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Variation in ecophysiological traits of dominant species in open and closed stands of a semiarid sandy grassland

Szilvia Veres[1], Orsolya Mile[1], Réka Láposi[1], Gyula Lakatos[2], Ilona Mészáros[1]*

[1]Department of Botany, University of Debrecen, Debrecen, Hungary, [2]Deptartment of Applied Ecology, University of Debrecen, Debrecen, Hungary

ABSTRACT Under the continental climate of the Carpathian Basin, semiarid grasslands represent one of the widespread vegetation types. Due to overgrazing and other disturbances, most of the semiarid grasslands in Hungary are the mosaics of more or less degraded patches. Our work has focused on the variations in the ecophysiological traits of the common dominant species in a moderately degraded (vegetation cover 70%) and a strongly degraded stand (vegetation cover 27%) of Potentillo-Festucetum pseudovinae community. As a result of low soil moisture content, species experienced significantly higher leaf water saturation deficit in the open stand. Carotenoid pool was larger for all the species in the strongly degraded stand. The protective xanthophyll cycle pool was also higher in the strongly degraded stand, and reached 30–33% of the total carotenoid content. The potential photochemical efficiency (F_v/F_m) was lower for monocot species. There was a decrease in the F_v/F_m values at noon, which was larger in the strongly degraded stand.
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KEY WORDS

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degraded stands
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photochemical activity

Dry grasslands are widespread in the sandy regions of Hungary and are strongly affected by the temporal variation of climatic conditions. The low soil water content in the summer months, due to the low water holding capacity, may affect the vegetation by forcing or retarding the vegetative growth of certain species, but it hardly alters the coenological state of communities (Körmöczi 1991). Due to the past overgrazing and other disturbances, most of the semiarid grasslands in Hungary are mosaics of more or less degraded patches (Précsényi and Mészáros 1997; Matus et al. 2003).

Several studies describe long- and short-term dynamics and floristic studies of sandy grasslands in Hungary (Körmöczi 1991; Fekete et al. 1995; Matus et al. 2003), but little is known about the ecophysiological strategies of sandy grassland species (Tuba 1984; Kalapos 1994; Mészáros et al. 1996; Nagy et al. 1998; Veres et al. 2002). The aim of our work was to investigate variations of plant ecophysiological traits in two differently degraded patches of sandy grassland *Potentillo-Festucetum pseudovinae*. The role of xanthophyll cycle and its relation to the photosynthetic activity was examined in the cases of dominant species.

Materials and Methods

The experimental site is situated in North-Eastern Hungary, 25 km from Debrecen, in the sandy "Nyírség" region of the Great Hungarian Plain (Kék-Káló Valley). The site is surrounded by parabola-shaped sand dunes. The site had been grazed by dairy cattle until the mid-1980s, but the number of cattle and the grazed area had strongly reduced by 2001. As a result of grazing the experimental area has mosaic-like vegetation among the sand dunes. Two vegetation patches were chosen and the common species were investigated. The following common dominant species of the two differently degraded stands – less degraded (vegetation cover 70%) and strongly degraded (vegetation cover 27%) – of semiarid grassland community (*Potentillo-Festucetum pseudovinae*) were examined *in situ* in summer: *Festuca pseudonvina* Hack. ex Wiesb., *Carex praecox*, *Potentilla arenaria* Borkh., *Achillea millefolium*, *Thymus degenianus* Lyka, *Rumex acetosella.* Samples were collected in liquid nitrogen in field. The concentrations of carotenoids were determined by reverse-phase method with HPLC (eluent A: ethylacetate, eluent B: acetonitril: water 9:1; column: Nucleosil C18, 5μ; Mészáros et al. 1996). Measurements on chlorophylls were performed spectrophotometrically from 80% acetone with 0,1% NH_4OH extract (Welburn 1994). The optimal photochemical efficiency of PSII (F_v/F_m) was measured with PAM 2000 fluorometer (WALZ, Germany). To characterize the soil and plants water status, soil moisture, plant dry weight and water saturation deficit (WSD) were measured in both stands. This paper presents the results of measurements performed in the morning and at noon in July of 1999.

*Corresponding author. E-mail: immeszaros@tigris.klte.hu

Results and Discussion

The vegetation period of 1999 was not dramatically droughty. The Gaussen-Bagnouls' xerothermic index was higher than 1 in all the months. There were significant differences ($p<0.001$) between the values of soil moisture measured in the differently degraded stands higher values were experienced in the strongly degraded stand (3.35-4.51 mg g^{-1} d.w.) than in

the less degraded stand (2.14-2.75 mg g^{-1} d.w.) both in the morning and at noon. Differences between patches were reduced by the warmer midday hours, but remained significant ($p<0.01$). Same tendencies occurred in the changes of leaf WSD values. Species growing in the open, strongly degraded stand reflected higher WSD (30-45%) than species in the less degraded stand (22-35%). Moreover, WSD values in the less degraded area only in the case of grasslike species, *Festuca* and *Carex* were significantly ($p<0.01$) higher. Interestingly, the total chlorophyll content on a dry weight basis was higher (with 10-25%) in the strongly degraded area, the differences between the patches were significant ($p<0.01$) in the case of Festuca, Carex and Potentilla. The higher chlorophyll content in the open stand may be attributed to the former intense grazing by geese and cattles in the study area and the related fertilization of the soil. Carotenoid content and composition is very important in avoiding stress situations resulted from excess light (Horton et al. 1996). Similarly to our previous results (Mészáros et al. 1998) all the examined species have high carotenoid concentrations on a chlorophyll basis in both stands. With the exception of Festuca and Carex the species exhibited higher leaf carotenoid content per chlorophyll basis in the strongly degraded stand than in the less degraded one.

Carotenoid concentration on a dry weight basis showed similar results to those on the chlorophyll basis, plants growing in the open habitat could be characterised by higher (with 10-25%) carotenoid contents on the dry weight basis ($p<0.05$). With respect to both stands, carotenoid contents were lower (0.45–0.52 mg g^{-1} d.w.) in Festuca and Potentilla than in other species, and the highest content was experienced in the case of Rumex (1.41 mg g^{-1} d.w ±0.14). As we previously reported these species have relatively large xanthophyllcycle pool (Mészáros, 1998; Veres et al. 2002). The xanthophyll cycle pool was also higher in the more degraded stand, and reached 30–33% of the total carotenoid content. In the case of grasslike species the differences were not significant. Rumex had the lowest xanthophyll pool in the percentage of the total carotenoid content (14%) in both stands.

The F_v/F_m was lower for the monocot species (0.75-0.77) than in the case of dicots (0.79-0.82) in both stands. With the daily increase of the photosynthetically active radiation, all the species showed reductions in their F_v/F_m at noon as compared to the early morning values under both field conditions. These decreases were larger in the strongly degraded stand and especially in the case of Potentilla and Thymus, where the midday values of F_v/F_m were around 0.6, reflecting strong photoinhibition.

The same plant species growing in differently degraded patches of sandy grassland showed alteration in physiological traits. These drought tolerant and xerophyte species exhibit a considerable capacity to dissipate excess excitation energy of photosynthetic apparatus, and maintain the recovery of photochemical efficiency to a large extent, which is connected to the plastic alteration of carotenoid composition.

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