

Nitrogen deficiency induced starch accumulation in maize leaves is not due to plasmodesmata occlusion

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Abstract

- Under nitrogen (N) deficiency, maize leaves exhibit higher starch concentrations than under N-sufficient conditions. Thus, photosynthate availability *per se* may not be the factor responsible for yield reductions under N-deficient conditions [1], rather impaired sugar mobilization and translocation out of leaves likely contributes to reduced yields.
- To test whether the sugar export pathways in maize leaves are occluded under N deficiency, tissue samples from ear leaves of N deficient and N sufficient plants, collected at silking and 20 or 21 days after silking (DAS), were examined by transmission electronic microscopy (TEM). In addition N, sugar, and starch concentrations were assayed.
- Consistent with other reports [1], ear leaves from N-deficient plants had lower N but higher starch concentrations than those from N sufficient plants, both at silking and 20 or 21 DAS. The TEM analysis revealed normal appearing plasmodesmata in both N-deficient and N-sufficient ear leaves. No occlusions were found between mesophyll cells (MC) and bundle sheath (BS) cells, and between BS cells and vascular parenchyma (VP) cells. The lack of plasmodesmata occlusions indicates that the symplastic pathway of sugar export from leaves is open. Additionally, the larger size of starch granules and greater granule number per chloroplast in N-deficient leaves at least partially explained their higher starch concentrations.

Material and Methods

Ear leaf samples of N deficient (NO) and N sufficient (N200) field-grown Pioneer '32D79' plants were collected from 9 am to 11 am at silking and 21 DAS in 2014; and at 8 pm and 8 am at silking and 20 DAS in 2015. Tissue samples were examined by transmission electronic microscopy (TEM). In addition N, sugar, and starch concentrations were assayed.

Results

- N-deficient ear leaves had lower specific leaf N (SLN) and higher C/N ratio than those under N-sufficient conditions (Fig. 1A and B).

