SILICON INDUCES THE BIOSYNTHESIS OF LIGNIN IN WHEAT CULTIVARS GROWN UNDER PHOSPHORUS STRESS

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Introduction

Although silicon (Si) and lignin are accumulated on plant cell walls and both confer resistance to multiple biotic and abiotic stresses (Liu et al. 2018; Song et al. 2021), the impact of Si on lignin production in plants grown under phosphorus (P) stress still remains unknown. We evaluated the effect of Si on the lignin accumulation pattern and the expression of lignin biosynthesis related genes in wheat plants grown at different P levels.

Material and Methods

Two wheat cultivars differing in tolerance to P deficiency (Púrpura-sensitive and Fritz-tolerant) were hydroponically grown in a continuously aerated nutrient solution proposed by Taylor and Foy (1985). Ten days later, plants were treated with P (0, 0.01 or 0.1 mM) in combination with Si (0, 1 or 2 mM). Twenty-one days after the initiation of treatments, plants were harvested and lignin concentration, lignin distribution pattern and the gene expression of phenylalanine ammonia lyase (*TaPAL*) and cinnamyl alcohol dehydrogenase (*TaCAD*) were analyzed in shoots.

Results and Discusion

Lignin concentration of both wheat cultivars did not vary at different P doses; nevertheless, 2 mM Si increased lignin accumulation mainly at either 0 mM P (cv. Púrpura) or 0.01 mM P (cv. Fritz), with a more noticeable effect in Púrpura than in Fritz (Figure 1).

