Agronomy Research **9** (Special Issue II), 479–488, 2011

The Effect of Grassland-based Forages on Milk Quality and Quantity

P. Stypinski

Warsaw University of Life Sciences (SGGW), Department of Agronomy
Nowoursynowska 159, 02-776 Warsaw, Poland, piotr_stypinski@sggw.pl

Abstract: Grassland is the first land use in the agricultural areas (AA) of Europe, covering, with rangeland, 56 million ha (33% of AA in EU). Grasslands are characterized by multiple functions and values but one of the most important is forage production for ruminants. In the "grassland region" milk production is connected with grassland management and proper utilisation, whereas in other parts of Europe milk production is based on maize and concentrates. Unfortunately, grassland, particularly grazing, seems to be less important than in the past. Milk quality depends on animal feed. Milk and meat produced from grassland, particularly from botanically diverse pastures, have higher concentrations of those fatty acids and antioxidants which are considered to be of benefit to human health.

Key words: fatty acid, grassland management, grassland potential, milk quality

INTRODUCTION

Grassland is the first land use in the agricultural areas (AA) of Europe. Grasslands and rangeland cover 56 million ha (33% of AA in EU), including about 17.5 million ha of rangelands (10% of AA), mainly in the mountain areas (EUROSTAT, 2008), (Peeters, 2009). However these numbers hide large differences among Member States of the EU: for example in the UK 65% of AA is covered by grassland, in Ireland more than 70%, while in Eastern Europe the proportion is lower, e.g. Poland (21%), Estonia (25%), Romania 33% (Table 1).

The seasonality of production of grassland and forage is primarily influenced by temperature and soil moisture which limit the length and determine the intensity of the growing season. In most of Europe, temperature dictates the main seasonal trends in herbage growth but in southern and Eastern Europe, in particular, summer trends are conditioned by the availability of soil moisture (Laidlaw et al., 2006). Milk production per 1 ha of agricultural land is generally connected with the share of grassland in total agricultural lands; the best milk productivity is observed in the Atlantic zone of Europe (Smit et al., 2008).

Dry matter production, forage quality, management, stocking rate and animal production differ in some European regions depending on many factors. Low production sward can only produce annually about 2–3 tonnes of dry matter (DM) per ha, while in contrast high production sward can yield as much as 10–12 t DM or even 15-20 t DM under good management and production conditions, and is usually used for

dairy cows. Grasslands are characterized by multiple functions and values. They provide forage for grazing and browsing animals, both domestic and wild, and support rural economies, functioning as the major source of livelihood for local communities. Grassland landscapes are aesthetically pleasing, provide recreation opportunities, open space and improve the quality of life of the whole society (Peeters, 2008).

Table 1. The percentage of grassland in agricultural land (AA) in different EU countries by EURASTAT, 2008.

Country	% of AA	Country	% of AA
Malta	0,0	France	33.4
Finland	1.3	Latvia	35.3
Cyprus	2.0	Belgium	35.7
Denmark	11.5	Bulgaria	35.8
Sweden	15.6	Spain	35.9
Hungary	18.6	EU	39.5
Poland	21.4	Portugal	48.6
Czech Republic	23.3	Netherlands	52.6
Estonia	25.0	Austria	54.5
Slovakia	26.3	Greece	54.8
Germany	28.8	Slovenia	60.0
Italy	29.9	UK	65.9
Lithuania	32.1	Luxembourg	70.0
Romania	32.4	Ireland	71.4

According to many studies grasslands in Europe have a huge potential for dry matter productivity (Fig. 1) and could be a source of good and cheap forage for ruminants. In some regions of Europe farmers have tried to reduce production costs by better use of grazing and grass silage. In the “grassland region” milk production is dependent upon grassland management and proper utilisation. In other parts of Europe milk production is based on maize and concentrates. Unfortunately, grassland, particularly for grazing, seems to be less important than in the past (Van den Pol-van Dasselaar et al., 2008).

According to the high feeding value and low cost of animal feeding it seems to be logical that grasslands should be used primarily for milk and beef production. The specialization of production resulted in the progressive disappearance of rotation farming. Some regions specialized in arable crops while others, usually rich in grassland, specialized in animal husbandry. Animal breeds were specialized for milk or

meat production, while dual-purpose breed populations were reduced. Dairy systems were concentrated in the lowland (74% of EU dairy cows) especially in the Atlantic climatic zone; beef meat production occupied more marginal soils and climates.