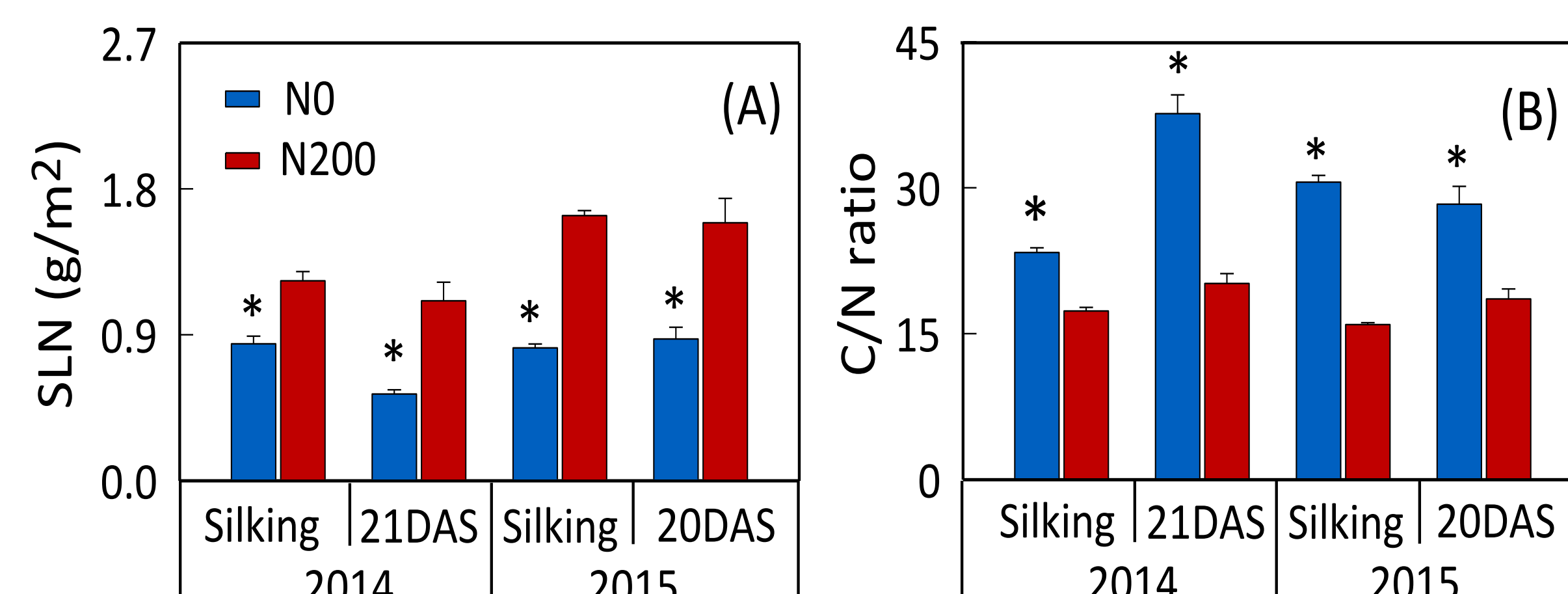


Fig. 1 SLN (A) and C/N ratio (B) in ear leaf. *, $P < 0.05$.

- Starch concentrations were higher in N-deficient ear leaves than those from N sufficient plants (Fig. 2A and B).

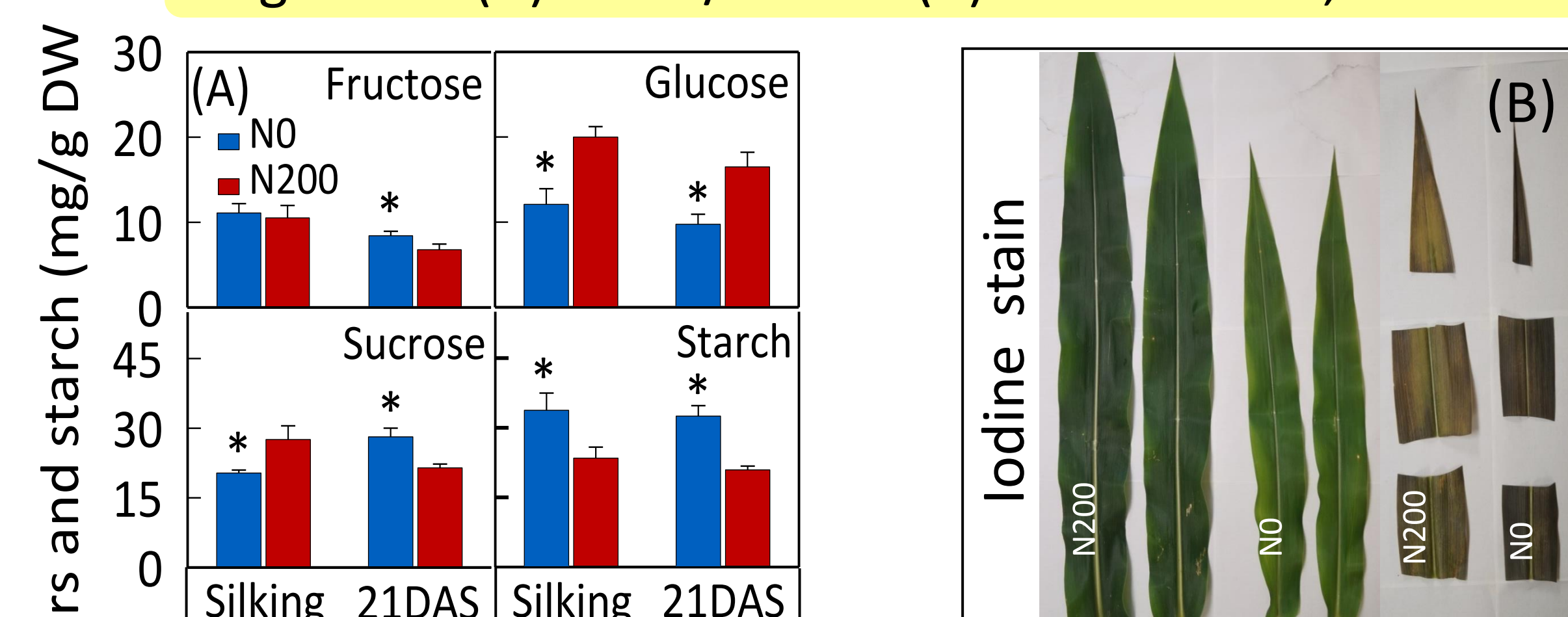


Fig. 2 Sugar and starch concentrations in ear leaf in 2014 (A) and Iodine stain (B). *, $P < 0.05$.

