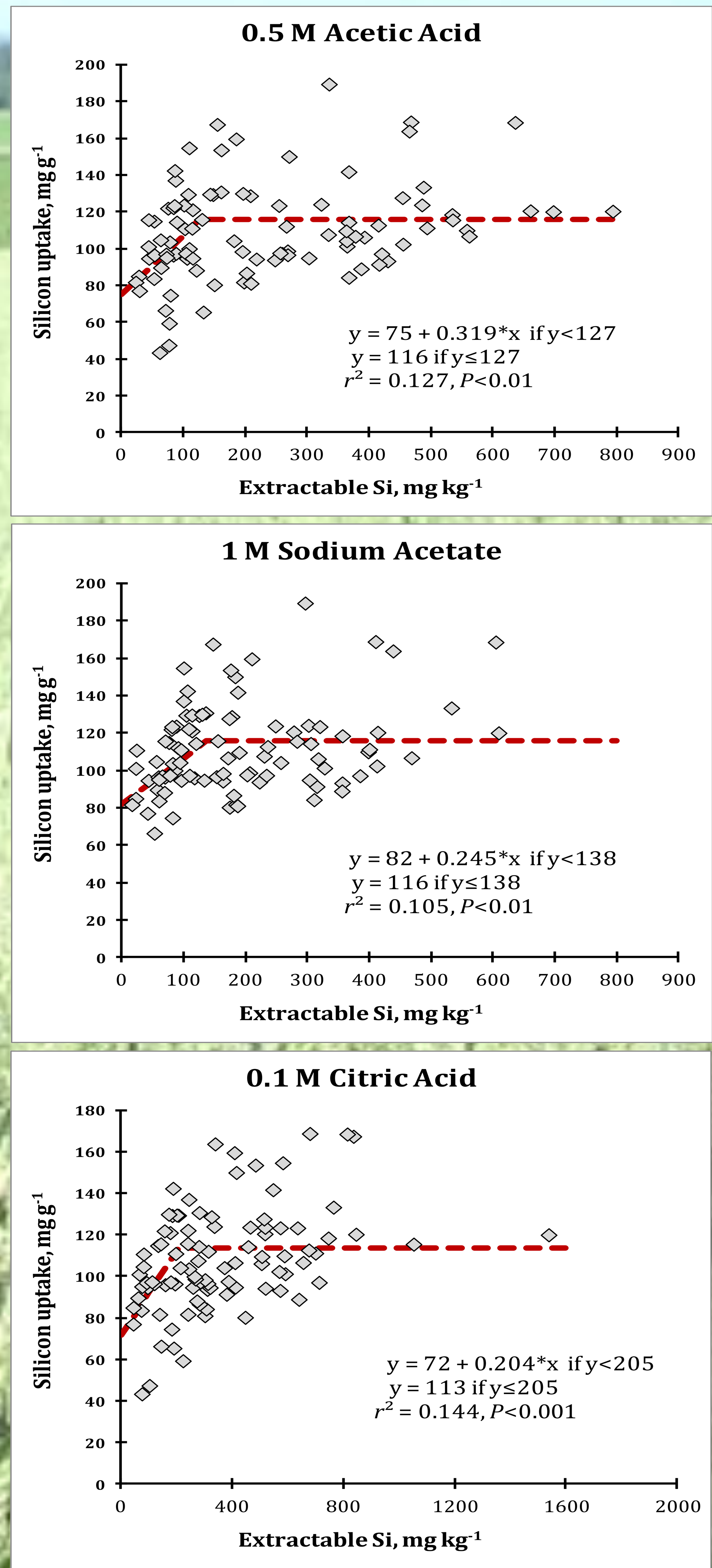

Figure3. Relationship of wheat silicon uptake to silicon extracted by 0.5 M acetic acid, 1 M sodium acetate, and 0.1 M citric acid.

Acknowledgement

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