Suitability of alternative grass species for grassland management in Austria under changing climatic conditions

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Abstract

Climate change causes increasing drought and heat stress, endangering the agricultural use of grassland especially in the outer alpine areas. A changing species spectrum towards heat tolerant grasses, forbs and legumes has therefore to be expected in the long term. The aim of this study was to test and compare various grass species both under humid and dry site conditions in Austria in terms of yield, forage quality and endurance.
The grass species studied were *Dactylis glomerata, Festuca pratensis, Festulolium loliaceum, Festuca arundinacea, Festuca rupicola, Festuca rubra, Poa angustifolia, Poa compressa, Poa pratensis, Bromus inermis* and *Bromus erectus*. The cultivars *Festuca arundinacea* and *Festulolium loliaceum* performed promising in terms of productivity and endurance and should therefore be further tested for grassland seed mixtures on dry sites of Austria. Also *Bromus erectus* and *Bromus inermis* adapted well to dry site conditions and should therefore be considered as potential components in grassland seed mixtures for referring sites.

Keywords – climate change, drought adapted genotype, grasses, forage quality

Introduction

In Austria, grassland management is mostly based on ruminants of which dairy cows taking the highest importance. Efficient and sustainable dairy production requires sufficient yields and high forage quality to minimize the use of farm-external and expensive concentrates. For satisfying growth, permanent grassland with *Lolium* species needs around 900 mm of precipitation, distributed equally over the whole year (Dietl *et al.*, 1998). Climate change causes increasing drought and heat stress, endangering agricultural use and ecosystem function of grassland, not only in alpine areas (Weißhuhn *et al.*, 2011). Thus, different adaptation strategies have to be developed and implemented into agricultural practice. In the long term, a changing species spectrum towards drought tolerant grasses, forbs and legumes can be expected. The aim of this study was therefore to test a set of various grass species for their suitability for grassland under changing climatic conditions concerning productivity, forage quality and endurance.

Material and methods

In a field study different grasses were cultivated in pure stands on two different sites over 3 years. Admont, located in the Enns valley, has a montane humid climate with the northern alpine characteristic of a relatively high precipitation. Piber, located in the western part of Styria has a montane climate with slight continental warm, semi-dry summer and comparatively low precipitation (see table 1).

Table 1. Mean air temperature (MAT) during the growing season (March to October), total annual precipitation and soil chemical properties of the two experimental sites

Site	Province in	Altitude (m);	MAT	Precipitation	Soil chemical properties		
	Austria	Exposition	average 2006-2008		pH_{CaCl2}	P (CAL)	K (CAL)
			°C	mm		mg kg^{-1}	mg kg^{-1}
Admont (humid)	Upper Styria	640; plain	11,8	1,286	5.2	49	76
Piber (dry)	Western Styria	450; E	12,4	881	5.5	25	78

Exact field trials, designed as a partially randomized block with plots of 5.56 m² onthe humid site at Admont and 7.14 m² on the dry site at Piber , were carried out between 2005 and 2008 each with three replications. The sowing time was 31 August 2005 on the humid site at Admont and 15 August 2005 on the dry site at Piber with differing seeding rates of 20 to 40 kg ha^{-1} depending on the various species and their seed weight. At the beginning of the experiment, all plots were fertilized with 50 kg N ha^{-1}, 40 kg P_2O_5 ha^{-1} and 100 kg K_2O ha^{-1}.The development and performance of 18 grasses were tested on both sites. Different origins (cultivars and genotypes) were chosen, coming from regions with dry conditions (among others e.g. Lower Austria, Marchfeld). Species studied were *Dactylis glomerata* (Tandem), *Festuca pratensis* (Pradel, Leopard), *Festulolium loliaceum* (Hycor), *Festuca arundinacea* (NS VISOKI VIJO, Keszthelyi-50, Molva, Belfine), *Festuca rupicola* (NÖ/Marchfeld), *Festuca rubra* (Echo)., *Poa angustifolia (*commercial seed, Gumpenstein*), Poa pratensis* (Oxford), *Bromus inermis* (Keszthelyi-51, OÖ-Unterheuberg, commercial seed) and *Bromus erectus* (commercial seed, NÖ Marchfeld). *Poa compressa* (commercial seed) disappeared after the first year from the plots and was therefore omitted from the trial. The trials were minerally fertilized every year with 150 kg N ha^{-1}, 80 kg P_2O_5 ha^{-1} and 160 kg K_2O ha^{-1} split in three applications.
The cover of weeds was surveyed in the year 2008 before the second cut as an estimate of endurance. Biomass production (DM-yield) of the different species and cultivars were analysed over a period of three years under a 3 cut regime. The cumulated yearly yields were averaged over the investigation period and taken in comparison. In vitro digestibility of organic matter dOM was analysed according Tilley and Terry (1963) andaveraged over all cuts of the year 2006. Results concerning weeds are presented as averages.

