Blue light and UV radiation accelerate spring and autumn leaf phenology in temperate tree species

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Blue light and UV effects on spring and autumn phenology in temperate tree species

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Understanding phenology

Rising global temperatures and light pollution are advancing the date of spring bud burst and delaying the onset of autumn leaf senescence in temperate tree species.

However, there is uncertainty in phenological models attempting to predict how the phenology of trees will respond.

It is vital that we account for all of the mechanisms involved, and identify all the cues that trees use to time their annual life cycle.

Light Cues for Photoreceptors

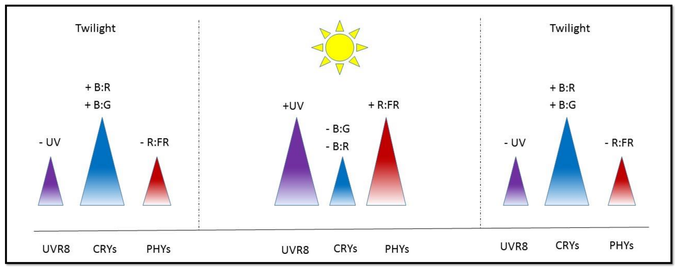


Figure 2: The composition of red: far-red light (R:FR), blue: green light (B:G), blue: red light (B:R) and UV radiation reaching the forest varies with time of day and year, as well as with latitude. In this sense it can be utilised by plants as a seasonal cue.

Plants are able to detect changes in blue light via cryptochrome photoreceptors (CRYs) , R:FR light via phytochrome photoreceptors (PHYs), and UV radiation via UVR8.

R:FR has been shown to affect spring and autumn phenology in tree species, **but what about blue light and UV radiation**?

Spring in the Lab: Methods

Figure 2: We collected dormant branches from *Alder glutinosa*, *Betula pendula* and *Quercus robur* in southern Finland.

These were then placed in containers with water, and kept in chambers of equal temperature and equal PAR full spectrum light. 3 chambers contained blue light, and 3 had blue light filtered out.

We used a 12 hour photoperiod to simulate early spring day length in southern Finland.

The number of days, and the degree-days (accumulated daily mean >0C˚) until 50% bud burst for each species in each chamber was recorded.

Spring in the Lab: Results

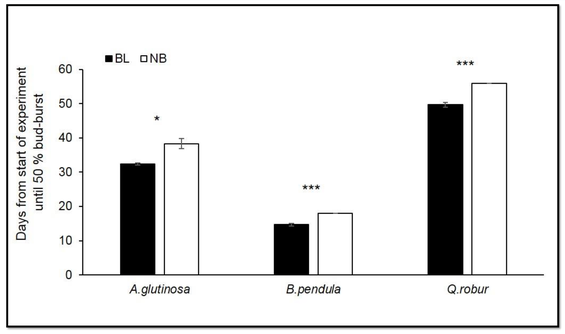
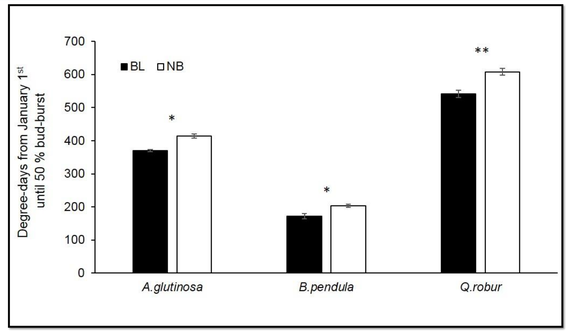


Figure 3: The number of days (A) or degree days >0°C (B) until 50% bud burst in three temperate tree species. Mean ±1 SE from 3 replicate chambers, each with 15 branches per species.

Blue light advanced bud burst in all species: in *B.pendula* by 3 days, in *A.glutinosa* by 6 days, and in *Q.robur* by 6.3 days.



The difference in terms of accumulated degree-days followed a similar pattern. Interestingly, blue light had the greater effect on late successional *A.glutinosa* and *Q.robur*. This may be due to the fact that bud burst in early successional species is predominantly affected by temperature.

