Ovary abortion of maize under water deficit is linked to a developmental process and not to carbon deprivation

Vincent Oury1, Duyên Prodhomme2, Yves Gibon2, François Tardieu1 and Olivier Turc1

1INRA, UMR759, Laboratoire d'Ecophysiologie des Plantes sous Stress Environnementaux, F- 34060 Montpellier, France

2INRA, UMR619, UMR Biologie du fruit, F- 33883 Villenave d'Ornon, France

Context

Water deficit during flowering can lead to abortion of most ovaries along the ear1. This is generally explained in the literature by carbon deprivation of ovaries as the result of photosynthesis inhibition due to water deficit. However several papers mention sugar accumulation in reproductive organs of water stressed plants2, while others report no reduction in grain number with carbon deprivation due to shading3. To investigate the chronology of developmental and physiological events that lead to abortion, we have characterized the development and the metabolic content of ovaries of maize plants subjected to a moderate water deficit, which reduced but did not stop plant growth and photosynthesis.

Methods

1- A moderate water deficit around flowering, from tassel emergence to 5 days after silk emergence.

2- Three sampling stages during water deficit: husk emergence, silk emergence, and silk emergence+5d. A final harvest was done 15 d after silk emergence (i.e. 8 d after re-watering) to quantify grain set and ovary abortion.

3- Plants were cultivated in controlled conditions at LEPSE phenotyping platform PHENODYN, allowing control of soil water content and plant transpiration rate for each plant with a 15 mn time step: http://bioweb.supagro.inra.fr/phenodyn

4- Metabolic phenotyping was achieved with robotized high-throughput system of UMR Biologie du fruit: www.cgfb.u-bordeaux2.fr/en/metabolome/

A moderate water deficit

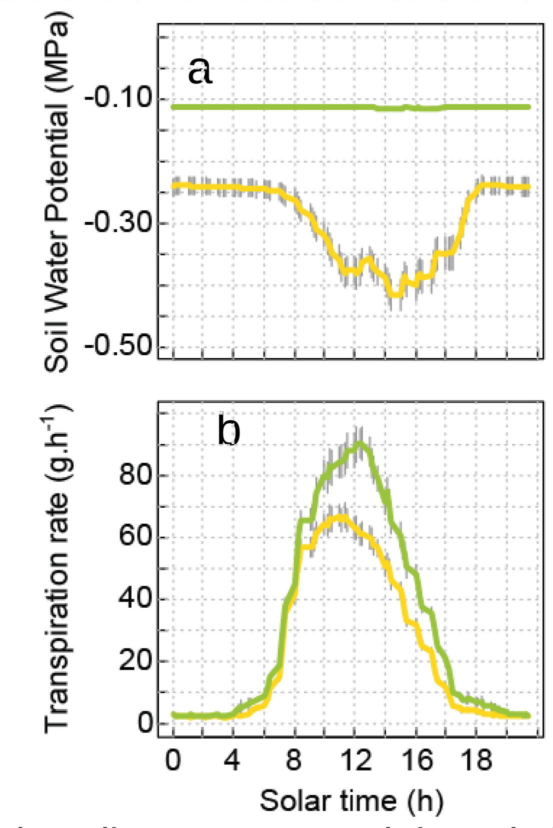


Fig.1: Kinetics of (a) soil water potential and (b) transpiration rate per plant on an average day during the period of water deficit (1 d after tassel emergence to 5 d after silk emergence). WW, well-watered plants; WD, plants in water deficit. Bars , 95% confidence intervals.

