Published in: Grassland Science in Europe, Vol. 19 – EGF at 50: the future of European grasslands, 139-141

Impact of climate change on grassland productivity and forage quality in Austria

Poetsch[1], E. M., Asel[2], A., Schaumberger[1], A. and Resch[1], R.

[1]Agricultural Research and Education Centre (AREC) Raumberg-Gumpenstein, A-8952 Irdning, Austria
[2]University of Natural Resources and Life Sciences, A-1180 Vienna, Austria

Abstract

Grassland farming is the main land use system in mountainous regions of Austria. Climate change scenarios assume an increase of temperatures up to 2° C for the next few decades and also expect reduced rainfall in summer for the alpine space. This change will have an impact on grassland productivity concerning yield and forage quality. To provide grassland farmers and policy makers with relevant information, a series of 27 field experiments was established along a strong gradient of site and climatic conditions in Austria. The sites were clustered into four different climate groups by means of long term temperature and precipitation values. Multivariate analysis showed that grassland yield and forage quality were mainly affected by the factors year, climate group and management intensity. In 2003 extraordinary weather conditions with high temperatures and below-average rainfall strongly affected grassland productivity concerning dry matter yield but had no significant impact on forage quality. In arid regions considerable yield losses up to 30% occurred, whereas in humid regions yields even increased partly. Our findings clearly demonstrate that adaptation strategies against climate change on grassland have to consider spatial aspects.

Keywords: drought periods, dry matter yield, adaptation strategies, spatial impact

Introduction

Permanent grasslands of different types cover an area of 1.44 million hectares, which is 50 % of the total Austrian agricultural area. 60,000 grassland farmers, mostly running small to medium size enterprises, mainly focus on the efficient use of farm manure and the production of high quality forage being the most relevant farm internal resources in mountainous regions. Through a change in climatic conditions and variability, e.g. extreme weather events (heat waves, droughts, etc.) are likely to occur more frequently in different spatial and time scales in future (Eitzinger et al., 2009). In order to respond in time it is of great interest for farmers but also for policy makers to receive basic information about the regional impact of climate change on grassland yield and forage quality (Meisser et al., 2013).

Materials and methods

A multi-site field experiment has been established by AREC Raumberg-Gumpenstein on 27 different locations in Austria in the year 2002. The experimental design using three replicates included three cutting intensities (2, 3 and 4 cuts year^{-1}) each with an appropriate level of fertilization (0.9, 1.4 and 2.0 LU ha^{-1}) using slurry or stable manure + liquid slurry resp. additional mineral nitrogen fertilizer (50 kg ha^{-1} year^{-1}) for the most intensive variant. The harvesting dates were adapted to the particular site conditions which varied from 6.4 – 11.1 °C of average yearly temperature, from 548 – 1,440 mm of annual precipitation and an altitude from 209 – 1,100 m a.s.l.. The experimental sites were clustered into four climate groups, based on average temperature and precipitation data. Multivariate statistical analysis were then carried out to identify the most relevant management and site factors which influence dry matter yield and quality parameters.

Results and discussion

Grassland dry matter yield was significantly influenced by the factors year, climate group and management intensity which explained more than 90% of the observed variation. There was no significant difference between the two humid climate groups which showed higher yields than the sites in arid regions with lowest yields occurring under warm conditions (Table 1). A multiple comparison of means showed, that in three years (2003, 2007 and 2011) of the total project period, significant lower yields occurred. In 2003 above-average temperatures were combined with below-average rainfall in almost all parts of Austria and caused dramatic damage and losses in grassland and arable farming. Our analysis (Table 2) show that there were great spatial differences concerning the impact on grassland yield in this extraordinary year (Schaumberger et al., 2012). Under humid/warm conditions no yield reduction was noticed, under humid/warm conditions even an increased yield occurred especially when grassland was cut twice (+10%) or three times (+ 12%) per year. In contrast a strong average yield decline of 24% in arid/cold regions resp. 29% in arid/warm regions was observed without any significant differences between the three tested cutting/fertilization intensities. The crude protein (CP) content was also significantly influenced by the factors year, climate group and management intensity explaining 63% of the variation. On average (2002-2011) the highest CP-content was found under humid/warm conditions (121g kg DM^{-1}), the lowest CP-concentration occurred in the climate group arid/cold with 115g kg DM^{-1} (Table 3). Within the climate groups a rising CP-content occurred with increasing management intensity (2 cuts > 3 cuts > 4 cuts). In contrast to the decreasing dry matter yield the CP-concentration in the dry year 2003 was significantly higher in all climate groups (ranging from 133 – 146g kg DM^{-1} with significantly highest values under dry/warm conditions) and also for all tested management intensities (Table 4). These results could also be found for the energy concentration (MJ net energy lactation kg DM^{-1}) in forage that was mainly affected by management intensity (2 cuts > 3 cuts > 4 cuts) but to a less extent by weather conditions (Table 3). In 2003 the highest values for energy concentration were measured in cold areas with normally low temperatures, the lowest energy concentration occurred under humid/warm conditions (Table 4). Even though forage quality was just slightly influenced by the extraordinary weather situation in the year 2003, considerable differences occurred for energy yield and crude protein yield under arid conditions, caused by strong yield decline in these climate groups. To provide present livestock on farm with sufficient amount of energy and crude protein additional feedstuff is required to bridge this critical shortage. Another challenge is to improve drought damage of the sward by renovation measures using well adapted seed mixtures for dry conditions

