FROM CONTINENTALITY TOWARDS OCEANITY: A SHIFT OF WEED SYNUSIA IN ENERGY PLANT STANDS IN CENTRAL EUROPE

ALEXANDER FEHÉR, DANIELA HALMOVÁ, LÝDIA KONČEKOVÁ
Faculty of European Studies and Regional Development, Slovak University of Agriculture in Nitra, Mariánska 10, 949 01 Nitra, Slovakia

The aim of the paper was to evaluate changes in biodiversity of spontaneous plant species in different microclimate conditions in agricultural crops, plantations of energy plants and a herbal fringe of an alluvial forest in the contact zone with an agricultural cropland. Alpha diversity was evaluated, and unweighted Ellenberg indicator values (EIV for temperature, light, moisture, continentality, pH, nitrogen; Ellenberg et al., 1991) were used to determine relationships between species composition and environmental conditions. The data obtained were analyzed by indirect gradient analysis (PCA). Higher alpha diversity and the occurence of species with a wider ecological valence to the light conditions were observed in the stands of energy plants and the herbal fringe of the alluvial forest. The closest relationship with all assessed species was determined for moisture, but the degree of its influence was generally low. The soil reaction and the soil nitrogen content were characterized by higher selective impact on the occurrence of certain plant species. The occurrence of Atlantic (oceanic) species (eg. Aster novi-belgii, Quercus petreae agg. juv.) was recorded only in the stands of energy plants (about 10% share). In these stands, the proportion of subcontinental and continental-subcontinental species was the lowest. Based on the results, it can be concluded that the stands of energy crops in the agricultural landscape mosaic foster the expansion of Atlantic species. However, these findings are preliminary and require a further study.

Keywords: biodiversity, short rotation coppice (SRC), continentality, oceanity, Slovakia

INTRODUCTION

Global climate changes are caused by natural processes and macro-processes generated by human activities, but we have little information on microclimate changes generated by humans (new types of crop stands, new cultivation technologies etc.).

The interaction of climate change with land-cover change could increase the impact of land-cover change on biodiversity and alter a spatial distribution of threats. The ranking of global biodiversity hotspots by threat depends critically on the interaction between climate change and habitat loss (Mantyka-Pringle et al. 1991). There were historical periods when Central Europe was more Atlantic than today, e.g. in the Holocene climatic optimum. During the whole climatic optimum, natural causes, such as minor shifts of temperature, did not induce substantial environmental changes, though some changes, such as temporary droughts, may have facilitated and amplified the observed human impact (Kalis et al. 2003). Climate is an important driving force behind the vegetation succession, but also vegetation affects climate, especially microclimate. Vegetation can also play an important role in the topoclimate of towns and the microclimate of buildings (Wilmers 1991-1992). While replacing hardwood with woodchips from short rotation was not found to be advantageous because of e.g. material depletion potentials, benefits were observed in land use reduction and climate change mitigation. Due to frequent rotations, the beneficial trends for the latter seem sufficient to compensate the negative effects of the other impacts on human health and ecosystem quality (Rugani et al. 2015). However, many of these findings are preliminary, sometimes purposeful, so this issue requires further study in various soil and climatic conditions. With increasing age, the ground flora decrease and species composition shift towards forest and nutrient-demanding species. Particularly, the age of plantations, irradiance and soil nutrient contents influence the species composition in woody energy plantations (Baum 2012).

Our work focused on species composition of spontaneous plant stands in various crops, including short rotation coppice, and on proportion of Atlantic and Continental species in the studied stands. The work builds on previous research of environmental gradients and positive and negative externalities of short rotation coppice (Fehér, Halmová, Končeková 2013, 2014, 2016).

MATERIALS AND METHODS

Our study was carried out on an agricultural land located in the research centre in Kolíňany. Cadastral area of Kolíňany is located in the province of West Pannonian Basin and Danubian lowland region (approx. 10 km northeast from Nitra, SW Slovakia) on the dividing line of Zobor hill and Žitava hill land. The study site was situated near the regulated water stream Bocegaj that is a right tributary of river Žitava. Altitude of the experimental base is 180 m a.s.l. Climate region is warm, moderately humid with mild winter (average annual temperature is 9.6 ºC and rainfall 560 mm). The main soil unit is haplic luvisols with pH 7.22 -7. Terrain steepness is from 0° to 2°.