Spring in the Forest: Methods

To test the effect of natural solar blue light and UV radiation on spring and autumn leaf phenology, we planted seedlings of *Acer platanoides* under different light filters in forest understoreys in southern Finland.

We used filters that attenuated four difference regions of the spectrum, which were:

1) **Control** filter which was transparent to all wavelengths,

2) **350nm** filter which attenuated that UV radiation below 350 nm

3) **No UV** filter which attenuated all of UV (400 nm)

4) **No Blue No UV** filter (shown right), which attenuated all blue light and UV radiation. (??? nm)

Since 2015, we have been monitoring the bud burst in spring and leaf senescence in autumn of over 120 *A.platanoides* seedlings under these filters.

Spring in the Forest: Results

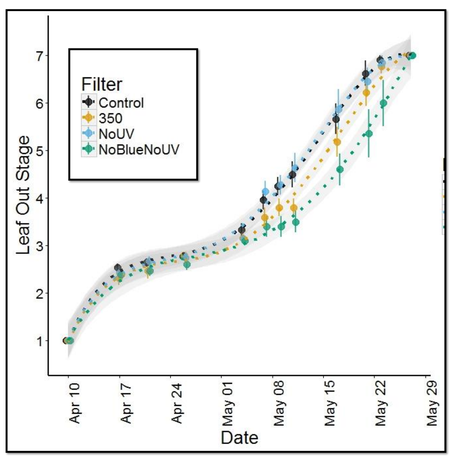


Figure 4: Leaf out stage for seedlings *of A.platanoides* grown under different light filters in a forest understorey. Means ±1SE for stage at which 50% bud burst occurred for 12 replicate plots.

- ~~We recorded leaf out stage on a scale of 1-7 whereby 1= dormant bud, 4= bud burst, and 7 = full expanded leaf.~~
- Filtering UV radiation below 350nm, and filtering total UV radiation had little effect on bud burst.
- When blue light was filtered out bud burst and subsequent leaf out was delayed in *A.platanoides* seedlings.
- This agrees with our lab findings under natural conditions!

Autumn in the Forest: Results

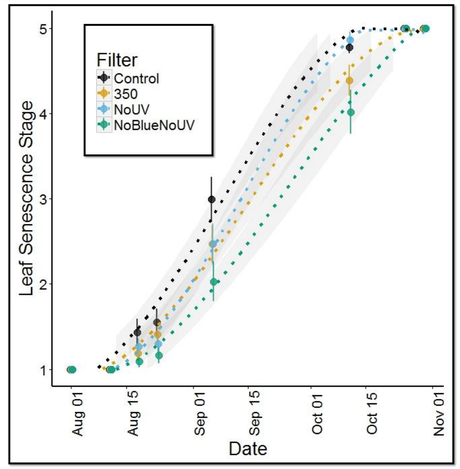


Figure 5: Leaf senescence stage for *A.platanoides* seedlings grown under different light filters in forest understoreys. Means ±1SE for date at which 50% seedlings reached that leaf out stage for 15 replicate plots.

Filtering out UV radiation below 350nm and filtering out total UV radiation delayed leaf senescence

Filtering our blue light delayed leaf senescence the most - by 15 days! But cannot prevent it from happening.

Conclusions

- The presence of blue light advances bud burst – both in the lab and in the field
- Blue light had a greater effect on the bud burst of later successional species
- Blue light and UV radiation both advance leaf senescence of *A.platanoides* in autumn
- Blue light has a greater effect on leaf senescence in A.platanoides, advancing final leaf senescence by 15 days!

Future Research

- Is the effect of BL on bud burst related to the diurnal change in the composition of blue light, and used as a seasonal cue as day length increases?
- Blue light has also been shown to increase photosynthesis, could it be a cue for sunny conditions which are favourable for bud burst and thus early photosynthesis in spring?
- How does BL and UV advance leaf senescence in autumn? Does the change in BL and UV provide seasonal cues? What are the signalling pathways?
- BL and UV radiation are more damaging to leaves in comparison to longer wavelengths of light – do they increase leaf senescence through damage to leaves over the growing season?

References

Acknowledgements