The Effect of Silicon Amendments on Arsenic Accumulation and Greenhouse Gas Emissions in Rice (*Oryza sativa* L).

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Introduction

- Arsenic contamination threatens rice production globally by lowering yield and poses a risk to human health due to grain accumulation of arsenic.
- Soil silicon additions can increase yield and decrease grain arsenic concentrations.[1, 2]
- While straw could be used for Si fertilization, its use in rice paddies is associated with increased methane emissions due to a high labile C content.[3]
- Rice husk, husk ash, and calcium silicate ($CaSiO_3$) are high in Si and low in C, making them suitable Si fertilizers.
- A pot experiment was conducted to test the effect of 3 silicon rich amendments on arsenic accumulation and greenhouse gas production.

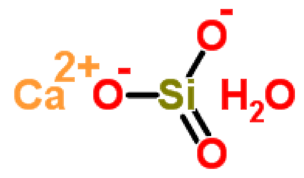
Si-rich husk is often discarded or burned for fuel in rice producing countries

Methods

3 silicon amendments:

Rice Husk

Rice Husk Ash



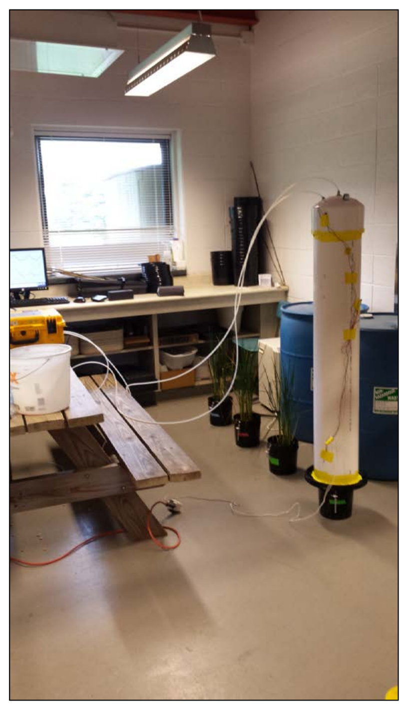
Calcium Silicate

Soil spiked with arsenic (desired porewater concentration 300 μg/L) → **3.5 kg Soil per pot** → Control / Calcium Silicate / Rice Husk / Husk Ash → **3 plants per pot (M206 variety)**

Rhizons installed to sample porewater

Weekly porewater sampling → pH; Redox; Colorimetry → Fe^{2+} Si; ICP-OES → Si, Fe; ICP-MS → As

