Effect of Climate Change in 50-Years Period on Grassland Productivity in Central Poland

Piotr Goliński
Poznan University of Life Sciences, Poland

Marek Czerwinski
Poznan University of Life Sciences, Poland

Barbara Golińska
Poznan University of Life Sciences, Poland

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Effect of climate change in 50-years period on grassland productivity in central Poland

Piotr Golinski*, Marek Czerwinski and Barbara Golinska
Department of Grassland and Natural Landscape Sciences, Poznan University of Life Sciences, Poznan, Poland
*Corresponding author e-mail: pgolinsk@up.poznan.pl

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Introduction

In Central Europe, the climate change is predicted to bring more rainfall in winter, less rainfall in summer, and an increased drought risk (Trnka *et al.*, 2011). Smit *et al.*, (2008) reported that significant drops in grassland productivity can usually be attributed to drier summers. Also in Poland, the most important abiotic factor limiting grassland productivity is water shortage and its distribution during vegetative season. Indicating the influence of climate on grass vegetation growth could be an important tool in grassland management on the national, regional and single grassland scales. The aim of the study was to evaluate the effect of climate change in 50-years period on productivity of grassland located on mineral and organic soils in Central Poland.

Materials and Methods

The data for the analysis were collected in 1965-2014 at the PULS Brody Experimental Station (52º26' N, 16º18' E; 92.0 m a.s.l.) located in Central Poland. Climate changes were investigated by the analysis of the long-term course of mean monthly and annual temperature, monthly precipitation sum and standardized precipitation evapotranspiration index, SPEI (Vicente-Serrano *et al.*, 2010), which incorporates both these climatic elements and characterizes drought severity. The SPEI uses a difference between precipitation P, expressed as the standardized precipitation index SPI (McKee *et al*., 1993) and potential evapotranspiration PET. The PET was calculated by temperature-based method (Thornthwaite, 1948). Temperature, precipitation and SPEI trends were determined by computing the Pearson correlation coefficient between the subsequent years and the corresponding SPEI values.

Grassland productivity in the analyzed period was evaluated using rising plate meter and ocular estimation of herbage fresh weight methods. Annual dry matter yield data were collected from ca. 50 ha grassland situated on mineral soils utilized mainly by grazing and ca. 150 ha grassland located on organic soils used exclusively by cutting. Vegetation of these grassland consisted of many sward species belonging in the phytosociological classification to the *Molinio-Arrhenatheretea* class. Grassland was dominated by perennial ryegrass on mineral soils and by smooth-stalked meadow grass on organic soils. Sward composition varied over successive years of utilization. The sward was several times improved through over seeding. The most important management factor influencing the grassland productivity was fertilization, the level of which differed during 50-years period of utilization.

To assess the influence of climate changes on grassland productivity, the significance of simple linear regression of yearly yield against SPEI was calculated. The SPI and SPEI were computed using the SPEI package (Beguería and Vicente-Serrano, 2013) in the R environment for statistical computing.

Results and Discussion

Analysis of changes in annual mean air temperature and precipitation sum from 1965 to 2014 in Brody showed significant regressions at $P< 0.001$ and $P< 0.05$, respectively. According to calculated models the annual mean air temperature increased from 7.4 °C in 1965 to 9.5 °C in 2014. Analyzing the same period, the annual sum of precipitation increased from 545.1 to 678.4 mm. Similar trends were observed by Trnka *et al.*, (2011) for many regions of North-Eastern and Central Europe. Taking into consideration that for grassland growth in temperate zones with climate distinguished by higher temperature the crucial factor is the amount and distribution of precipitation (Smit *et al.*, 2008), the one-month SPEI calculated for each month of a year was used to determine which period of vegetative season lasting about 230 days (end of March till beginning of November) had the highest impact on grassland productivity. The Pearson's correlation coefficients between years and one-month SPEI for twelve months (January-December) were as follows: 0.29, 0.27, 0.18, -0.25, -0.07, 0.01, 0.05, 0.17, 0.07, -0.08, -0.07, 0.01. This indicates that droughty conditions which have high impact on annual grassland yield occurred in spring (April-Mai).

The results of regressions of annual grassland yield located on mineral and organic soils against the SPEI (Table 1) confirmed that weather conditions characterized by SPEI had significant effect on grassland productivity located on mineral soils in all analyzed periods, particularly April-September. In the case of grassland on organic soils, all but one-month SPEI calculated for April had no significant effect on their yielding.

