LEAF-FALL

Does carbon allocation determine the timing of autumn leaf senescence in deciduous trees?

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INTRODUCTION

Autumn leaf senescence

- The **last developmental stage** of the leaf cells
- A highly regulated **form of programmed cell death** that, unlike aging, **leads to leaf death**

Functions

- **Nutrient recapture for:**
  - younger/more vital organs
  - completion of the life cycle
- **Stress resistance**
  - control over the access to valuable resources (N), necessary for spring
  - increasing photoprotective capacity
  - avoiding water loss (by transpiration)

Potential key environmental factors for leaf senescence onset and progression

- **Temperature**
- **Water**
- **Photoperiod**
- **Nutrients**

Questions?

1. Which **key environmental factors control** the onset and progression of leaf senescence?
2. Does **wood growth cessation** determine the timing of the onset of autumn leaf senescence?

METHODS

We expected that:

- in the absence of unfavourable growth conditions, tree growth cessation directly controls the onset of autumn leaf senescence.
- in the presence of unfavourable growth conditions, photoperiod controls the onset of autumn leaf senescence. This prevents trees from starting to senesce too early.

Since 2017, the **chlorophyll content index (CCI)** was measured and the **loss of canopy greenness** was estimated for:

- multiple mature *Fagus sylvatica*, *Betula pendula*, *Quercus robur* and *Populus tremula* trees in multiple stands in Belgium, Spain and Norway. The observations were done during summer and autumn.
- several *Fagus sylvatica*, *Betula pendula*, *Quercus robur* and *Populus tremula* saplings in pot-experiments, in greenhouses, glasshouses and outside plots. These pot-experiments tested the effect of droughts and fertilization on autumn leaf senescence.

Since 2017, **microcores** were taken from all these trees to investigate the timing of the wood cessation (i.e. the xylogenesis).

RESULTS

Preliminary evidence suggest:

- a **fixed onset** of Autumn senescence, showing that **light related variables (e.g. photoperiod)**, rather than drought stress, is the **main cue for Autumn leaf senescence** in both young and mature trees (Fig. 1, panel A).
- **Recent droughts** (e.g. 2018) in Belgium had a **big effect on tree and leaf mortality**, rather than the timing of autumn leaf senescence (Fig. 1, panel B).

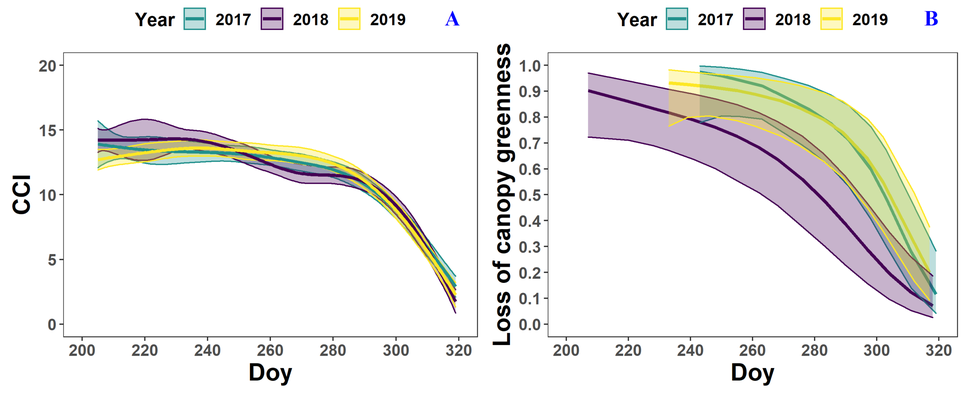
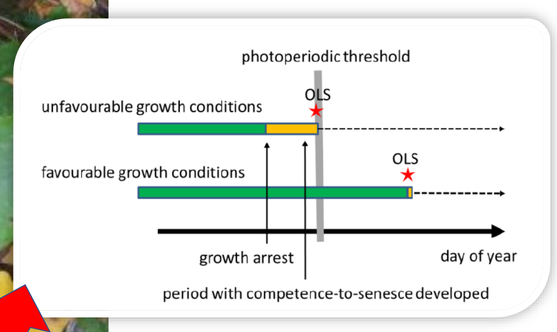


Fig. 1: Generalized additive mixed model fits for the chlorophyll content index (CCI; n = 8; panel A) and loss of canopy greenness (n = 16; panel B) of the mature *Fagus sylvatica* trees at the Klein Schietveld and Park of Brasschaat. The colored solid lines represent smooth terms, while the colored shaded bands around the smooth terms represent approximate 95% simultaneous confidence intervals (panel A) and 95% pointwise confidence intervals (panel B). The colors represent the CCI or the loss of canopy greenness of the mature beech trees in 2017 (green), 2018 (purple) and 2019 (yellow).

- that a **summer drought influences the xylem development** later on in the season in temperate deciduous trees but not as pronounced in every species.
- suggests that the onset of autumn leaf senescence is generally triggered **by the same drivers** as the timing of the cessation of the wood growth. However, **some processes** (e.g. tissue lignification, coarse root growth) **slowly continue during winter** fueled by carbohydrate reserves.



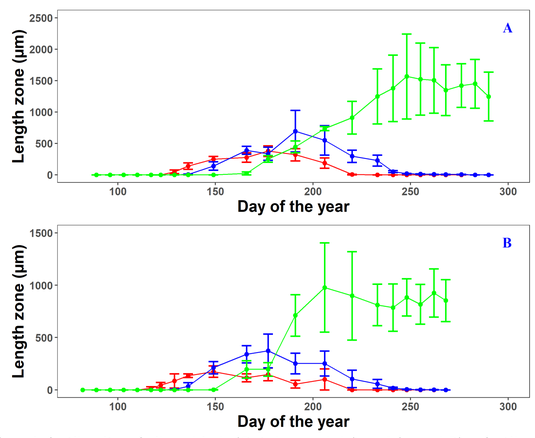


Fig. 2: Seasonal development of wood formation at (panel A) an infertile site of silver birch (*Betula pendula*) and (panel B) a fertile site of beech (*Fagus sylvatica*) in Belgium 2018, with the width of the current forming ring section with enlarging cells (enlarging zone) in red, with thickening cells (wall thickening zone) in blue and with mature cells (mature zone) in green. Points are means (n=4) and the associated error bars represent the standard errors of the means. Dox et al. 2020. Timeline of autumn phenology in temperate deciduous trees. *Tree Physiology*. doi:10.1093/treephys/tpaa058 (in press).

DISCUSSION & CONCLUSION

We found **little difference in the timing of the onset of autumn leaf senescence** (i.e. the CCI decline) between trees in favourable and unfavourable conditions.

- Therefore, **Light related variables** serve likely as **main cue** for Autumn leaf senescence.

Drought stress did affect the **tree and leaf mortality** (i.e. the loss of canopy greenness decline).

The timing of **below- and aboveground wood growth cessation** is different.

References

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