Results

Abortion affected apical ovaries

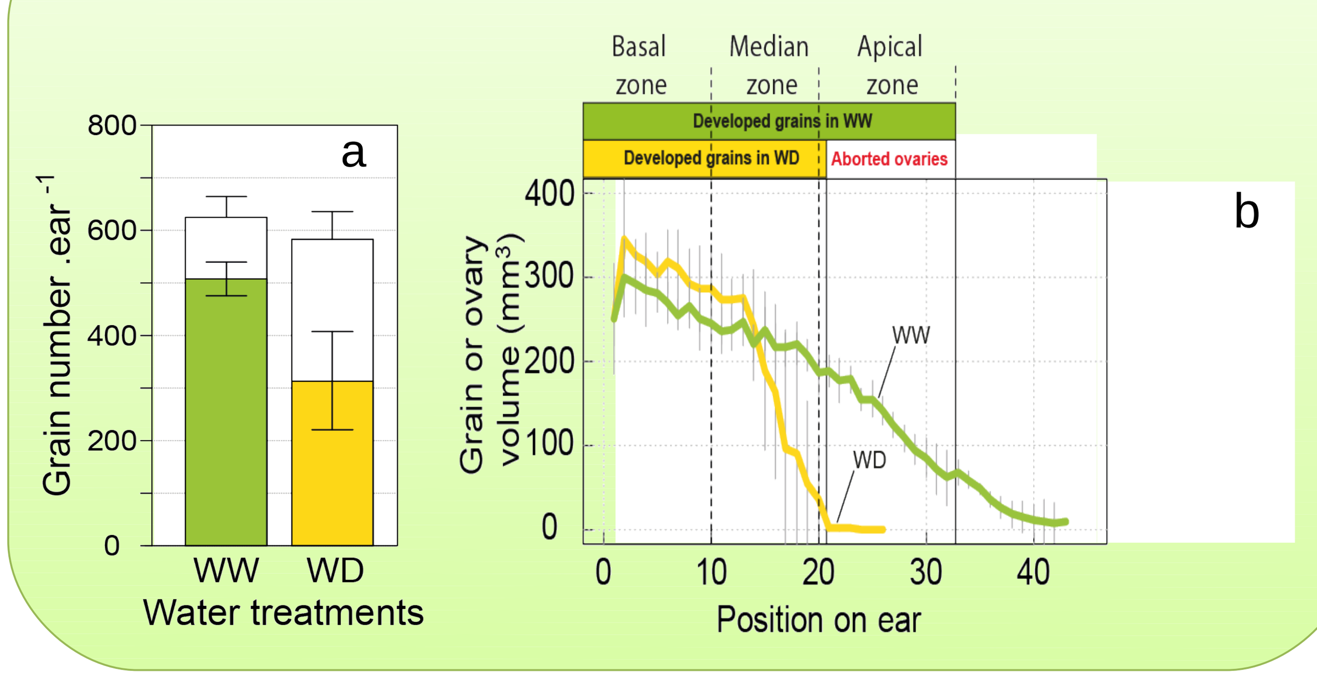


Fig.2: (a) Number of developed grains (colored bars) and aborted ovaries (white bars) per ear; and (b) grain and ovary volume according to their position along the ear 15 d after silk emergence. Basal, median and apical zones correspond to the portions of the ear used in metabolic analyses. WW, well-watered plants; WD, plants in water deficit. Bars, 90% confidence intervals. *n*≥3.