Results and discussion
Established cultivars which are used in quality seed mixtures for Austrian grassland (ÖAG, 2011), were compared to potentially new cultivars. In order to make reasonable assessments, potential new cultivars were each compared to established ones, as far as possible origin from the same species group. For species without comparable cultivars (e.g. *Bromus erectus* and *Bromus inermis*), *Dactylis glomerata* was used; *Festulolium loliaceum* was compared to *Festuca pratensis*.
The average DM-yield over the sites of the tested cultivars was 117.7 dt ha^{-1} $year^{-1}$ but it has to be considered that in some variants weeds strongly contributed to the biomass production. At the dry site at Piber, a generally higher DM-yield over the years 2006 to 2008 and a lower dOM could be achieved than on the humid site at Admont.
All cultivars of *Bromus erectus* showed higher values regarding weed infestation in comparison to *Dactylis glomerata*, which clearly indicates the strong competitiveness of *Dactylis glomerata;* DM-yield and dOM were comparable to *Dactylis glomerata* at the dry site at Piber which indicates the good adaption to dry sites. At the humid site Admont, *Bromus erectus* cultivars showed a clearly higher weed infestation, lower DM-yield but comparable dOM in comparison to the dry site at Piber, (Table 2).
Related to *Dactylis glomerata*, generally higher values regarding weed infestation were assessed for *Bromus inermis*. In comparison to *Bromus erectus* the *Bromus inermis* cultivars showed higher weed cover and higher DM-yield whereasdOM was comparable.
The *Festuca arundinacea* cultivars showed better results on both sites regarding weed infestation and DM-yield compared with *Festuca pratensis*, dOM was lower. However, there are some new cultivars with high digestibility on the market, worth to be examined in further trials.
The cultivar of *Festuca rupicola* showed worse results on both sites. Related to *Festuca rubra*, it could not profit from its specific competitiveness on extreme dry and nutrient low sites under the existing trial conditions.

Table 2: weed cover in %, dry matter yield (dt ha^{-1} $year^{-1}$) and digestibility of the organic matter (dOM) of the different grass species examined

	number of	weed cover (2008)		DM (2006-2008)		dOM (2006)	
established cultivars	cultivars	Admont	Piber	Admont	Piber	Admont	Piber
Dactylis glomerata	1	3	3	115	130	64	63
Festuca pratensis	2	26	34	116	131	69	61
Festuca rubra	1	21	45	123	136	65	53
Poa pratensis	1	29	77	88	110	66	58
potential new cultivars							
Bromus erectus	2	40	34	97	132	64	65
Bromus inermis	3	48	40	104	122	65	63
Festuca arundinacea	4	29	24	116	132	66	58
Festuca rupicola	1	75	63	80	122	58	58
Festulolium loliaceum	1	25	8	134	151	64	67
Poa angustifolia	2	27	73	89	117	61	61

The cultivar *Festulolium loliaceum* showed significant better values in comparison to *Festuca pratensis* on the dry site at Piber. The weed infestation only reached 8% after three years, DM-yields and dOM showed the highest values on the dry site at Piber. In comparison to the other potential new cultivars, *Festuca loliaceum* could therefore be an alternative grass species for the use in seed mixtures on dry sites. However on the humid site at Admont *Festulolium loliaceum* showed values comparable to *Festuca pratensis.*
The *Poa angustifolia* cultivars showed comparable but slightly higher values than *Poa pratensis* on the dry site at Piber. Here the weed infestation of both species exceeded 70 % representing the highest values of the whole trial. On the humid site Admont, the values were comparable.

Conclusion

Clear differences among the potential new cultivars have been found on the two different sites. The cultivars of *Festuca arundinacea* and *Festulolium loliaceum* performed promising under the dry conditions in terms of productivity and endurance and should therefore be further tested for grassland seed mixtures on dry sites of Austria. To guarantee high forage quality on dry sites of Austria in the future, breeding of varieties from *Bromus erectus* and *Bromus inermis* should also be taken in consideration. The cultivars of *Festuca rupicola, Poa pratensis and Poa angustifolia* performed very badly and are therefore no alternatives to already established cultivars. For continuative information about yield, energy content and endurance of promising species and varieties they should be implemented into seed mixtures for grassland and again tested at several sites.

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