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Reliable estimation of parameters of the Farquhar-Von Caemmer-Berry Biochemical model cannot be obtained by fitting A_n/C_i curves

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Highlights: Because of the limited accuracy and limited number of data points of an A_n/C_i curve, the parameters of the Farquhar-von Caemmerer-Berry photosynthesis model cannot be reliably estimated by analysis of A_n/C_i datasets with the data measured from currently available commercial gas exhange device. However , the fitted parameters remains useful to predict photosynthesis.

Keywords: FvCB model, prameters, fitting, A_n/C_i curve,

The Farquhar-von Caemmerer-Berry (FvCB) leaf photosynthesis model for C_3 plants (Farquhar et al, 1980) has been widely used to simulate CO_2 assimilation and the response of plant to climate change from leaf to canopy scales due to its solid theoretical basis and simplicity. The fitting methods can be divided into two types: type I method fits parameters with the original FvCB model (Sharkey et al. 2007). Type II fits parameters with the quadratic equation (Gu et al., 2010). Each method relies on different assumptions and has technical limitations. Depending on the methods used, the estimated parameters can be substantially different. To the best of our knowledge, there is no publication on testing the fitting methods with generated ideal data sets and data sets superimposed by possible measurement errors, an essential step for fully evaluating the fitting methods because the true parameter values are known and the A_n/C_i curves can be stimulated under all possible conditions. The objectives are to verify the reliability of parameterization approaches for fitting A_n/C_i curves by three approaches. One was from type I, a commonly used method of Sharkey et al. (2007); the second is from type II methods, which have been stated to overcome some major issues of extant methods (Gu et al., 2010); and the third is the analytical method that assumes the errors in A_n/C_i data are negligible.

Two groups of data sets with different accuracies are generated for examining the reliability of three different methods. One group of datasets are generated with 15 data points with three different fixed accuracies: (1) data with high accuracy of 9 decimal places (DSH-15); (2) data with the same accuracy of the currently available commercial gas exchange device (DSL-15) without measurement error; (3) data with the same accuracy of the currently available commercial gas exchange device and with measurement error imposed (DSE-15). Another group of datasets are generated with either varied accuracy or varied number of data points.

All three methods cannot estimate reliable parameters of the FvCB model by analyzing A_n/C_i curves with the same accuracy of the measured data produced from the currently available commercial gas exchange device. The method of Sharkey et al. (2007) cannot obtain accurate parameters even with highly accurate datasets because one equation used is theoretically incorrect and has unrealistic assumptions. Analytical methods and the method of Gu et al. (2010) can estimate reliable parameters from highly accurate datasets with enough data points. However, the resulting fitted parameter set by methods of Sharkey et al. (2007) and Gu et al. (2010) remains useful to predict A_n under the same conditions under which the A_n/C_i curves were derived.

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