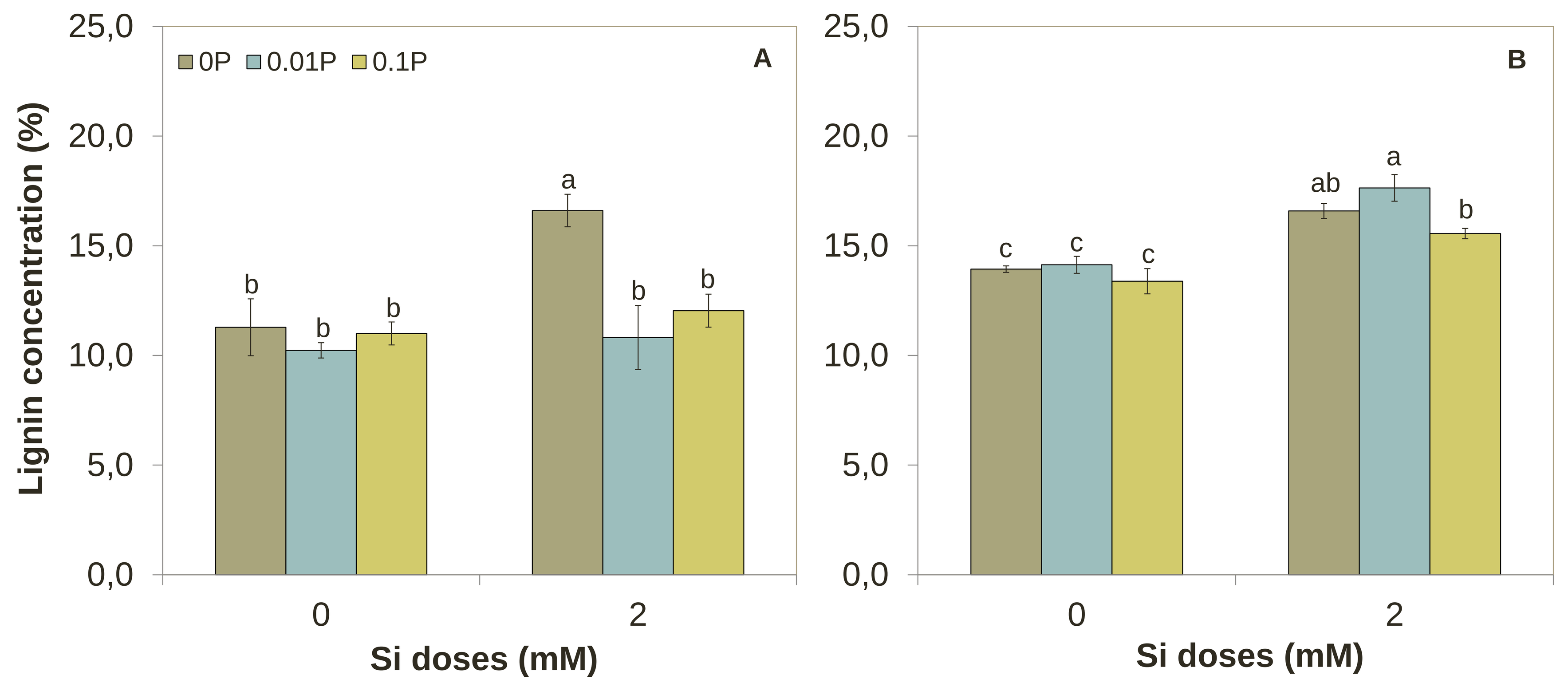

Figure 1. Lignin concentration in shoots of wheat cultivars Purpura (A) and Fritz (B) hydroponically grown with different P and Si doses during 21 days. Data are means of three replicates ± standard deviation. Different letters indicate statistically significant differences (p ≤ 0.05) among treatments.

This increase was in agreement with the stronger intensity of *Safranine O* staining observed after Si was added to both cultivars grown at sufficient or deficient P levels (Figure 2), and supports previous findings showing the alleviative Si role by increasing lignin production under stressful conditions (Yang et al. 2003; Shetty et al. 2011; Ribera-Fonseca et al. 2018; Vega et al. 2020; Hussain et al. 2021).