Observations of spontaneous plant species were made during growing season in stands of agricultural crops (wheat, maize), plantations of perennial rhizomatous grass *Miscanthus ×giganteus*, tree plantation of Swedish willow variety Tordis and herbal fringe of an alluvial forest in the contact zone with an agricultural cropland. The method for recording vegetation structure was sampling by phytocoenological relévés. The abundance of the taxa was evaluated by the Braun-Blanquet scale (Braun-Blanquet, 1964). Ecological analysis by Ellenberg's indices is among the simplest and quite effective methods of evaluating changes in communities. It represents an evaluation of environmental conditions based on bioindication properties of plant species, i.e. expresses the relationship of individual species to selected ecological factors based on qualitative and quantitative features of phytocoenosis (species diversity, abundance and dominance). Unweighted Ellenberg indicator values (EIV for temperature, light, continentality, pH, nitrogen; Ellenberg, 1991) were used to determine relationships between species composition and environmental conditions. Nomenclature of the taxa was revised by checklist of vascular

plants (Marhold and Hindák, 1998). Alien species were classified according to Medvecká et al. (2012). Gradient analysis (principal component analysis, PCA) was made by multivariate ordination methods by means of the PC program Canoco for Windows version 4.5 (ter Braak and Šmilauer, 2002). The interaction values accounted for eigenvalues have been visualized by CanoDraw for Windows 4. Principal component analysis (PCA) with additional variables of EIV was used to determine the ecological characteristics and differences between clusters in CANOCO for Windows 4.5.

RESULTS

The results of the spring aspect evaluation showed that stands of the agricultural crops are species-poor. The lowest alpha diversity of spontaneously occurring vascular plants was represented by 4 species growing in winter wheat. In the case of maize it was 12 species. Stands of energy plants are floristically more species-diverse/richer. 18 plant species were recorded in the understorey of the energy grass *Miscanthus ×giganteus* and 23 species in the energy willow variety Tordis. The alpha diversity was evaluated also in a herbal fringe of an alluvial forest in the contact zone with an agricultural cropland, where intermedial number of higher plant species (17) was detected.

Based on the evaluation of species requirements to environmental conditions, it can be stated that the *M. ×giganteus* stands, stands of willow variety Tordis and herbal fringe of an alluvial forest hosted wider range of species with wider ecological valence to the lighting conditions. Weed species that occurred in the maize stand are more heliophilous, which was associated with less closed stand in the June aspect (Fig. 1). In the case of the agricultural crop stands, the light spectrum shows the majority of the species occurring in the range of 6-8, indicating a moderate light-shade tolerant species.

In terms of requirement on temperature conditions, a higher share of thermophilic species (e.g. *Cardaria draba*, *Echinochloa crus-galli*) was detected only in the maize stand (Fig. 2). Due to the fact that temperature effect is manifested also in the resistance of plants to drought, most drought-resistant plants were found also in the maize stand. The highest proportion of hydrophilic species occurred in the alluvial forest fringe, resulting from the habitat conditions. The ecological profile of communities in relation to the continentality exhibits the lowest proportion of subcontinental and subcontinental-continental species in the energy crop stands, where Oceanic (Atlantic) species consisted of approximately 10 % (Fig. 1). Invasive neophyte *Aster novi-belgii* and *Quercus petreae* juv. agg. (ecovalue 2) are considered to be species typical for Oceanic climate (Fig. 4). Oceanic species in other studied stands were absent.

Principal components analysis (PCA) enabled us to further describe ecological nature of the monitored clusters and compare them with each other (Fig. 2). The results of the analysis showed that while the climate influenced the species diversity of plants in the studied stands in different ways, it is not a determining factor of the species composition.

Based on the assessment it can be further noted that, nevertheless, the climatic factors created a separate cluster of effects. However, the cluster was not compact. Other evaluated environmental factors: soil pH and content of mineral nitrogen in soil did not create a separate cluster, but they had a selective effect on the occurrence of particular species, e.g. *Avena fatua*, *Convolvulus arvensis*, *Cirsium arvense*, *Persicaria lapathifolia*, etc. Although soil moisture had the tightest relationship with all assessed species within the ordination diagram, the degree of its gradient impact was generally low.

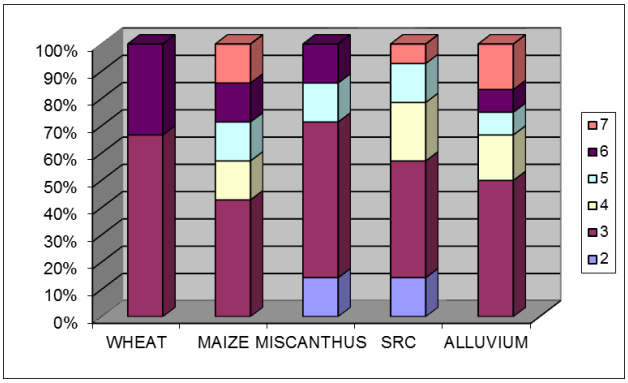

Fig. 1. Share of Ellenberg`s continentality values for weeds in stands of crops, energy plants and alluvial plant community. Continentality value has a predominant distribution range from the Atlantic coast (1) to the inland parts of Eurasia (9).

