Strategies of Na and Cl accumulation in *Solanum lycopersicum* and its wild halophyte relative *Solanum chilense* under salt stress : focus on Na in the inflorescences

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Context

Salinity is a growing global concern that affects the yield of crop species, including tomato (*S. lycopersicum*). In contrast to *S. lycopersicum*, its wild relative *S. chilense* has halophyte properties [1,2]. However, this species is not as well known than other wild tomato relatives. Especially, accumulation of Cl and Na in reproductive parts is still unknown.

Na enters in aerial parts of the plant via transpiration flux and a few transporters are known to mitigate the accumulation of Na in aerial parts. Genes involved in Na transport are numerous. Genes from the SOS (Salt Overly Sensitive) pathway are involved in Na exclusion from the cell [3,4,5]. HKT1;2 (High-Affinity K^+, class I-HKT), decreases the Na^+/K^+ ratio in inflorescences [6]. NHX (vacuolar Na^+/H^+ antiporters) are believed to be involved in vacuolar Na^+ sequestration [7]. HAK (High-Affinity K^+) transporters are involved in K nutrition [8] and AKT2/3 (inward-rectifying K^+ channel) is a K transporter involved in sucrose transport in the phloem, activated in response to salt stress [9,10].

Our study aims to observe the strategies of accumulation of Na and Cl in the whole plant and in inflorescences of both species, with a special focus on Na accumulation in flowers. Gene expression of mineral transporters in flowers were also analyzed to try to explain the difference in Na accumulation.

Material and methods

Plants: *S. lycopersicum* cv. Ailsa Craig (LA2838A), *S. chilense* (LA4107)

Treatments:

0, 100 or 120 mM NaCl (for 85 days);

perlite/vermiculite with Hoagland solution; greenhouse conditions (24°C/21°C day/night, 65% RH, 16h-photoperiod)

Measurements:

Na and Cl concentrations (AAS and HPLC) (stems, leaves, roots, inflorescences),

Na localization in flowers (LA-ICP-MS), gene expression of mineral transporters (qPCR).

Results

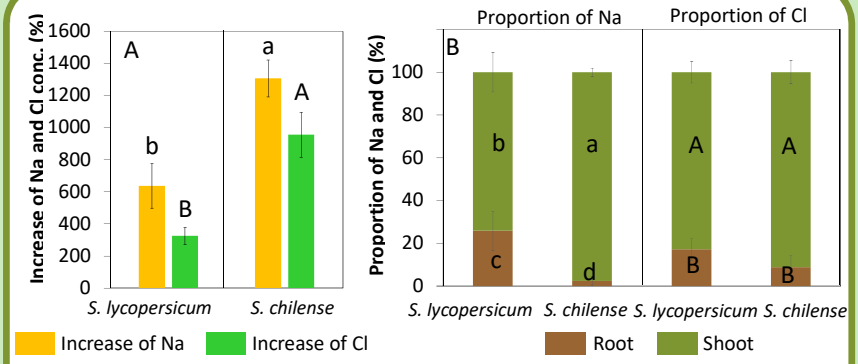

Fig. 1. (A) increase of Na and Cl concentration in the whole plant at 120 mM NaCl compared to 0 mM. (B) proportion of quantities of Na and Cl in the shoot and root parts. Different letters for a same parameter indicate significant differences at $p<0.05$ for a same element.

- Accumulation of Na and Cl: *S. chilense* > *S. lycopersicum* (Fig. 1A)
- Accumulation of Na > Cl in both species (Fig. 1A)
- Proportion of Na in root: *S. lycopersicum* > *S. chilense* (Fig. 1B)
- Proportion of Na in shoot: *S. chilense* > *S. lycopersicum* (Fig. 1B)
- Proportion of Cl in root and shoot similar in both species (Fig. 1B)
- Both species limited the accumulation of Na and Cl in the inflorescences with a more marked effect on Cl (Fig. 2).
- **In flowers**: Na mainly located in male organs of *S. chilense* and in non-reproductive organs of *S. lycopersicum* (Fig. 3).
- Correlations between [Na] in flowers and gene expression of transporters (Fig. 4):
  - *HKT1;2* : negative correlation with [Na]
    positive correlation with Na male/female
  - *SOS1*, *SOS2* : positive correlation with [Cl] and
    with Na vegetative/reproductive