Flux measured weekly using custom-built chamber



Upon maturity, rice plants were harvested and digested for Si and As analysis

Results

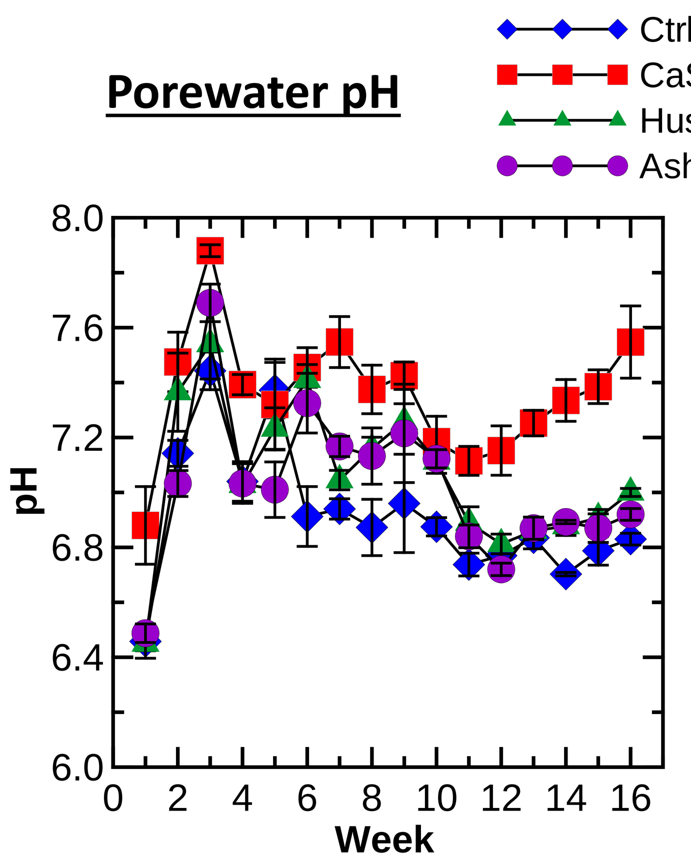


Figure 1. Weekly porewater pH measurements (pH ± SD) *n = 4*

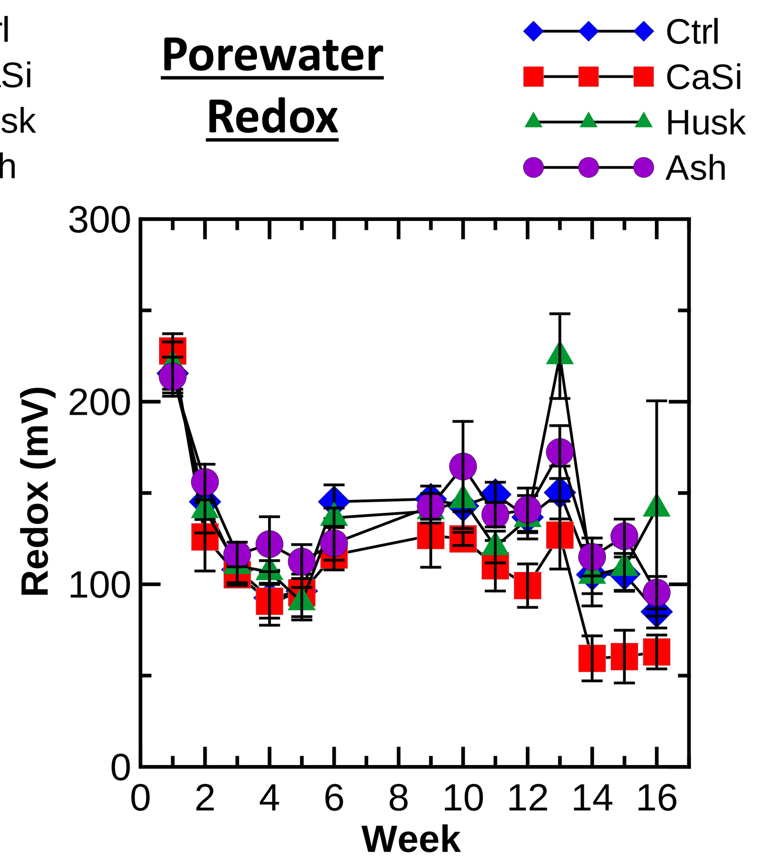