Silks were the first organs whose growth was limited by drought

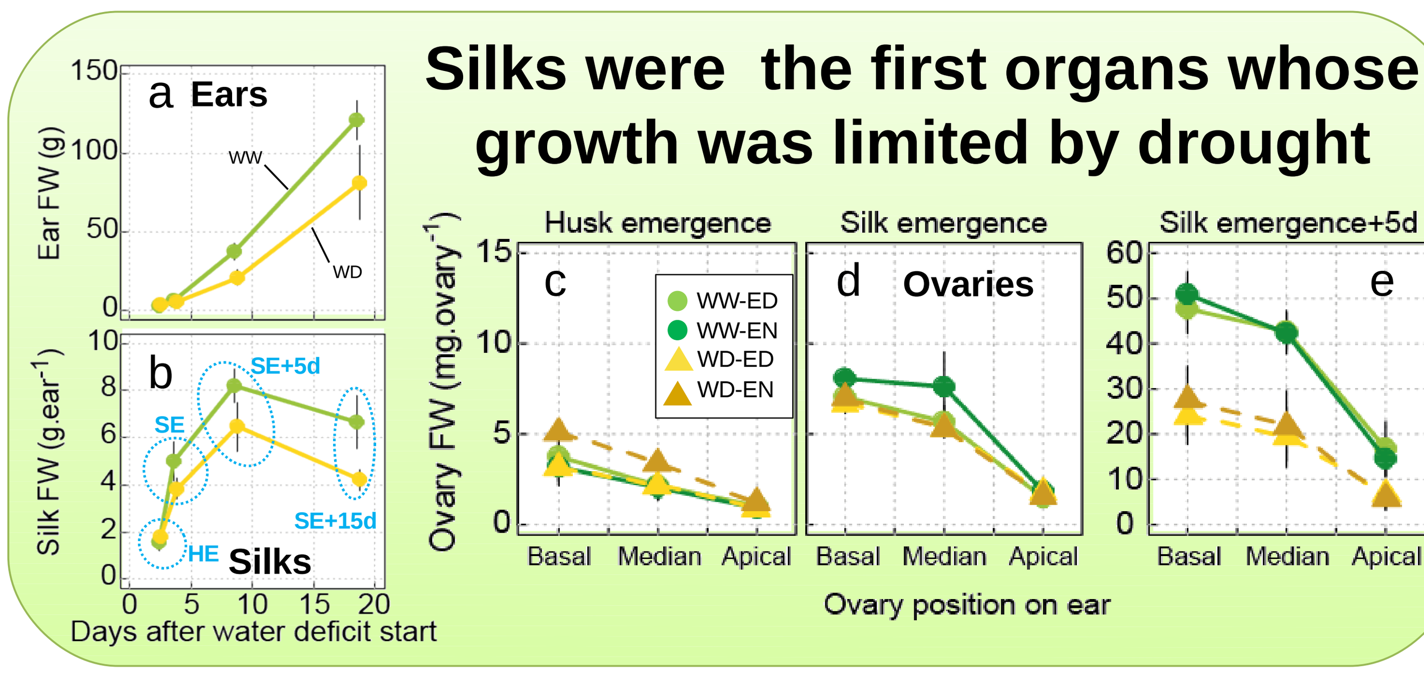


Fig.3: Fresh weight of (a) ear, (b) silks, and (c,d,e) ovaries as a function of water status, developmental stage, time of day, and position along the ear. WW, well-watered plants; WD, plants in water deficit. HE, husk emergence; SE, silk emergence. ED, end of day; EN, end of night. Bars, 90% confidence intervals. *n*≥3.

