Silicon Delays *Tobacco ringspot virus* Systemic Symptoms in *Nicotiana tabacum*

Silicon (Si) has been shown to provide many benefits to stressed plants, including protection against attack from certain fungal and bacterial pathogens. However, the effects of this element on viral infections is unclear. In this study, the ability of Si to influence *Tobacco ringspot virus* (TRSV) and *Tobacco mosaic virus* (TMV) infection in *Nicotiana tabacum* was investigated.

N. tabacum seeds were germinated hydroponically in nutrient solution containing 0.1 mM soluable K_2SiO_3 to a four-leaf stage. Immediately prior to inoculation with pure TRSV or TMV, plants were transferred to 4L tubs containing nutrient solution plus 0.1 mM (control) or 1.0mM Si (elevated). Plants were examined daily for the formation of symptoms up to 15 days post-inoculation. Once systemic viral symptoms were observed (at approximately 9 days post-inoculation (DPI)), digital images were taken and the Assess Program was used to calculate the percent of leaves affected by the virus.

Overall, the majority of the plants with elevated Si (Si+) never exhibited levels of symptomatic leaf coverage to the same extent as the controls (Figure 1A). To examine the effectiveness of Si on the control of TRSV systemic infection, the area under the disease progress curve (AUDPC) was calculated for the four time points, 9, 11, 13, and 15 dpi. The AUDPC values show that Si confers a beneficial effect on tobacco by reducing the systemic TRSV symptomatic leaf area (Figure 1B).

Leaf Si levels were influenced by TRSV infection. Plants inoculated with TRSV and supplemented with Si contained four-fold higher Si foliar concentrations compared to Si-supplemented, mock-inoculated plants (Figure 2A). In contrast, root Si concentrations were dependent on Si supply, but independent of TRSV infection (Figure 2B). The effects of Si on TMV were also investigated to determine if the beneficial effects of Si on TRSV are virus-specific. No obvious differences of TMV spread or distribution was observed between control and Si-supplemented plants. Si accumulation in TMV-infected leaves at 18 DPI was entirely dependent on upon Si application, but independent of viral infection.

Si specifically delays TRSV systemic symptom formation and this response correlates with higher Si levels in virus-infected plants. This effect appears to be virus-specific.

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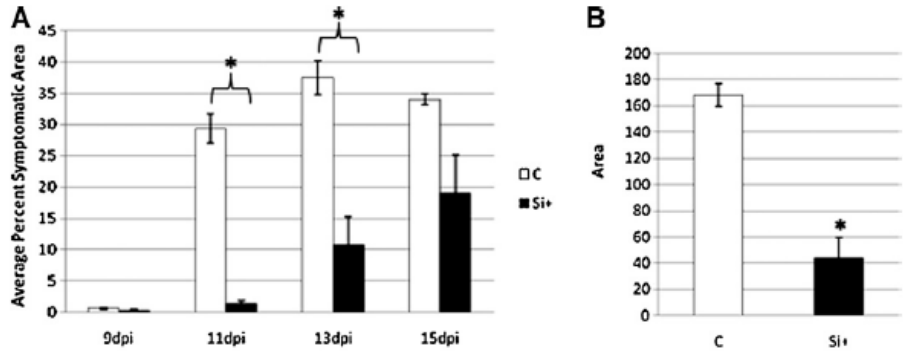

Figure 1. TRSV systemic symptom spread and detection in *N. tabacum*. (A) Average percent TRSV symptomatic leaf area (Y-axis) on *N. tabacum* treated with 0.1 mM (C, white) or 1.0 mM K_2SiO_3 (Si+, black) at 9, 11, 13, and 15 DPI; the time points are indicated in the figure (X-axis). Average values and SEM are given, asterisks indicate significant difference between the C and Si+ plants at a particular time point ($p < 0.05$). Df = 1; F values are .663 for 9 DPI, 34.85 for 11, 6.555 for 13 and 1.4 for 15. (B) AUDPC average and SEM is given for C (white) and Si+ plants (black); asterisk indicates a significant difference between the values ($P < 0.05$) with Df = 1 and an F value of 12.127.

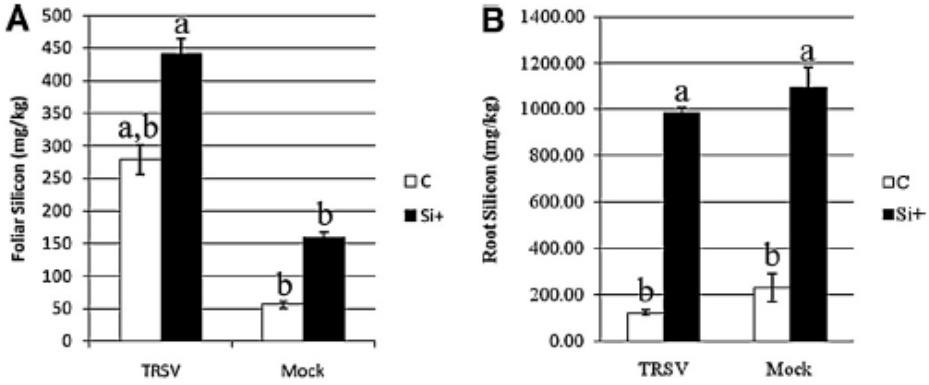

Figure 2. Si concentration (mg/kg) within virus-infected plants determined by ICP-OES. Plants infected with TRSV (A, B). Si levels in leaves (A) and roots (B) of *N. tabacum*; white bars, control plants (0.1 mM K_2SiO_3); black bars, treated with elevated Si (1.0 mM K_2SiO_3). Bars indicate average, error bars, SEM; letters indicate statistically significant differences as determined by Tukey's HSD test ($p < 0.05$).

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