Figure 2. Weekly redox (vs. SHE) (mV ± SD) *n = 4*

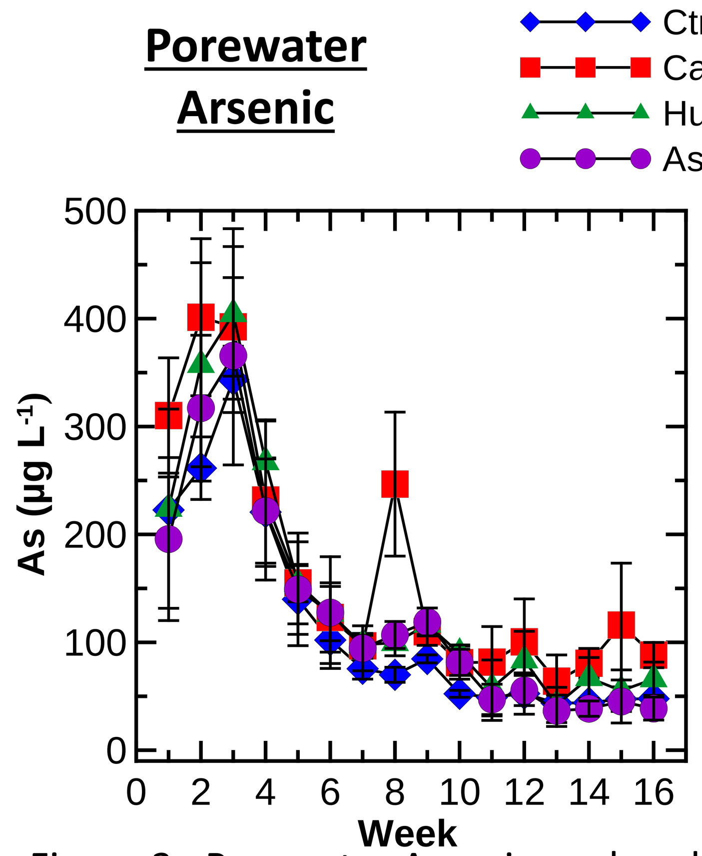


Figure 3. Porewater Arsenic analyzed by ICP-MS (μg L^{-1} As ± SD) *n = 4*

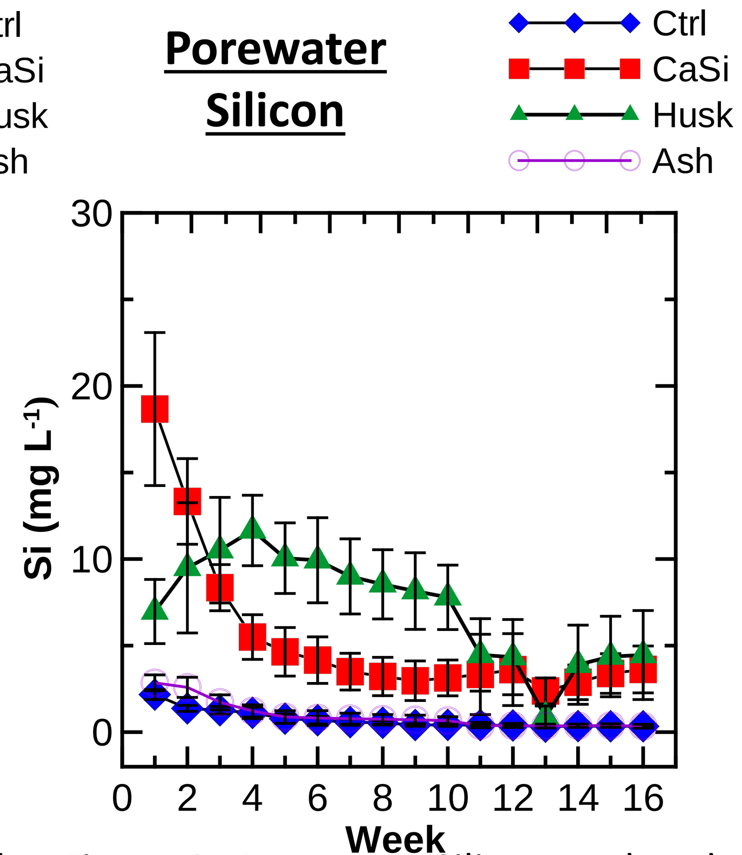


Figure 4. Porewater Silicon analyzed by ICP-OES (mg L^{-1} Si ± SD) n = 4

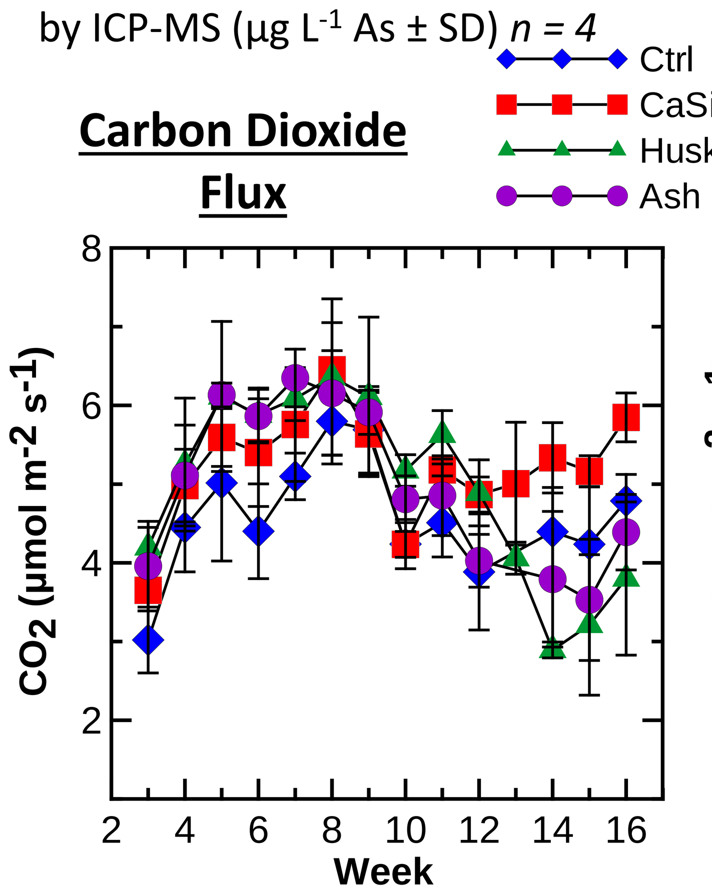


