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Light-inhibition of respiration affects GPP of herbaceous vegetation

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Gross primary production (GPP), the total amount of carbon fixed by plants *via* photosynthesis, is the largest CO_2 flux in terrestrial ecosystems and impacts global carbon budgets. Yet, quantification of GPP is methodologically challenging, and the estimation of global GPP, ranging from 100 to 150 pg C y^{-1}, is associated with a high uncertainty. Using gas exchange approaches (eddy flux tower or mesocosm facilities) net primary production (NPP) and plant (or ecosystem) respiration in the dark (R_{dark}) can be measured, but the determination of GPP also requires estimates of plant (or ecosystem) respiration in the light (R_{light}). R_{light} is routinely assumed to be equal to the measured R_{dark} at the same temperature at both leaf- and canopy-scale, and termed the 'standard partitioning approach'. This approach does not consider inhibition of plant respiration by light (also known as the Kok effect), and thus overestimates GPP.

GPP and R_{light} of plant stands, can be partitioned with an isotopic disequilibrium method (that is $^{13}CO_2$/$^{12}CO_2$labelling). Using this method, we studied GPP and R_{light}/R_{dark} in a total of 28 monocultures of three herbaceous species, *Cleistogenes squarrosa* (a wild perennial C_4 grass), *Lolium perenne* (a cultivated perennial C_3 grass) and *Helianthus annuus* (a cultivated annual C_3 dicot), growing in a diverse set of environmental conditions, including different CO_2 concentrations, N nutrition, irradiance, day length and vapour pressure deficit, using mesocosm-scale gas exchange facilities with continuous measurements of $^{13}CO_2$/$^{12}CO_2$ exchange.

Our results confirm that the standard partitioning approach overestimates GPP. As expected, the magnitude of the error depends on the degree of inhibition of stand-scale respiration by light. Almost all plant stands showed a significant inhibition of respiration by light, with a clear difference between the C_4 and the C_3 species: $R_{light}/R_{dark}$of *C. squarrosa* (C_4) was significantly lower than that of the C_3 species. This effect must have been related to the CO_2 concentrating mechanism of C_4 photosynthesis that enables much higher refixation of respired CO_2. These results are directly relevant for modelling and predicting land-atmosphere CO_2 exchange of grass dominated biomes.