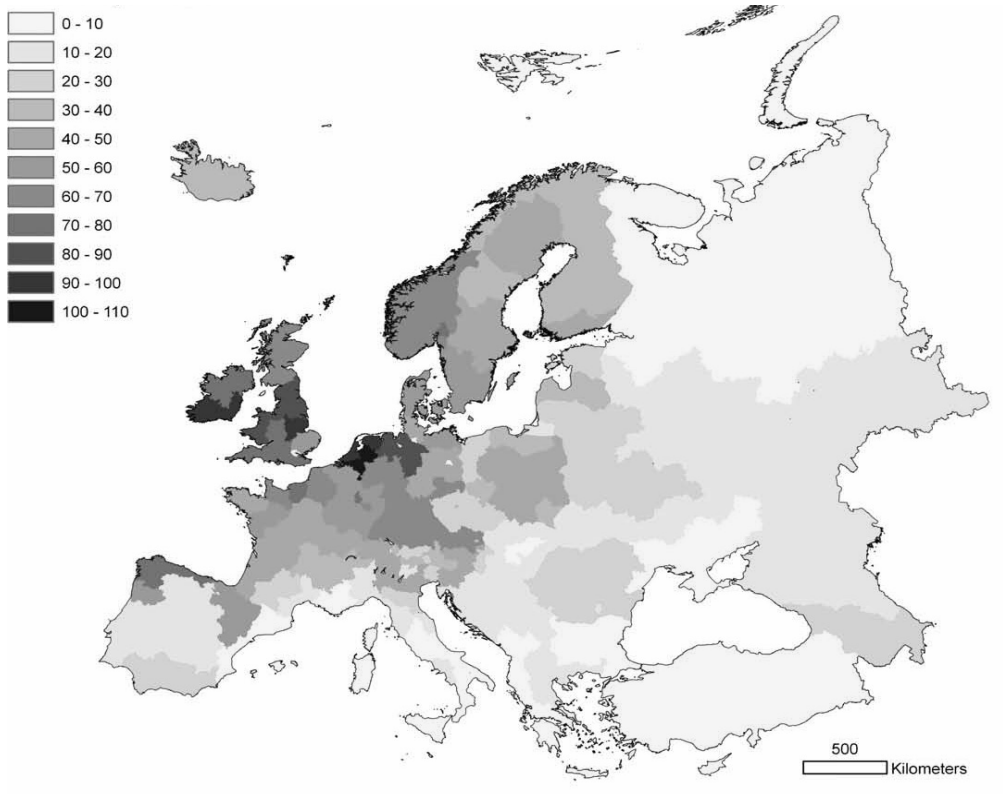

Figure 1. The potential grassland productivity in decitons per hectare in Europe (Smit et al., 2008).

As a consequence of specialization, animal performance increased from an average of 4,500 litres of milk per cow/per year to 7,500 l per cow, in the 1970s, while some herds or cows are now reaching an annual production of 10,000 to 12,000 l per cow (Peeters, 2008). In the northwestern European countries it is possible to achieve high milk production, with an estimated annual milk yield of 9,000–13,000 kg ha^{-1} of forage crops (Kristensen et al., 2005). Milk production in Europe is variable depending on the region, but generally it is a relationship between the area of grassland and total milk production according to date, as shown by Smit et al. (2008). There are many reasons for differences in average milk yield in European countries, but enlargement of the European Union affected increased performance per cow in the majority of member countries. On the European milk market, yield per cow is less important than milk obtained from a unit of agricultural land (Fig. 2).

The increase in animal performance and average milk yield per cow and per 1 ha AA was one of the effects of CAP, but in that same time frame the decrease of the cattle population in Europe was observed. Farmers did not trust grass quality and grass intake potential of their high-yielding cows and tended to use more maize silage at the expense of grass razing and grass silage. Thus they tend to keep cows indoors, partially, or to systematically complement grass grazing with maize silage. The result has been a decrease of grassland in the percentage of agricultural land (AA). It is also clear that average grassland yield is connected mostly to the number of animals, as we can see in the Polish example. Unfavourable soil conditions accompanied by worsening climatic conditions could be one explanation of lower agricultural productivity, but in the case of grassland management the yields are also connected with animal production and stocking rate.