Figure 5. CO_2 flux (μmol $m^{-2}s^{-1}$ CO_2 ± SD) *n = 4.* Cutoff for flux curve $R^2 \geq 0.9$

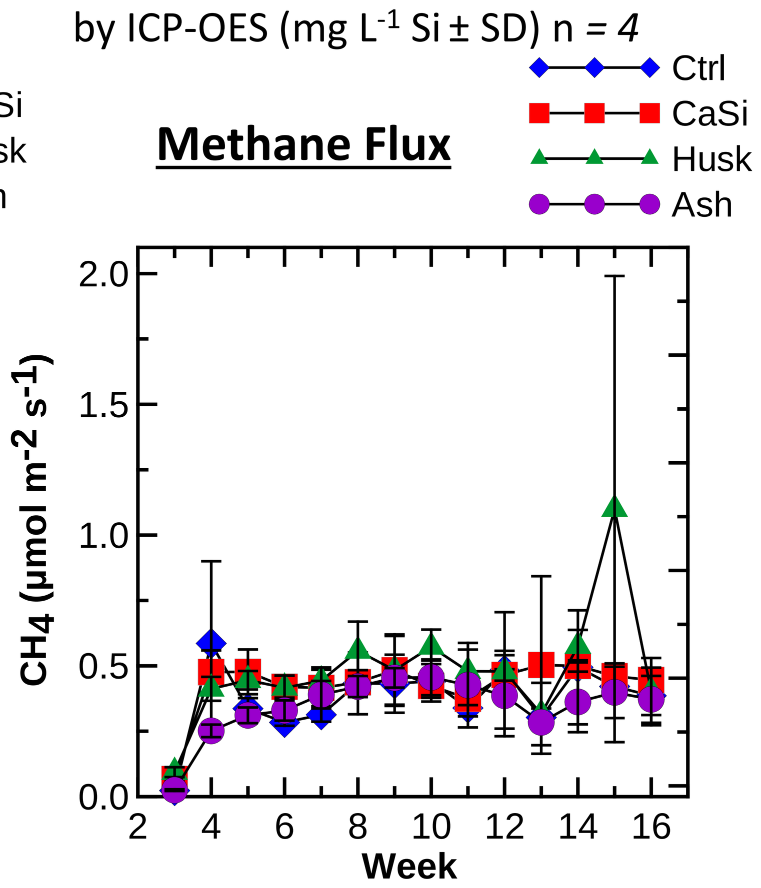
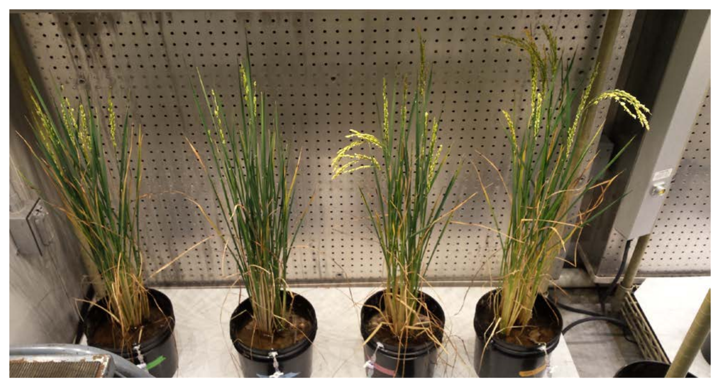


Figure 6. CH_4 flux (μmol $m^{-2}s^{-1}$ CO_2 ± SD) *n = 4.* Cutoff for flux curve $R^2 \geq 0.9$



