13C allocated to the leaf growth zone of *Poa pratensis* reflects soil water and vapor pressure deficit

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**Introduction**

Water stress affects the relationship between stomatal conductance and photosynthetic capacity and modifies discrimination (\( \Delta \)) of the herbivorous food plant, which integrates over the mosaic of soils, and on a larger temporal scale, because daily fluctuations in VPD level out while the effects of the slowly changing SWC accumulate. This agrees with the finding by Schnyder et al. (2006) that the influence of SWC was independent from VPD, although at low VPD also SWC usually had a smaller range than at high VPD (the standard deviation of SWC was 175 mm at VPD = 0.5 kPa, while it was 105 mm at VPD = 1.2 kPa). The regressions were shifted between months, but, interestingly, the slope of \( \Delta \) towards SWC did not differ with month (different VPD). This indicated that the influence of SWC was independent from VPD, although at low VPD also SWC usually had a smaller range than at high VPD (the standard deviation of SWC was 175 mm at VPD = 0.5 kPa, while it was 105 mm at VPD = 1.2 kPa). The influence of SWC was sub-proportional (logarithmic) indicating that an increase in water supply had a stronger effect if the initial SWC was low than on an initially wet soil. Furthermore, the influence of SWC seemed to be smaller (\( r^2 = 0.18 \), \( P < 0.05 \)) than that of VPD (\( r^2 = 0.48 \), \( P < 0.001 \)) that although VPD differed only by a factor of three, while SWC differed by two orders of magnitude. The regression of the SWC was more pronounced at high VPD than at low VPD (the standard deviation of SWC was 175 mm at VPD = 0.5 kPa, while it was 105 mm at VPD = 1.2 kPa). The increased importance of SWC seemed to be smaller (\( r^2 = 0.18 \), \( P < 0.05 \)) than that of VPD (\( r^2 = 0.48 \), \( P < 0.001 \)).

In consequence, the influence of SWC must become more important on a larger spatial scale, which integrates over the mosaic of soils, and on a larger temporal scale, because daily fluctuations in VPD level out while the effects of the slowly changing SWC accumulate. This agrees with the finding by Schnyder et al. (2006) that the variation in discrimination between pastures and years was closely related to the variation in SWC on the pasture scale.

**Results & Discussion**

The air temperature at the time of sampling varied between 10 and 25 °C, VPD varied between 0.5 and 1.2 kPa. SWC varied between 15 and 500 mm between sites and dates while plant available water differed between 10 and >200 mm.

**Materials & Methods**

At the Grünschwaige Grassland Research Station, situated at the north end of the Munich Gravel Plain, Germany (435 m a.s.l.), the LGZ (lower half between the last nodium and the ligule) of *Poa pratensis* was sampled three times (early spring to mid summer) at 10-11 sites differing in soil water capacity to cover wide ranges in SWC and VPD. Volumetric SWC was determined by taking soil cores of the peat soil. The soils were well drained peat soils overlaying gravel, which provided a wide range of rooting depths that were well defined due to a sharp discontinuity between peat and gravel. Other soil properties and grazing conditions were similar.

Here, we tested the hypothesis that the LGZ is a high-resolution recorder of water stress. We use this to quantify the influence of VPD and SWC within a wide range in natural conditions. To do this, we took advantage of fully drained peat soils overlaying gravel, which provided a wide range of rooting depths that were well defined due to a sharp discontinuity between peat and gravel. Other soil properties and grazing conditions were similar. The δ13C of the LGZ was measured and \( \Delta \) was calculated by taking into account the seasonal variation of δ13C in air CO2 following Wittmer et al. (2008).

**Conclusions**

The leaf growth zone recorded the relationship between stomatal conductance and photosynthetic capacity as influenced by water stress with high temporal resolution. In this study, atmospheric vapor pressure deficit had a stronger effect than soil water content. Together both drivers changed CO2 concentration in the intercellular space by 35%.

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**References**