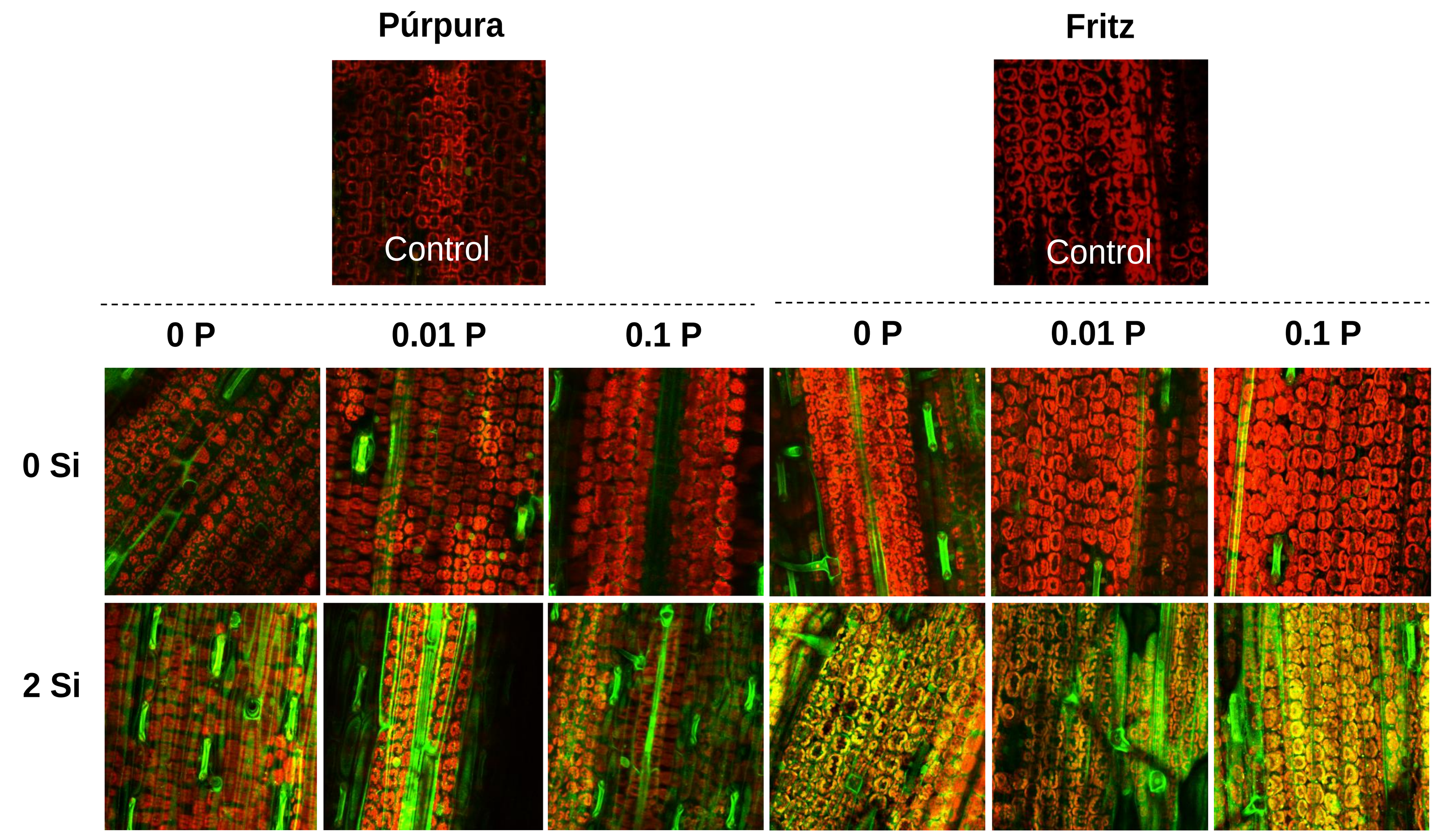

Figure 2. Representative confocal images of lignin accumulation pattern in shoots of wheat cultivars subjected to different P and Si doses. Lignin fluorescence (green) was collected by excitation/emission wave lengths 543 nm/590 nm by Confocal Laser Scanning Microscope.

Such effect may be related with either increased hydrogen peroxide production or peroxidase activity in cell walls as well as with the modulation of the activity and/or gene expression of some key enzymes involved in lignin biosynthesis. In this way, we also found that Si induced the expression of lignin biosynthesis genes (Figure 3).

