Seasonal growth of the dominant alpine sedge *Carex curvula* is controlled by internal signals

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Background

Temperate alpine grassland is adapted to a short growing season of a few months, constrained by cold temperature and snow cover. Ongoing climate warming has advanced snowmelt and confronts alpine plants with a longer growing season. This may prolong and enhance plant growth above- or belowground. Here, we assessed whether *Carex curvula* (the dominant alpine species on acidic soils in the Alps) is capable to sustain growth and/or delay senescence when the season length is artificially prolonged by two to four months. Along with aboveground activity, we also studied whether roots will continue growing as long as environmental conditions allow to.

Objective

This study aims at assessing whether alpine grassland sustains growth or delays senescence when the growing season is prolonged.

Conclusions

1) Growth and senescence of *C. curvula* follows an internal signal, independent of growing season length.
2) However, senescence was slowed under sustained summer conditions.
3) Peak root growth occurred within the first two months, independent of season length.

Results and Discussion

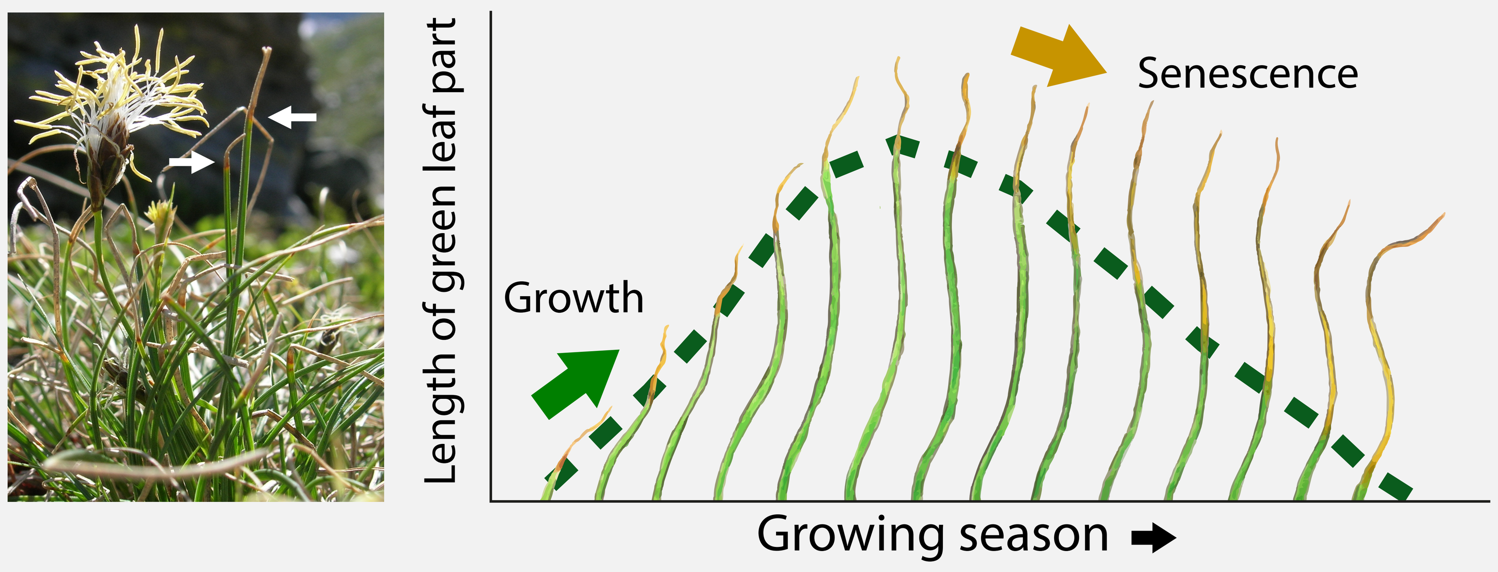

Figure 1 Left: *C. curvula* after senescence started. White arrows show retraction progress. **Right:** Expansion and retraction of the green leaf part of *C. curvula* are a proxy for growth and senescence over one growing season. *C. curvula* produces 1–2 leaves per year, which get several years old and expand/retract every season.

The growing season lasted 222, 159 and 90 days for the three groups (blue, red, black, respectively). Senescence of *C. curvula* started 55, 53 and 40 days after the start of the season, even in absence of an environmental trigger (blue, red, Fig. 2). Leaf retraction was slower when the season was longer, taking 54 and 53 days to retract half of the leaf compared to 36 days for the *in situ* season. Hence, green leaf fraction was below 50% during 51%, 33% and 16% of the total season length.

