Higher plasticity of form and function for invasive species? A test on grasses

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Introduction

Invasive species capable of rapid colonization of new habitats – where canopy is most often discontinuous – are expected to face a higher degree of environmental heterogeneity – hence more variable light climate – than non-invasive species do. This may require an efficient adjustment of plant morphology and physiology to the environment in order to minimize associated limitations. We tested the hypothesis that invasive species exceed their non-invasive relatives in the capacity for physiological and associated morphological/anatomical adjustments to short-term changes in the environment. On C3 grasses low light may impose serious constraint, thus we studied plant adjustments to reduced light intensity. Due to a stronger structure-function relationship we expected C4 grasses to be less responsive in leaf traits than C3 grasses.

Material & Methods

Grasses from seminatural semiarid temperate grasslands or arable land established in their place were grown in growth room under variable moderate light intensity (440-810 and 135-180 µmol photon m⁻² s⁻¹ in summer and winter respectively), and plant traits were compared with those in the plants’ original habitat. Leaf morphology (size, shape), coarse structure (leaf mass per area (LMA), thickness and bulk tissue density) and changes in CO₂ and H₂O gas exchange in response to rapid change in irradiance (first drop from 1300 to 270 then increase again to 1300 µmol photon m⁻² s⁻¹) were compared. The species studied were two invasive C₄ (Cynodon dactylon (L.) Pers. and Sorghum halepense (L.) Pers.), two non-invasive C₃ (Bothriochloa ischaemum (L.) Keng and Chrysopegon glyrrhus (Tom.)(F.) mn) and two expanding native C₃ species (Bromus inermis Leyss. and Calamagrostis epigeios (L.) Keng) for leaf structure, while gas exchange light response was investigated only for the four C₃ species.

Main results and interpretation

Grasses with high capacity for colonization (invasive C₄ or expanding C₃) had 43.4-54.1% lower leaf mass per area (LMA) in the growth room than in the field, mostly due to a lower leaf thickness, while for non-invasive C₃ grasses this change was 5.7-21.2% only. In response to marked decline in irradiance net photosynthetic rate (A) decreased suddenly, usually within 2 minutes, that was followed by the partial closure of stomata (decline in gs) with 1-4 min delay. Sorghum halepense had the lowest – and statistically non-significant – difference between the duration of drop in photosynthesis (tₜₘᵦₚ) and that of stomatal conductance (tₜₘᵦₚₕₜ), while for the rest of the species closing of stomata took 1.8-3 times longer than the decline of A. Thus, during the high-to-low light transient instantaneous photosynthetic rate efficiency (PWUE = A/gs) dropped quickly to a minimum and then – with partial closure of stomata – slowly increased again to a value matching or even exceeding prior steady state value. In this process, integrated PWUE loss (contₜₘᵦₚₕₜ) was significantly lower for S. halepense than for B. ischaemum, while the other two species were intermediate.

Conclusions

These results suggest that among C₃ grasses invasive species possess a greater degree of leaf morphological and anatomical plasticity than non-invasive species. In contrast, our data do not support the hypothesis of reduced ability of invasive C₄ grasses to alter leaf morphology and structure in response to low-light environments compared to C₃ grasses of high colonization potential. Among C₃ grasses the closure of stomata with light intensity drop was faster and more efficient for invasive than for non-invasive species. This results in a more efficient use of water during the transient state form high to low light.

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