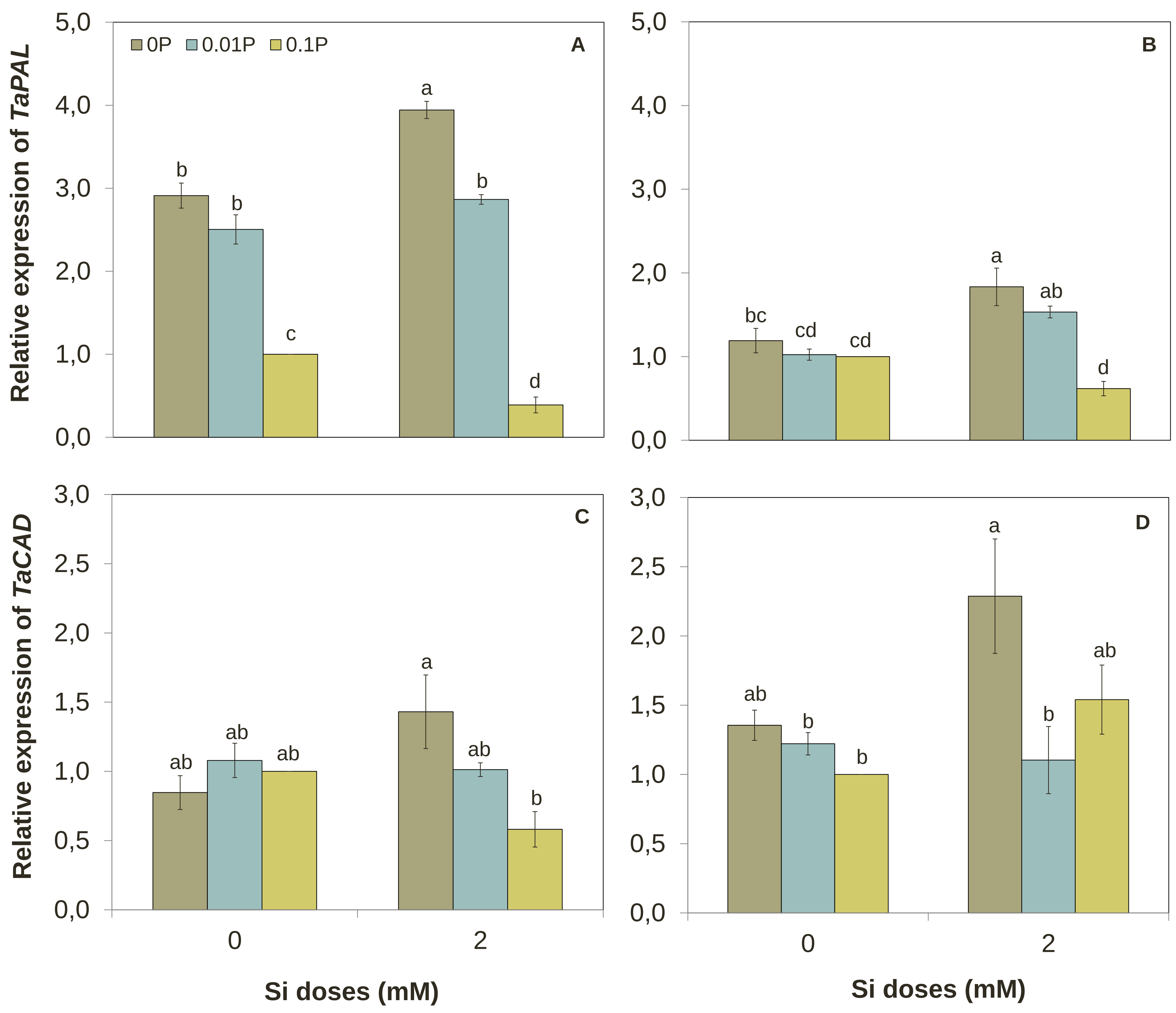

Figure 3. Gene expression analysis of *TaPAL and TaCAD* by qRT-PCR in shoots of wheat cultivars Purpura (A-C) and Fritz (B-D) hydroponically grown with different P and Si doses during 21 days. The expression levels were normalized in relation to *Actin* or *eEF1A* gene expression. Data are means of three replicates ± standard error. Different letters indicate statistically significant differences (*p* ≤ 0.05) among treatments.

Up-regulation of *TaPAL* was detected in cv. Púrpura grown at low P levels, with a further increase in plants treated with Si (Figure 3A). Likewise, Si addition to P-stressed plants of cv. Fritz increased the transcript level of *TaPAL* by about 1.5-fold (Figure 3B). Moreover, the expression level of *TaCAD* augmented by about 1.7- fold as a result of Si supply to both cultivars grown in the absence of P (Figure 3C-D).

Conclusion

Overall our results shows that Si induced the biosynthesis of lignin in shoots of wheat plants grown under P stress.

References

Liu et al. Int J Mol Sci (2018) 19: 335; Song et al. Biol Res (2021) 54: 19; Taylor and Foy. Am J Bot (1985) 72: 695-701; Yang et al. Sci Agric Sin (2003) 36: 813-817; Shetty et al. Plant Physiol (2011) 157: 2194-2205; Ribera-Fonseca et al. Crop Pasture Sci (2018) 69: 205-215; Vega et al. Agronomy (2020) 10: 1138; Hussain et al. J Hazard Mater (2021) 401: 123256.

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