Transpiration and transporters:
Teasing apart drivers of passive versus active transport of plant silicon

BACKGROUND:

All plants contain some silicon (Si), but some species take it up passively through the transpiration stream, while others also actively accumulate Si by producing transporters. Existing literature paints a conflicting picture for the relationship between plant Si accumulation and water uptake, with studies highlighting positive, negative, or no relationship between plant Si and transpiration rates and little information about relative importance of each under different conditions. In addition, the causal relationships between plant Si accumulation and water movement remains uncertain. Does plant Si content control transpiration rates, or do transpiration rates drive Si accumulation? And how does stress influence these relationships?

METHODS

Database search for TOPIC: (silicon OR silica) AND TOPIC: (transpiration OR stomatal conductance) AND TOPIC: (plant OR leaf OR leaves OR foliar)

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376 papers → Excluded papers about rice (active Si accumulator, dominates research)

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146 papers → Excluded papers not relevant, with foliar Si application or no variance provided

↓

26 papers

↓

Data analysis including linear regressions and meta-analysis using '*metaphor*' in R

EGU General Assembly 2020

Vienna | Austria | 3-8 May 2020

Does **transpiration drive plant Si accumulation?**

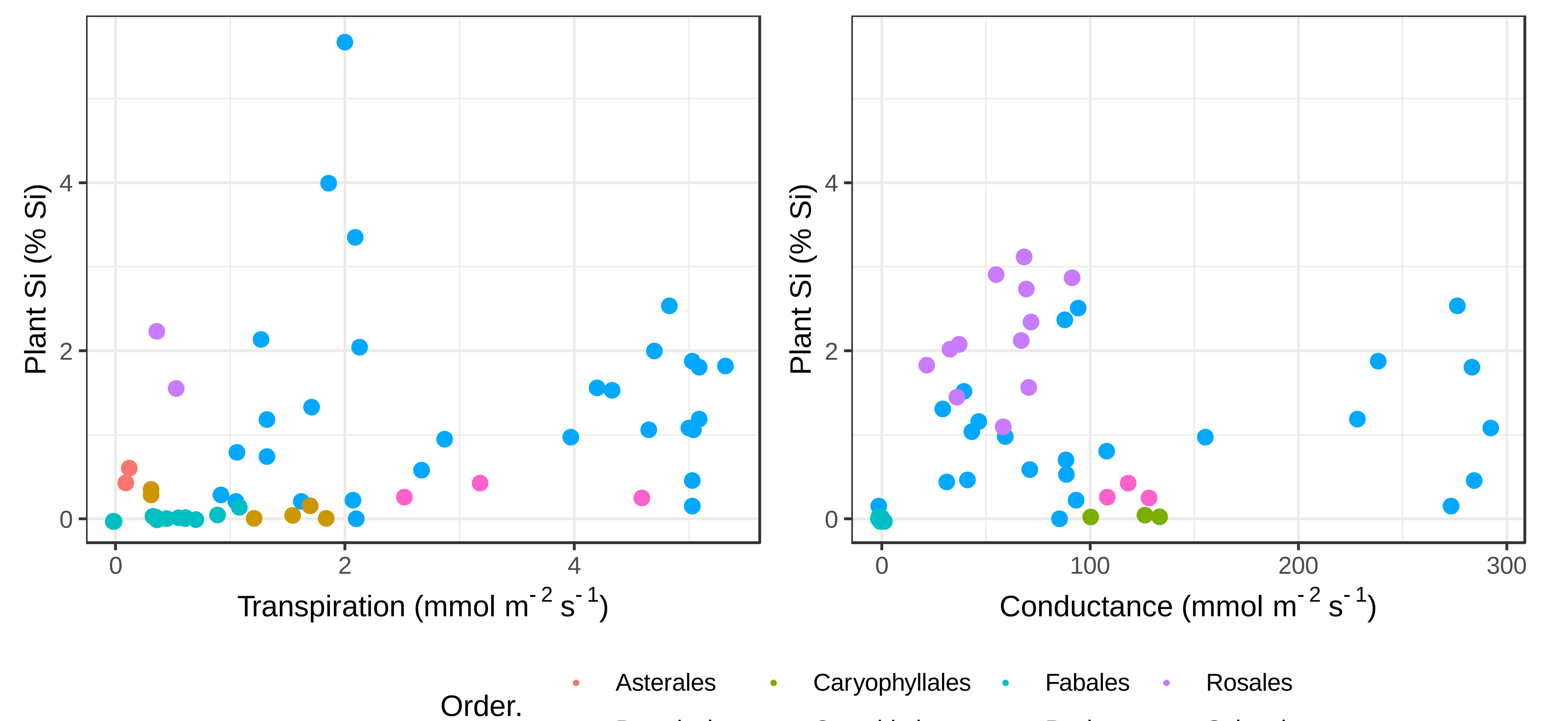

Figure 1

Or does **plant silicon impact water transport?**

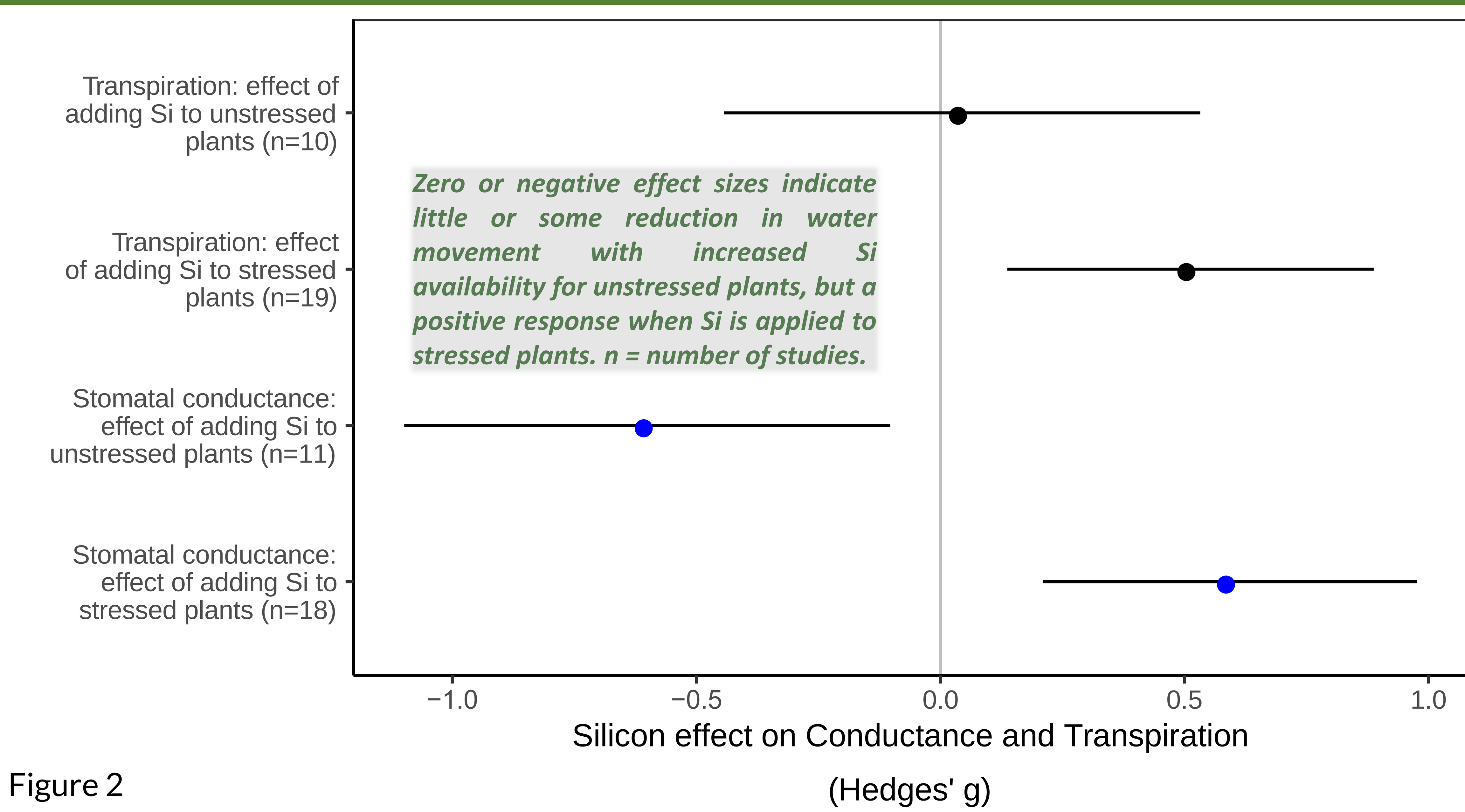

Figure 2

RESULTS:

While species from the same order were fairly clustered in their response, we found no simple relationship between shoot/leaf Si and transpiration rate or conductance, either overall, or within taxonomic order (Fig. 1). Collated results from manipulative experiments show a very mixed response of Si on water movement, from positive to neural to negative, and dependent on whether plants were stressed (Fig. 2).

DISCUSSION & IMPLICATIONS

Given the frequent paired mentions of Si and transpiration in the literature, there were surprisingly few papers with measurements of both variables. However, available data suggest plant Si uptake is mainly independent of water uptake (Fig. 1), supporting findings that plant Si accumulation is driven largely by Si availability and transporters (Ma and Yamaji, 2015). These factors, together with inducible upregulation in some species by herbivory (e.g. Hartley et al 2016), may be better predictors of plant Si compared to water uptake.

The mixed changes in water movement with increased Si availability (Fig. 2) has implications for agricultural production under future scenarios of water stress, as well as nutrient uptake and carbon fixation. Variation in stomatal density with plant Si (McLarnon et al. 2017) and limited impact of Si deposition on stomatal conductance in certain cell types of high Si accumulating species (Motomura et al. 2008) adds further complexity in the Si-water uptake relationship. A possible negative feedback of plant Si on stomatal conductance in unstressed plants warrants further investigation beyond these preliminary investigations.

References: Ma and Yamaji (2015). *Trends in Plant Science* 20.7 (2015): 435-442; McLarnon et al. (2017). *Frontiers in Plant Science* 8 (2017): 1199; Motomura et al. (2008) *Annals of Botany* 101.3 (2008): 463-468.

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