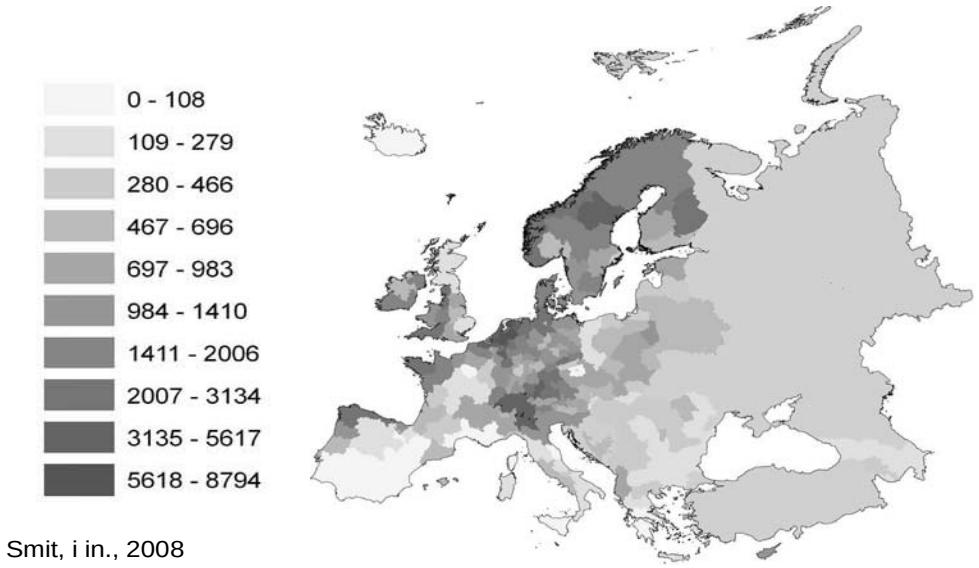

Figure 2. Milk production in kg per ha of agricultural land (Smit et al., 2008).

As has been presented by Stypinski et al. (2009), the number of cattle decreased in Poland during the last decade from 8 to 5.5 million; the decrease was correlated with dry matter yield (Fig. 3).

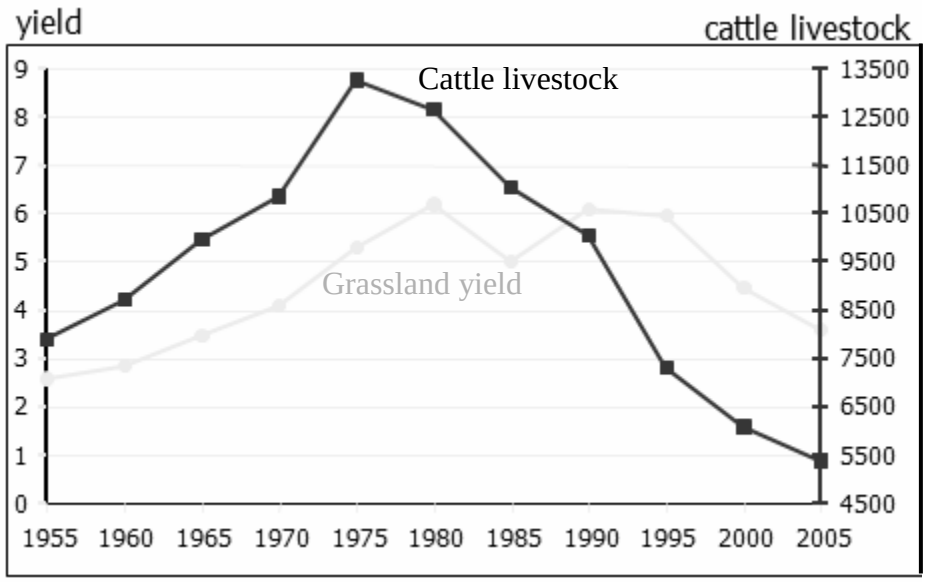

Figure 3. Cattle livestock (thousands head) and grassland yields (t ha^{-1}) in Poland during the years 1955–2005.

A similar situation has occurred in the "old member" countries of the EU. During the last 20 years dairy cow stock decreased on an average of 30–50% in Spain and as much as 75% in Portugal. Milk yield per cow has recently increased in Europe, for example, in Poland from 3,453 in 2000 to 4,455 litres per cow in 2009, but it is still considerably lower than in the EU (Table 2). It is necessary to underline also that animal feed itself has changed during that time. Farmers now use more concentrates and maize silages, and grassland production seems to be less important; farmers are not very interested in increasing grassland yield.