Control $CaSiO_3$ Ash Husk

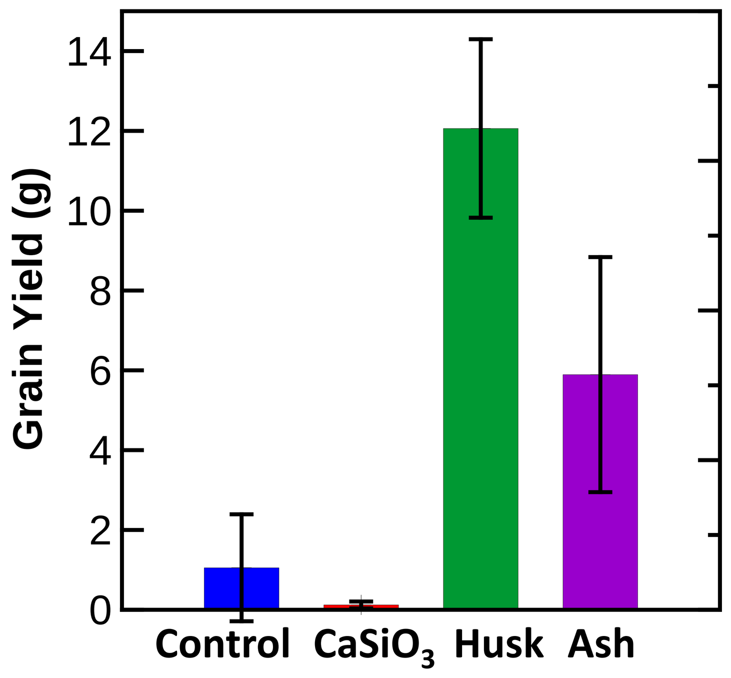


Figure 7. (**at left**) Yield differences between treatments were visually striking, with husk and ash treatments having greater than a 6 and 3-fold increase in ripe grain in comparison to control and calcium silicate treatments, respectively. (**at right**) Average grain weight per treatment (±SD) *n = 4*

Results (Plant Digestions)