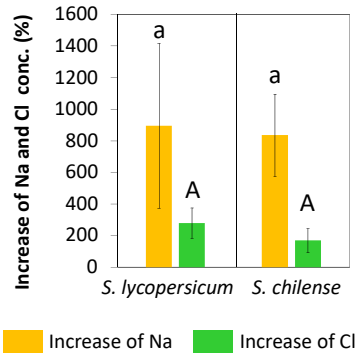

Fig. 2. Increase of Na and Cl concentration in inflorescences at 120 mM NaCl compared to 0 mM. Different letters indicate significant differences at $p<0.05$ for a same element.

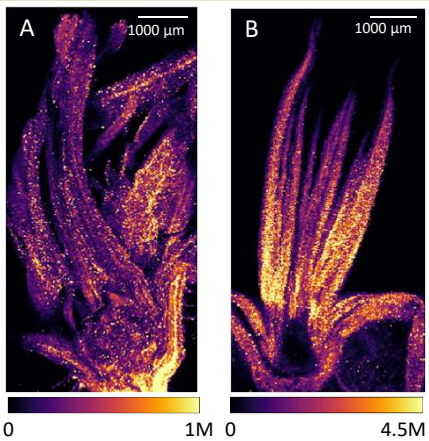

Fig. 3. Na distribution in flowers of *S. lycopersicum* (A) and *S. chilense* (B) grown with 100 mM NaCl as revealed by LA-ICP-MS and visualized using ImageJ. Color: number of counts per pixel (20*20 µm) of each analysis.

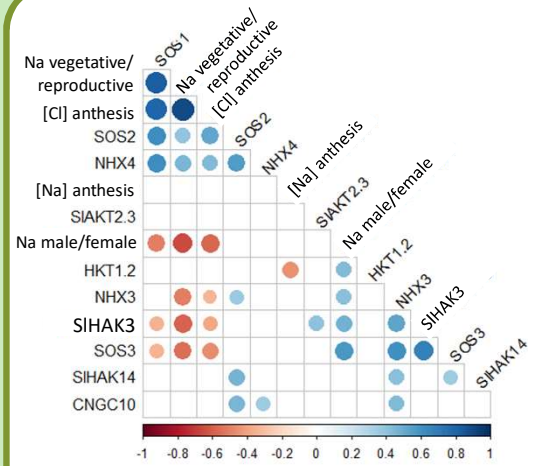

Fig. 4. Correlations between Na and Cl concentrations and gene expression of mineral transporters in the flower.

Conclusions

- *S. lycopersicum* and *S. chilense* have respectively an excluder and includer behavior toward Na but not toward Cl
- Both species limited the accumulation of Na and Cl in the reproductive organs (inflorescences and flowers)
- Na accumulation and repartition in flowers could be partly explained by gene expression of transporters

[1] Martínez et al., 2012, DOI: 10.1017/S001447971200066X; [2] Gharbi et al., 2016, DOI:10.1016/j.jplph.2016.12.001; [3] Asins et al. 2015, DOI:10.1007/s00122-015-2462-8; [4] Assaha et al. 2017, DOI:10.3389/fphys.2017.00509; [5] Basu et al. 2020, DOI:10.1111/ppl.13112; [6] Romero-Aranda et al. 2020, DOI:10.1016/j.plaphy.2020.05.012; [7] McCubbin et al., 2014, DOI: 10.3390/plants3030409; [8] Rubio et al., 2014, DOI: 10.1111/ppl.12205; [9] Deeken at al., 2002, DOI:10.1007/s00425-002-0895-1; [10] Maathuis et al., 2006, DOI: 10.1093/jxb/erj001.