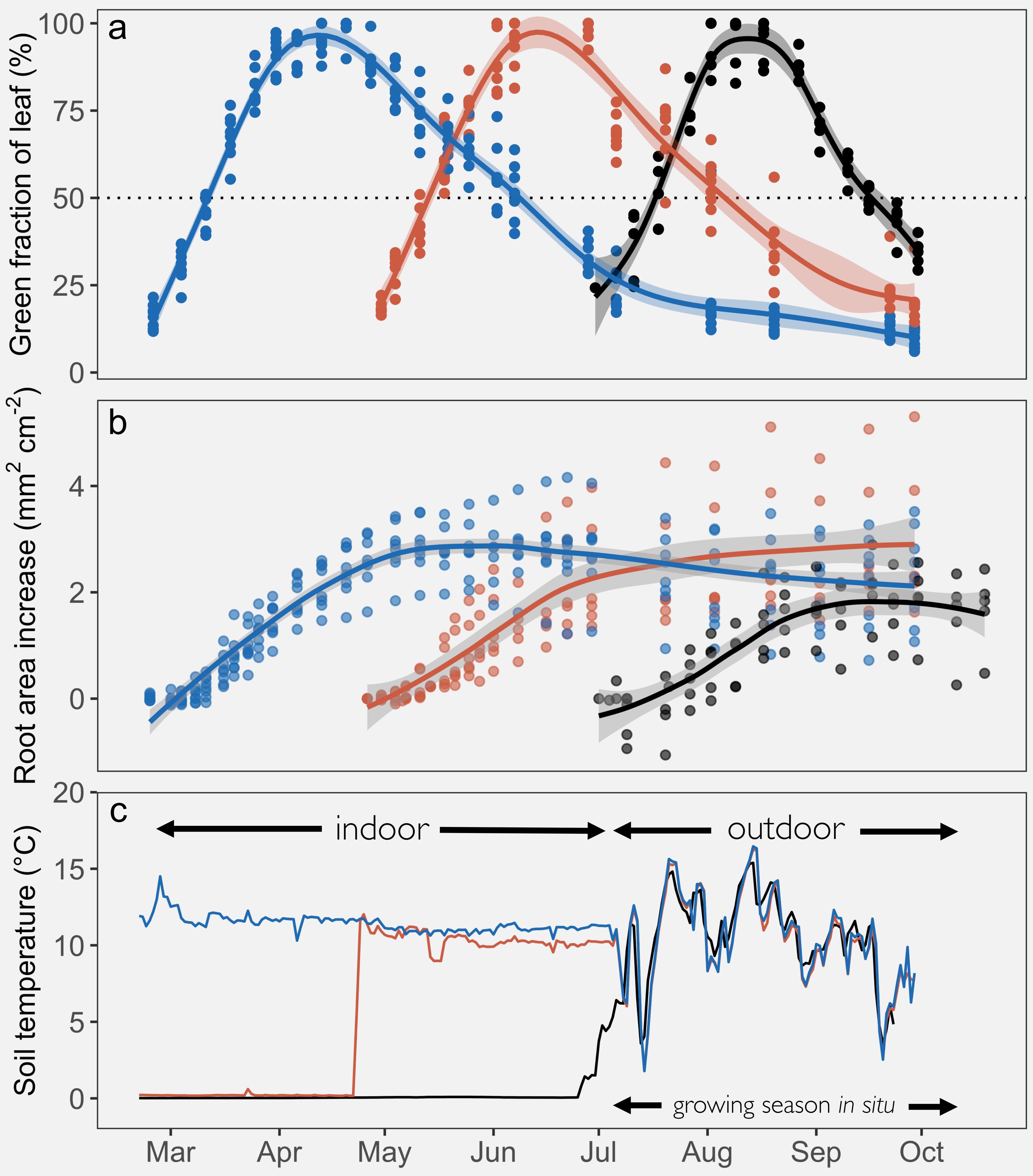

Figure 2
a) Seasonal pattern of the green part of *C. curvula* leaves for three groups with different season start. Black = vegetation growing *in situ*. A loess smoothed curve was fitted (±SE) in a and b.

b) Seasonal pattern of root growth of the entire grassland community. Root area is expressed as root area per soil surface in the scanned image.

c) Daily mean soil temperature during the experiment. Diurnal temperature patterns were provided in the climate chambers, but are not visible in this figure. Snow covered plants experience 0 °C.