The C status of ovaries was unaffected

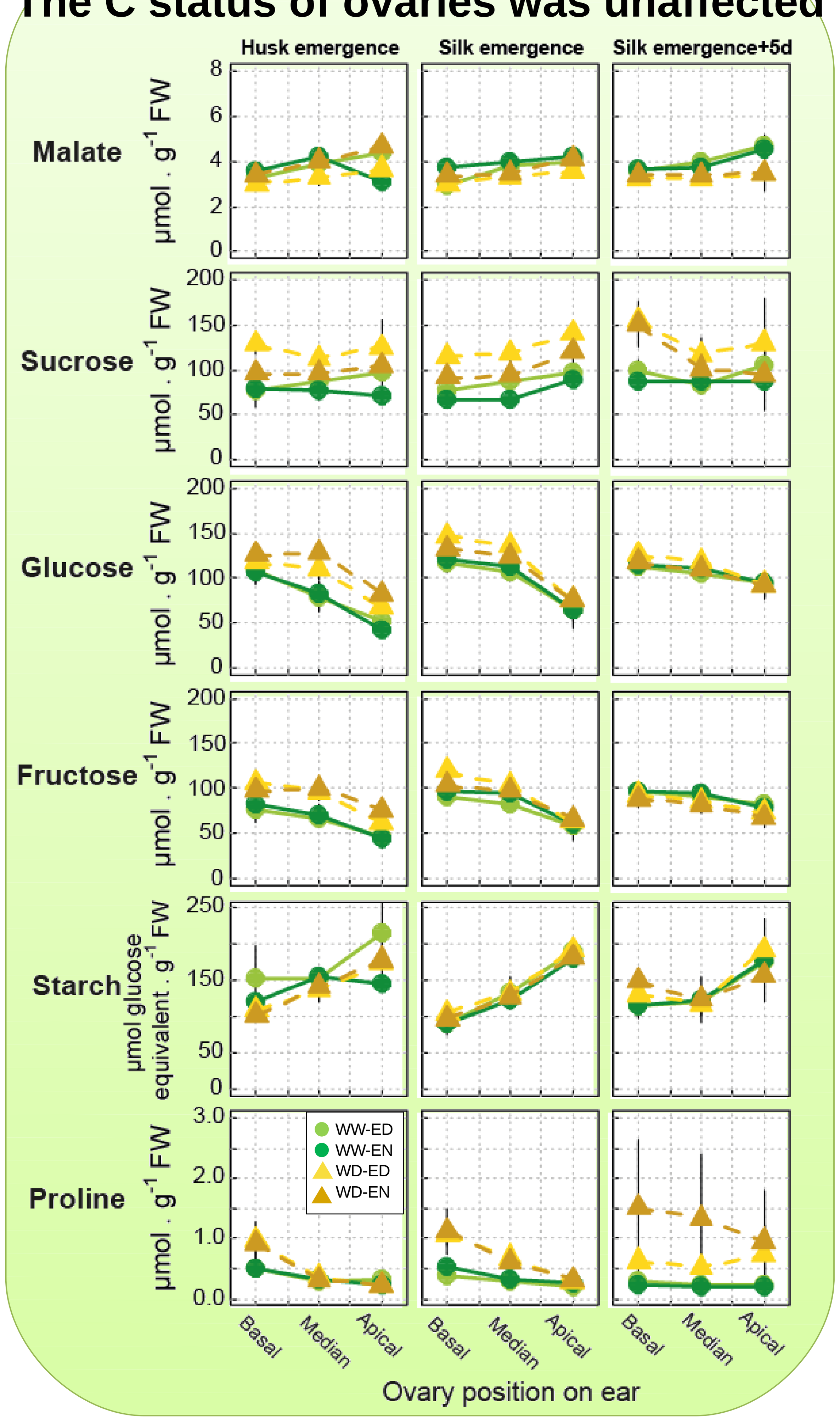