Results

- Normal appearing plasmodesmata of both N-deficient and N-sufficient ear leaves, lacking occlusions between mesophyll cells and bundle sheath cells, and between bundle sheath cells and vascular parenchyma cells (Fig. 3).

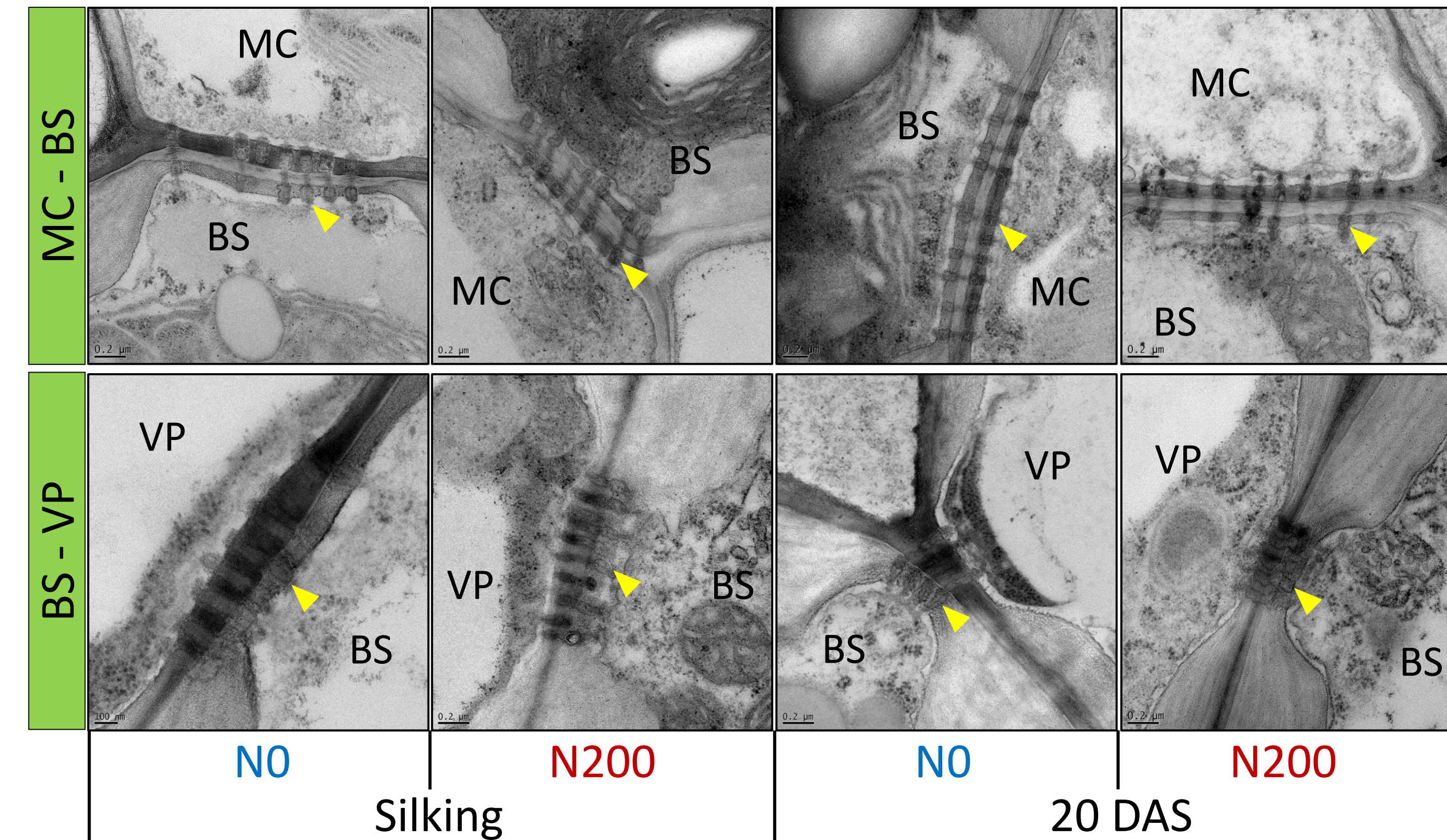


Fig. 3

TEM images of plasmodesmata appearance (arrows) at the MC and BS interface, and BS and VP interface in ear leaf tissues in 2015.