Root growth peaked during the first half of the season, independent of season length (Fig. 2b). Accordingly, 80% of total root growth was reached already after 65, 78 and 61 days for the earliest, middle and *in situ* season start. Our data indicate that growth and senescence of the dominant species *C. curvula* are strongly controlled by internal signals that are tuned to the naturally occurring growing season length.

Materials and Methods

Sixteen vegetation patches in buckets (monoliths) of alpine grassland were overwintered in a cold and dark room. Premature summer conditions were induced in climate chambers (Fig. 3a), starting in February (n = 8) and April (n = 8), while naturally growing vegetation experienced snowmelt in early July (n = 5 plots, Fig. 3c). Growth and senescence was quantified in *C. curvula* by measuring the length of the green part of individual leaves (Fig. 1). Roots of the plant community were scanned using rhizotrons. Images (Fig. 3d) were analysed with automated root-soil segmentation (machine learning).

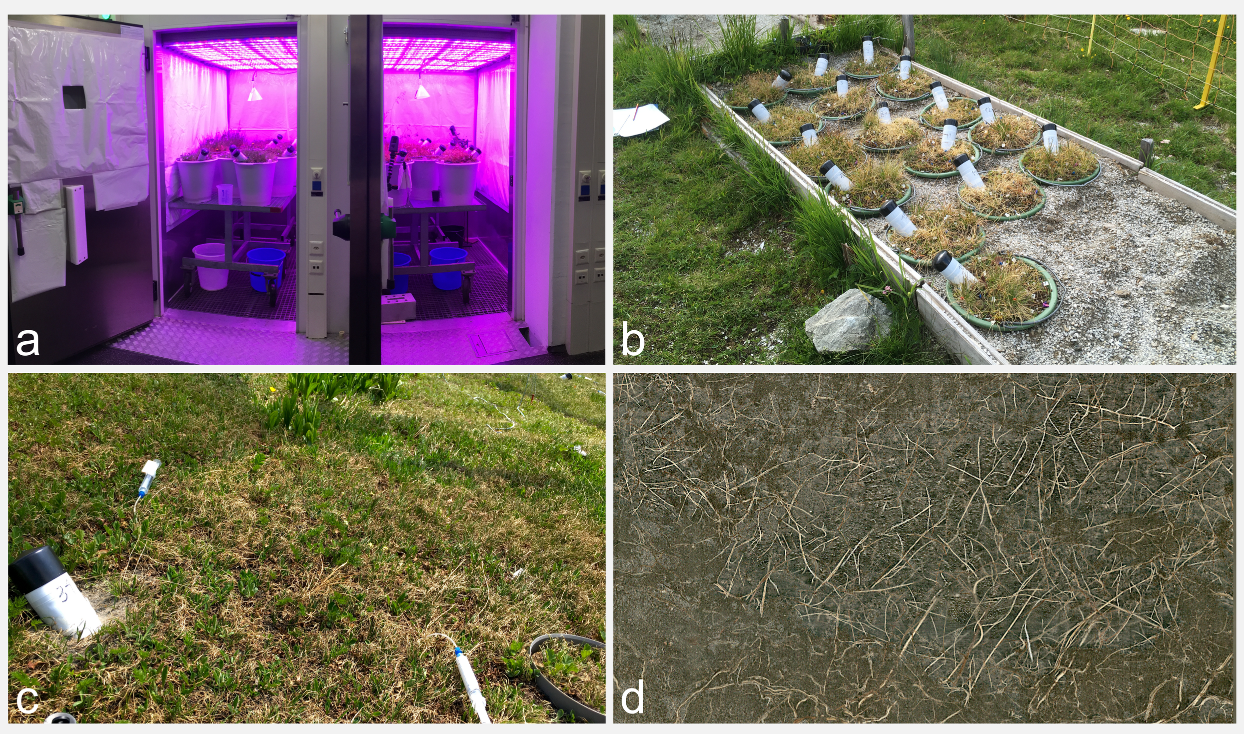

Figure 3
a) Monoliths of alpine grassland exposed to premature summer conditions in climate chambers.
b) Monoliths at the alpine site during actual summer.
c) Control vegetation plot with a rhizotron tube embedded in the soil.
d) Root image scanned through a transparent rhizotron tube in one of the monoliths.

References
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Photo Fig. 1: C. Körner

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