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Bryophyte acclimation to sun conditions is influenced by both photosynthetic and ultraviolet radiations

Encarnación Núñez-Olivera[1], Gonzalo Soriano[1], María-Ángeles Del-Castillo-Alonso[1], Laura Monforte[1], Javier Martínez-Abaigar[1]

[1] Facultad de Ciencia y Tecnología, Universidad de La Rioja, 26005 Logroño (La Rioja), Spain (encarnacion.nunez@unirioja.es)

We studied the acclimation of bryophytes to sun and shade under ambient conditions, measuring variables usually influenced by photosynthetically active (PAR) and ultraviolet (UV) radiations. Our aim was to elucidate to what extent the responses to changing radiation were influenced by PAR and UV wavelengths. For this aim, we used three taxonomically and structurally different species: the thalloid liverwort *Marchantia polymorpha* subsp. *polymorpha*, the leafy liverwort *Jungermannia exsertifolia* subsp. *cordifolia* and the moss *Fontinalis antipyretica*. In the field, liverworts were more radiation-responsive than the moss, and the thalloid liverwort was more responsive than the leafy liverwort. Sun plants of *Marchantia polymorpha* showed, in comparison to shade plants, higher sclerophylly, lower Chl *a*+*b* contents, higher Chl *a*/*b* ratios, higher (antheraxanthin + zeaxanthin) / (violaxanthin + antheraxanthin + zeaxanthin) ratios (xanthophyll index), lower F_v/F_m values, higher contents of methanol-soluble vacuolar UV-absorbing compounds (soluble UVACs), higher values of the ratio between the contents of methanol-insoluble cell wall-bound UVACs (insoluble UVACs) and soluble UVACs, higher contents of soluble luteolin and apigenin derivatives and riccionidin A, and higher contents of insoluble *p*-coumaric and ferulic acids. Overall, these responses reduced light absorption, alleviated overexcitation, increased photoprotection through non-photochemical energy dissipation, increased UV protection through UV screening and antioxidant capacity, and denoted photoinhibition. *Jungermannia exsertifolia* showed moderate differences between sun and shade plants, while responses of *F. antipyretica* were rather diffuse. The increase in the xanthophyll index was the most consistent response to sun conditions, occurring in the three species studied. The responses of soluble UVACs were generally more clear than those of insoluble UVACs, probably because insoluble UVACs are relatively immobilized in the cell wall. These modalities of radiation acclimation were reliably summarized by Principal Components Analysis. Using the most radiation-responsive species in the field (*M. polymorpha*), we found, under close-to-ambient greenhouse conditions, that sclerophylly and Chl *a*+*b* content were only influenced by PAR, F_v/F_m and luteolin and apigenin derivatives were only determined by UV, and xanthophyll index was influenced by both radiation types. Thus, responses of bryophytes to radiation can be better interpreted considering the influence of both PAR and UV radiation.

Keywords: Radiation acclimation, ultraviolet radiation, chlorophyll fluorescence, photosynthetic pigments, flavonoids