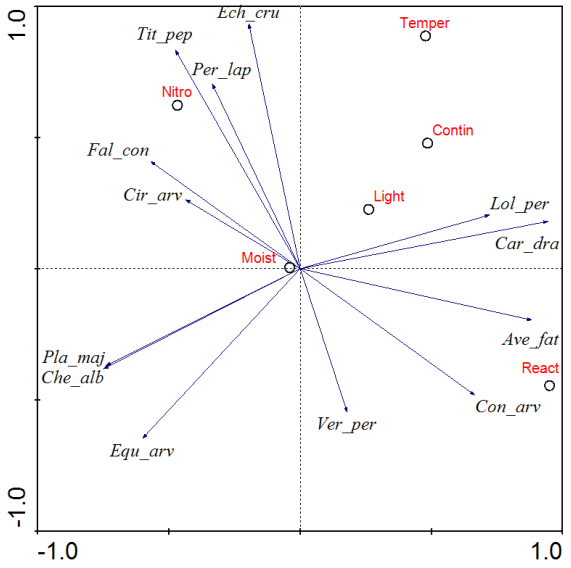

Fig. 2. Biplot of principal components analysis (PCA) of weeds and their ecological condition preferences in energy plant stands (developed by Canoco 4.5 and CanoDraw 4).

CONCLUSION

Based on the results, it can be concluded that the stands of energy crops in the agricultural landscape mosaic foster the expansion of Atlantic species. However, these findings are preliminary and require a further study.

Acknowledgement

This study was supported by FP7-REGPOT-2011-1 STAR-AgroEnergy Scientific and technological advancement on research in agro-energy: an integrated approach to renewable energy generation according to sustainability criteria, VEGA Grant Nr. 2/0117/13 Assessment of status and dynamics of habitats using combination of modelling and remote sensing, VEGA Grant Nr. 1/0942/12 Variety dependence of production and energetic potential of fast growing woody plants of genus *Salix* and *Populus* in the first and second three-years harvest cycles and COST Action FP 1301 Innovative management and multifunctional utilization of traditional coppice forests – an answer to future ecological, economic and social challenges in the European forestry sector (EuroCoppice).

LITERATURE

Baum, S. 2012, Phytodiversity in short rotation coppice plantations. Dissertation zur Erladung des Doktorgrades. Fakultät für Forstwissenschaften und Waldökologie, Georg-August-Universität, Göttingen.

ter Braak, C. J. F., Šmilauer, P., 2002, CANOCO reference manual and CanoDraw for Windows user´s guide. Software for Canonical Community Ordination (version 4.5). Biometris, Wageningen, České Budějovice.

Braun-Blanquet, J., 1964, Pflanzensoziologie. Grundzüge der Vegetationskunde. Springer Verlag, Wien-New York.

Ellenberg, H. et al., 1991, Zeigerwerte von Pflanzen in Mitteleuropa, Scripta Geobotanica; 18, Verlag Erich Goltze KG, Göttingen.

Fehér, A., Halmová, D., Končeková L. 2013, Gradient analysis of importance of spontaneously occurring vascular plant species in energy tree and grass stands. Acta Regionalia et Environmentalica 10: 33-35.

Feher, A., Halmova, D., Koncekova, L. 2014, Evaluation of biodiversity of ground flora in short rotation coppice: positive and negative externalities. 22nd European Biomass Conference and Exhibition, Hamburg. pp 342-345.

Fehér, A., Halmová, D., Končeková L. 2016, Fostering biomass for energy use: the environmental, social and economic evaluation of plant biodiversity in energy tree and grass plantations. In: Filho Leal, W. (ed.), Handbook of Renewable Energy, Springer Science and Business Media. pp. 2400 (in press)

Kalis, A.J., Merkt, J., Wunderlich, J. 2003, Environmental changes during the Holocene climatic optimum in central Europe - human impact and natural causes. Quaternary Science Reviews 22(1): 33–79.

Marhold, K., Hindák, F. (eds.), 1998, Checklist of non-vascular and vascular plants of Slovakia. Veda SAV, Bratislava.

Mantyka-Pringle, Ch.S., Visconti, P., di Marco, M., Martin, T.G., Rondinini, C., Rhodes, J.R. 2015, Climate change modifies risk of global biodiversity loss due to land-cover change. Biological Conservation 187: 103–111.

Medvecká, J. et al., 2012, Inventory of the alien flora of Slovakia. Preslia, 84(2): 257–309.

Rugani, B., Golkowska, K., Vázquez-Rowe, I., Koster, D., Benetto, E., Verdonckt, P. 2015, Simulation of environmental impact scores within the life cycle of mixed wood chips from alternative short rotation coppice systems in Flanders (Belgium). Applied Energy 156: 449-464.

Wilmers, F. 1990-1991, Effects of vegetation on urban climate and buildings. Energy and Buildings 15(3–4): 507-514.