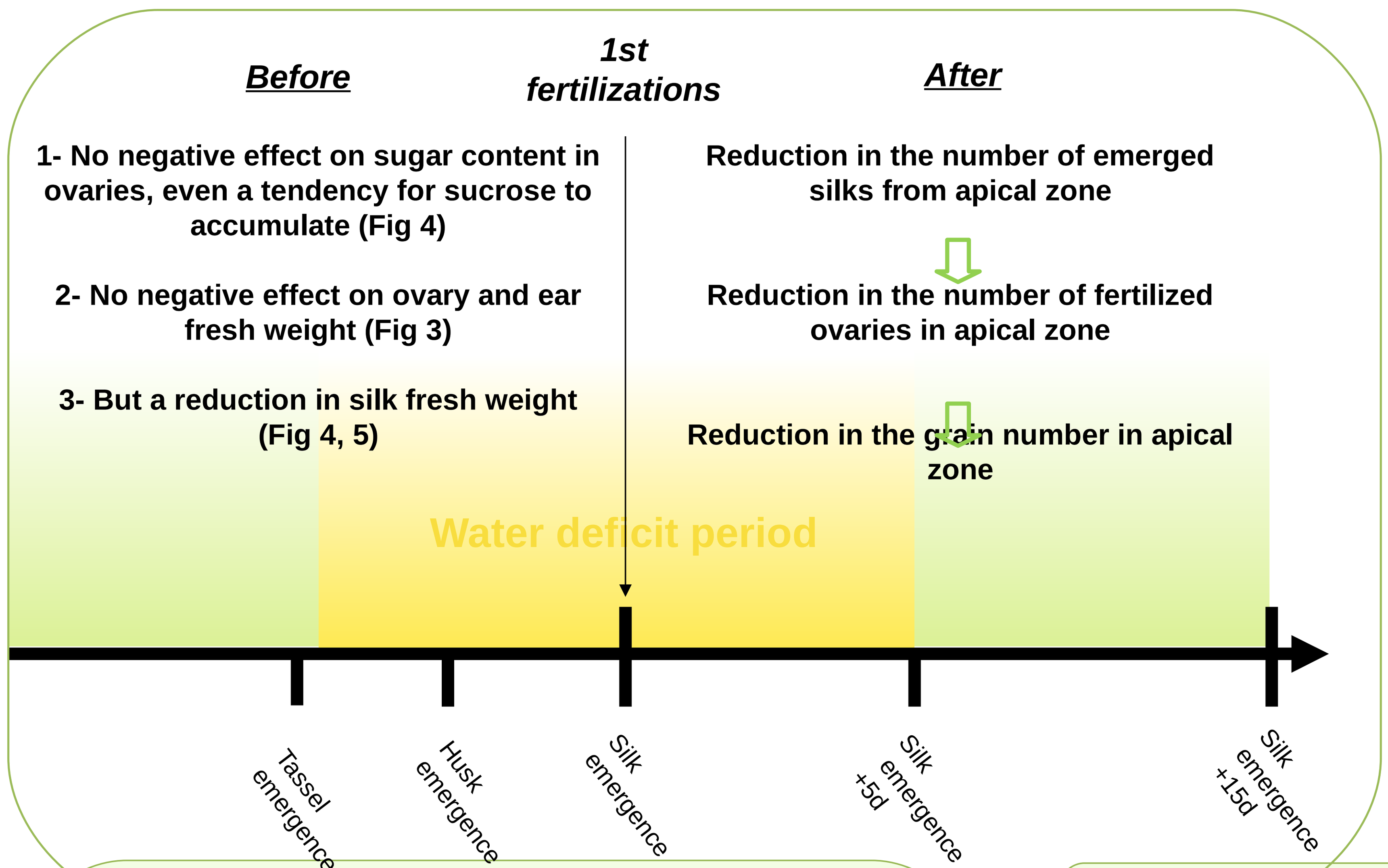
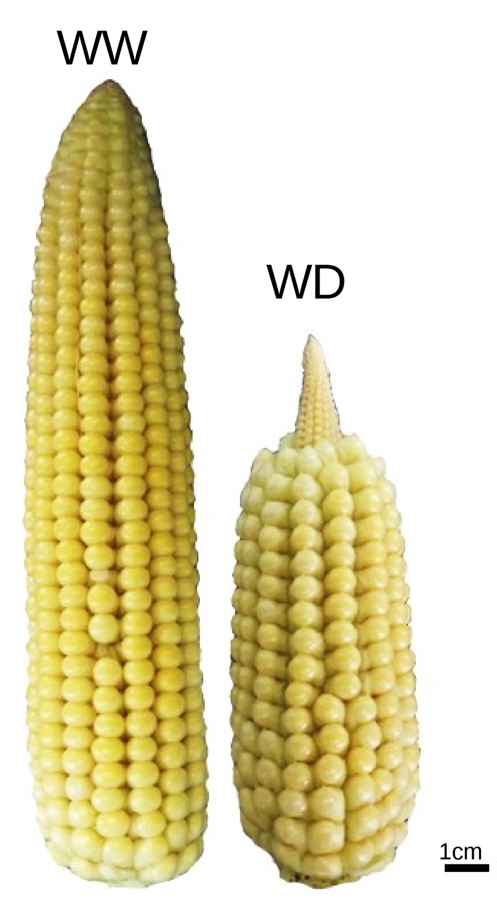