Table 1: Estimates of the population parameters and significance of the simple regressions of annual yield against the SPEI

Period of vegetation season	**Grassland located on:**					
	Mineral soil			**Organic soil**		
	Y intercept	**regression coefficient**	***P*-value**	**Y intercept**	**regression coefficient**	***P*-value**
April	8.63	0.424	0.0448*	6.50	0.487	0.0236*
April-June	8.62	0.542	0.0107*	6.50	0.262	0.2384
July-September	8.62	0.490	0.0189*	6.52	-0.194	0.3734
April-September	8.60	0.723	0.0005***	6.51	0.004	0.9870

Table 1 presents the empirical data and estimated trends of productivity of two types of grassland (mineral vs. organic soils) in dependency on SPEI for 6-months from April to September for 50-years period. It confirmed the results of Trnka *et al.* (2011) that grasslands would differ in their response to climate change depending on their type (plant community, soil, management).

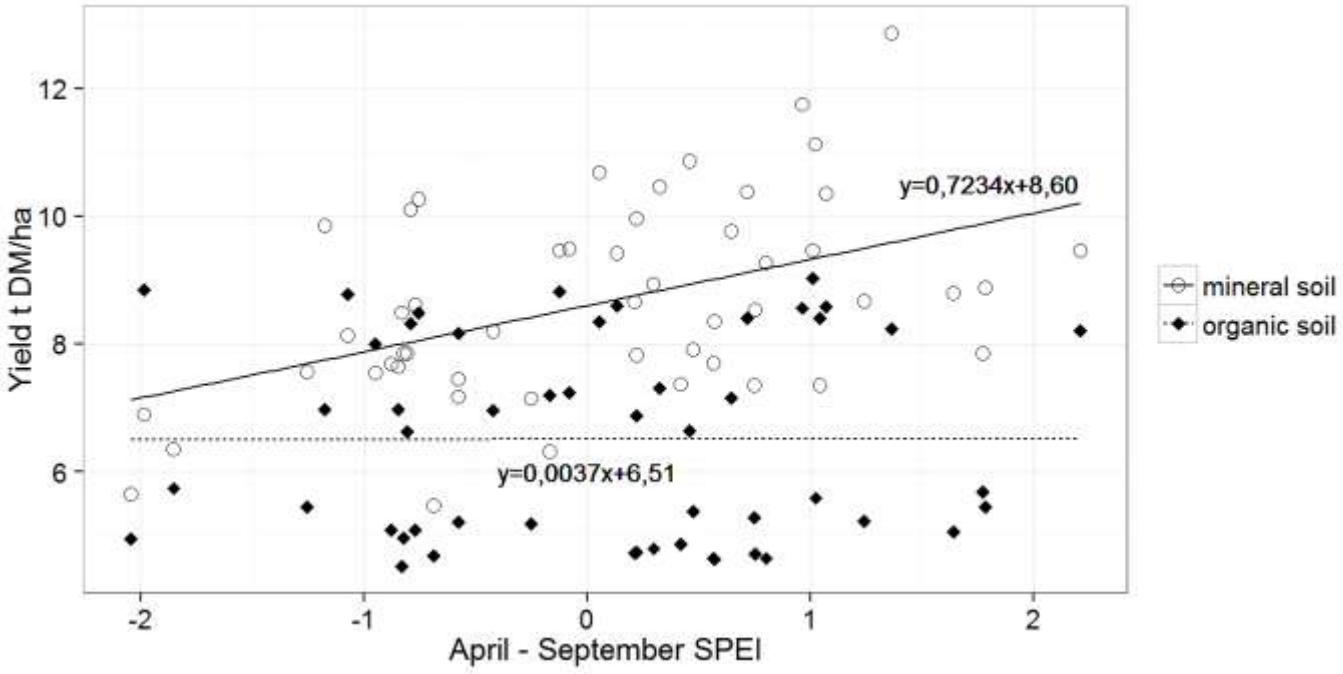

Fig. 1: Relation between annual grassland productivity and SPEI for 6-months period from April to September in the background of type of soil

Conclusion

Climate change at the analyzed site in Central Poland in 50-years period reflected by increasing air temperature and precipitation had significant impact on grassland productivity located on mineral soils. The relation between SPEI estimated for 6-months period from April to September and annual DM yield was positive. The effect of climate change on grassland productivity located on organic soils was not significant.

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