BS, bundle sheath; MC, mesophyll cell; VP, vascular parenchyma.

- N-deficient ear leaves had larger starch granules and more granules per chloroplast than those from N sufficient plants (Fig. 4 and 5).

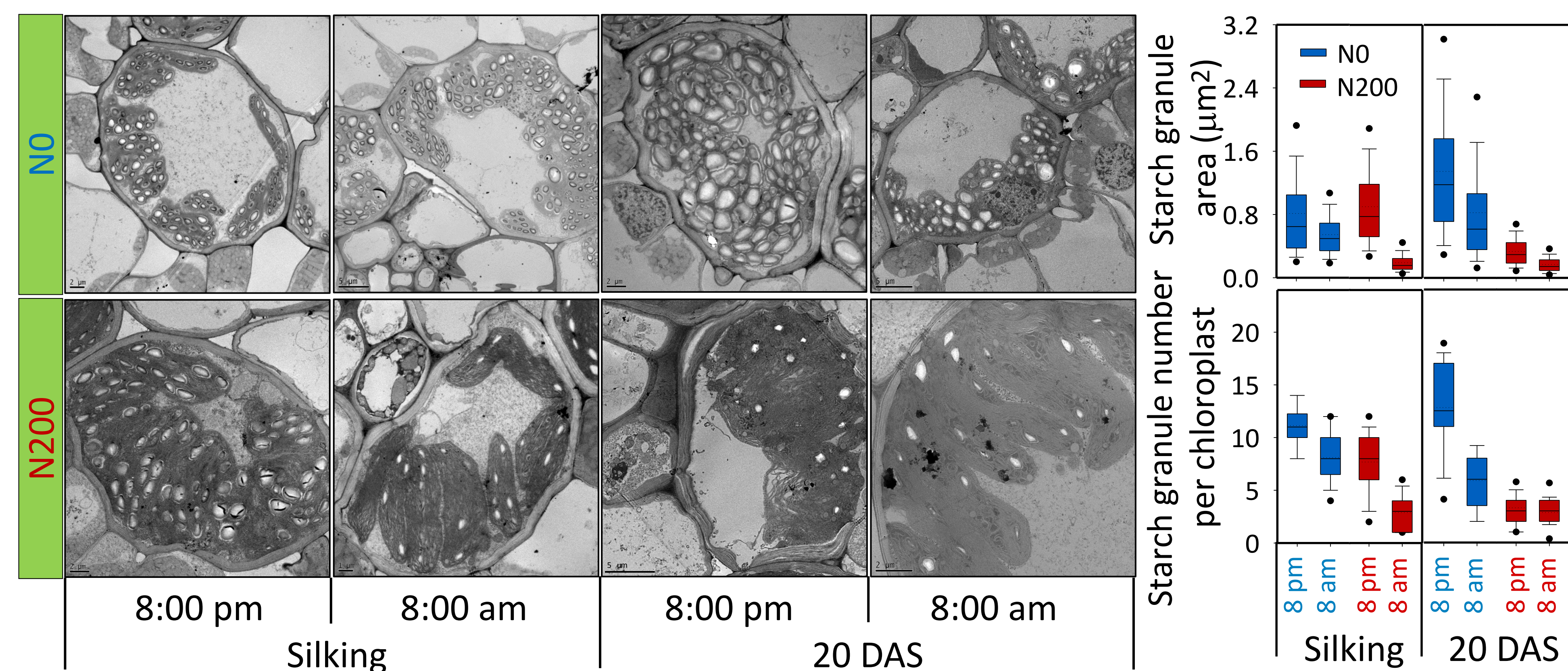


Fig. 4 The diurnal changes of starch granules appearance in the bundle sheath of ear leaf tissues in 2015. Leaf tissues were collected at 8 pm and 8 am at silking and 20 DAS.

Fig. 5 The diurnal changes of starch granules size and number in 2015.

Conclusions

- The lack of plasmodesmata occlusions indicates that the symplastic pathway of sugar export from leaves is open.
- Larger starch granule size and more granules per chloroplast in N-deficient leaves at least partially explained their higher starch concentrations.

References

- Peng, Y., Li, C., Fritschi, F.B. (2014). Diurnal dynamics of maize leaf photosynthesis and carbohydrate concentrations in response to differential N availability. *Environ. Exp. Bot.*, 99, 18-27.

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