Fig.4: Ovary metabolite content as a function of water status, developmental stage, time of day, and position along the ear. WW, well-watered plants; WD, plants in water deficit. ED, end of day; EN, end of night. Bars, 90% confidence intervals. *n*≥3.





A central role for silk growth

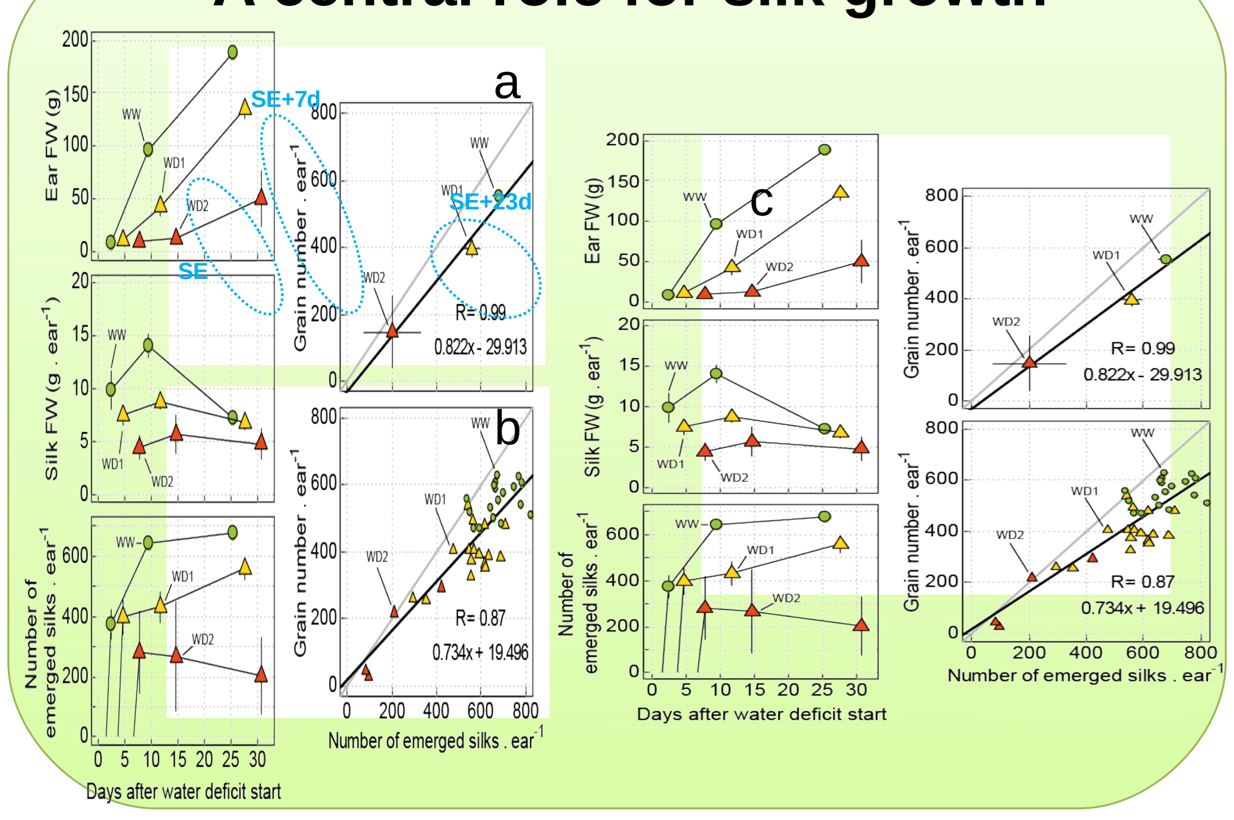


Fig.5: Effect of water deficit on (a) silk fresh weight per ear, and (b) number of emerged silks per ear, at different developmental stages. SE, silk emergence. Bars, 90% confidence intervals. *n*≥3. (c) Relationship between number of emerged silks and grain number. 1 point per plant. WW, well-watered plants; WD1 and WD2, plants resp. in moderate and severe water deficits.

Conclusion

Our results show that ovary abortion occurred in water deficit conditions without carbon deprivation in ovaries. Silks were the first organs affected by water deficit, before fertilization, due to the high sensitivity of silk elongation to drought4. As a consequence, water deficits reduced the number of emerged silks and therefore the number of potential grains. Hence, our results suggest a central role for hydraulic and developmental processes rather than a sugar signal.

We are currently analyzing the genetic variability of the processes presented here

1McLaughlin *et al.,* 2004. *Annals of Botany*, 94: 675–689.
2Muller *et al*., 2011. *Journal of Experimental Botany,* 62(6): 1715-1729.
3Hiyane et al., 2010. *Annals of Botany,* 106: 395–403.
4Fuad-Hassan et al., 2008. *Plant, Cell and Environment,* 31: 1349–1360.