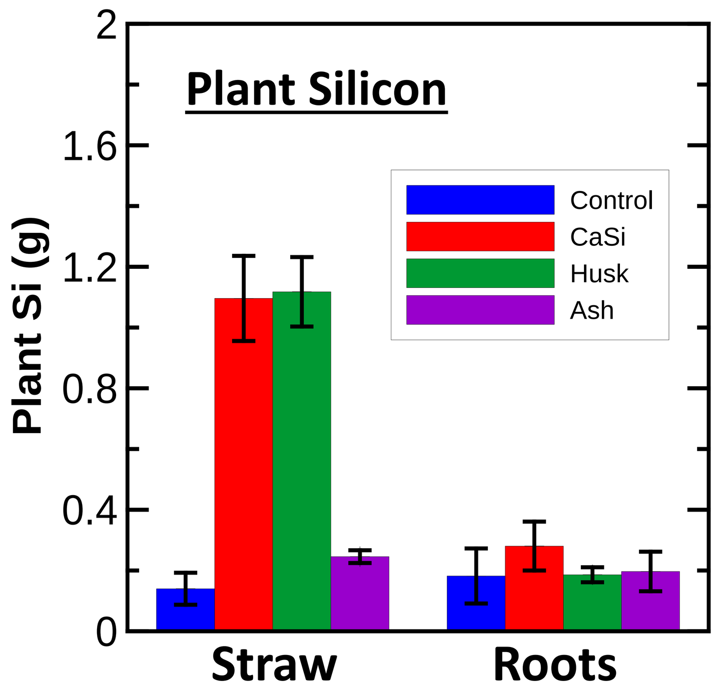


Figure 8. Average digestible silicon in straw and roots (g Si ± SD) *n = 4.*

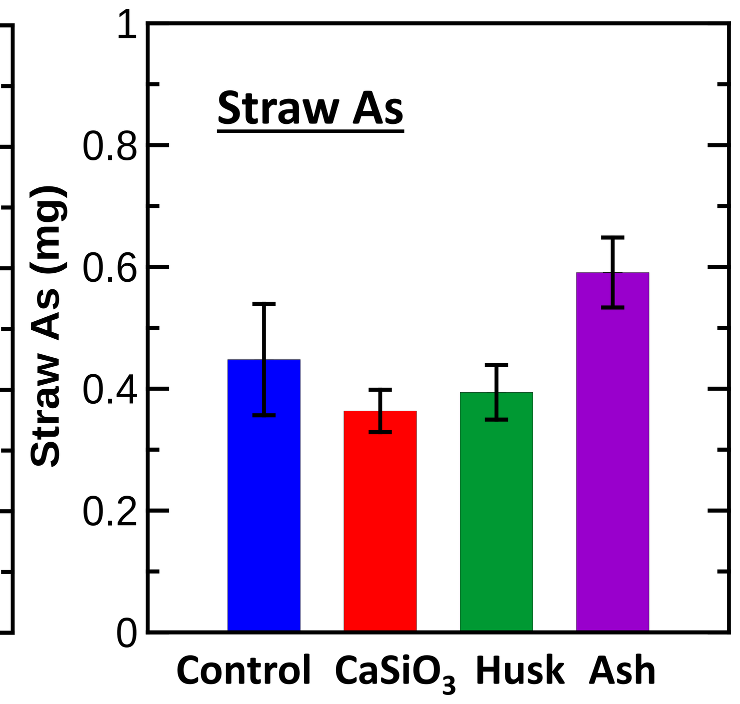
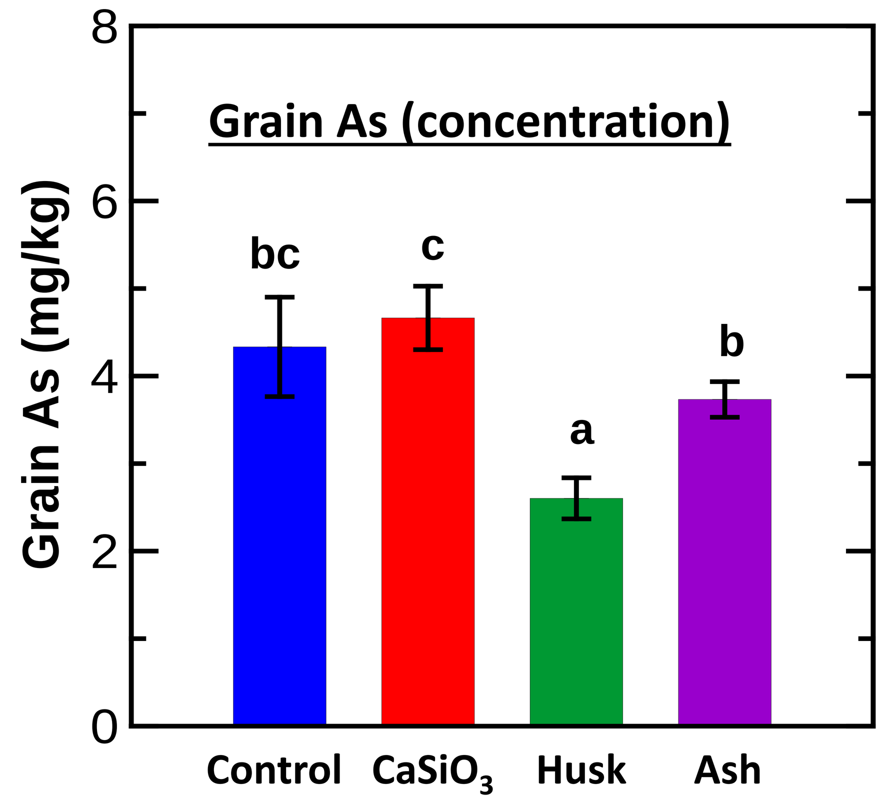


Figure 9. Average digestible straw arsenic (mg As ± SD) *n = 4.*

Figure 10. Average grain digestible arsenic (mg/kg As ± SD) *n = 4.* Rice husk significantly decreases grain arsenic 40% relative to control. Average standard As recovery = 101%.



Conclusions

- Husk amendment increases grain yield and decreases grain arsenic concentration in comparison to other treatments
- Although calcium silicate increased straw silicon content, its effect on yield and grain As accumulation may limit its potential as a remediating agent/fertilizer
- Similar straw digestible As in husk and $CaSiO_3$ treatments may indicate As transport to grains is limited by husk treatment
- Husk may be an effective resource for lowering grain arsenic concentrations and increasing rice yield without increasing methane emissions

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References

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2. Datnoff, L.E., Raid, R.N., Snyder G.H., Jones, D.B., Effect of calcium silicate on blast and brown spot intensities and yields of rice. *Plant Disease.* 1991, 75, 729-732
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