Conclusion

Our findings clearly indicate that the impact of climate change on grassland productivity in mountainous regions of Austria shows a strong spatial variability and requires therefore different strategies of adaptation. Whereas humid regions with sufficient water supply even benefit from higher temperatures, in arid regions considerable yield losses have to be taken into account. Forage losses can be compensated by purchase of external feedstuff for the short term. To counterbalance negative climate change impact on grassland in the long run, an increased use of drought tolerant species like lucerne, better adapted grass and clover cultivars respectively seed mixtures but also irrigations systems have to be considered seriously.

References

Eitzinger J., Kersebaum K.C. and Formayer H. (2009) Landwirtschaft im Klimawandel. Auswirkungen und Anpassungsstrategien für die Land-und Forstwirtschaft in Mitteleuropa. Agrimedia GmbH. Clenze, Deutschland.

Schaumberger A., Pötsch E.M. and Formayer, H. (2012) GIS-based analysis of spatio-temporal variation of climatological growing season for Austria. 24th EGF General Meeting "Grassland - a European Resource", Lublin, Poland, Grassland Science in Europe, Vol 17, pp. 634-636.

Meisser, M., Deleglise, C., Mosimann, E., Signarbieux, C., Mills, R., Schlegel, P., Buttler, A. and Jeangros, B. (2013) Auswirkungen einer ausgeprägten Sommertrockenperiode auf eine montane Dauerweide im Jura. Agrarforschung Schweiz 4, pp 476-483.

Table 1. Dry matter yield of grassland under different climate conditions in Austria (average of the period 2002-2011)

Climate groups	humid/warm n=549	humid/cold n=360	arid/warm n=783	arid/cold n=675
DM-yield (t ha^{-1} year^{-1})	8.10^{a}	8.32^{a}	6.82^{b}	7.55^{c}
SD	+/- 2.734	+/- 1.696	+/- 2.723	+/- 2.395

a, b – indicate significant differences between climate groups (p<0.05)

Table 2. Dry matter yield of grassland under different climate conditions in Austria (average of the dry year 2003)

Climate groups	humid/warm n=63	humid/cold n=27	arid/warm n=81	arid/cold n=72
DM-yield (t ha^{-1} year^{-1})	8.14^{a}	8.96^{a}	4.83^{b}	5.73^{b}
SD	+/- 2.457	+/- 0.931	+/- 2.482	+/- 1.816

a, b – indicate significant differences between climate groups (p<0.05)

Table 3. Crude protein and energy content of forage under different climate conditions in Austria (average of the period 2002-2011)

Climate groups	humid/warm	humid/cold	arid/warm	arid/cold
CP (g kg DM^{-1})	115.2^{a}	117.7^{b}	118.6^{bc}	120.8^{c}
MJ NEL (kg DM^{-1})	4.53^{a}	4,79^{c}	4,65^{b}	4,90^{c}

a, b, c – indicate significant differences between climate groups (p<0.05)

Table 4. Crude protein and energy content of forage under different climate conditions in Austria (average of the dry year 2003)

Climate groups	humid/warm	humid/cold	arid/warm	arid/cold
CP (g kg DM^{-1})	135.2^{a}	134.0^{a}	145.7^{b}	131.9^{a}
MJ NEL (kg DM^{-1})	4,49^{a}	4,87^{b}	4,84^{b}	4,92^{b}

a, b – indicate significant differences between climate groups (p<0.05)