Grassland versus other crops for forage potential and milk production

In order to understand and to forecast the potential role of grassland in the European farming systems it is necessary to compare grassland with other main forage crops. It is known that the feeding value of hay and pasture sward is rather good but it is changing because of environmental conditions, fertilization, management and method of conservation. A poor-quality, low digestibility hay has high fibre (crude fibre (CF) about 35–40% of DM) and low protein content (crude protein (CP) about 6.25% of DM) while a highly digestible young grass is fibre-poor (CF about 15–20% of DM) and protein-rich (CP about 18–22% of DM; Peeters, 2008). If we compare the feeding value of some basic forage used in dairy cattle feed we can conclude that conserved and grazed grasses are complete feeds, rich in energy, protein and minerals. Sometimes grazed grass is even too rich in protein and vitamin K, and must be complemented by energy-rich and protein-poor feeds like maize silage. Grazed pasture is usually a cost effective feed option for producers and in recent years, pasture-based systems have come to be regarded as more environmentally and animal–welfare friendly alternatives to intensive/feedlot systems of production (Moloney et al., 2008).

Table 2. The average annual milk production per cow in different EU countries.

Country	Milk production, kg cow^{-1} year^{-1}	Country	Milk production, kg cow^{-1} year^{-1}
Romania	3260	EU	6013
Bulgaria	3280	Italy	6064
Greece	3647	France	6240
Poland	4420	Portugal	6264
Latvia	4598	Czech Republic	6470
Ireland	4751	Hungary	6691
Lithuania	5005	Spain	6850
Malta	5334	Luxembourg	6914
Slovakia	5407	Germany	6923
Estonia	5589	UK	7187
Slovenia	5813	Netherlands	7450
Cyprus	5885	Finland	7706
Austria	5955	Sweden	8162
Belgium	5981	Denmark	8288

The sensory quality of food can be defined by the texture, odor, aroma and taste. The sensory quality of dairy products is influenced by the manufacturing process applied but it can be also be strongly modified by animal diet (Coulon & Priolo, 2002). The influence of feed type (e.g. maize silage vs. grass silage or hay) and method of forage conservation is well documented for butter and cheese. Apart from well-known effects of certain specific plants like cabbage, garlic or onion on milk or cheese off-flavors, the specific effect of the botanical composition of pasture sward still needs more studies. The influence of botanically diverse pasture on milk sensory properties has been studied in experiments in France. The sensory panelists were not able to discriminate between the milk from different types of grassland. The authors conclude that the variability of the floristic composition of grassland does not impact the sensory properties of milk (Moloney et al., 2008). On the other hand, however, cheese makers and very often consumers believe that botanical composition has an important influence on cheese sensory parameters.

One of the important tasks of many research trials being carried out on grassland is to explain the impact of species richness on chemical composition of the herbage and animal performance. Intensification of grassland production causes the increase of total biomass yield but as it was shown by Huyghe et al. (2008), there is a negative relationship between biomass production and dry matter digestibility. It means that even if we are able to obtain high dry matter yield, lower digestibility could be a reason for worsened animal intake and consequently lower milk production. Species diversity

may have a positive effect on voluntary intake as diversity offers a choice of herbage species and choice was shown to significantly increase intake in pasture (Huyge et al., 2008). We are able to improve the feeding value of some grass and legumes by genetic improvements of cultivars (contents of water soluble carbohydrate WSC or some enzymes like polyphenol oxidase) but the feeding value of some forbs in feed quality is still not fully understood.

Grassland management systems and animal feeding also have an important effect on feeding value. Grazing seems to be the best method for animal feeding and for many reasons grazing sward should be the key source of forage for dairy cows. In practice however, milk production in Eastern and Southern Europe is still being moved from grassland to arable land (Roeder et al., 2007). A similar trend is being observed in Poland, Slovakia and the Czech Republic (Stypinski et al., 2009) and even extra agro-environmental substitutes do not increase the cause of more farmers showing interest in grassland, because, unlike arable land, it is not attractive from an economic point of view (Stypinski et al., 2006). In large dairy cattle farms changes in the fodder area are also being observed. The permanent grasslands are used less intensively, and the area for production of legumes has rapidly decreased with an increase of maize for feed (silage). It should be underlined that even good pasture sward fulfils only part of the animals' complete feeding needs, and allows production of only about 20 kg of milk per day per cow. For higher production the use of supplementary food is absolutely necessary.

In Poland, there exists a big difference between pasture potential and practical implementation. Farmers very often do not give enough attention and effort into pasture management; on the other hand some good milk producers prefer keeping and feeding animals indoors instead of grazing them on pastures. The area of pastures has decreased in Poland recently, and a similar problem is being observed in other European countries; the question "To graze or not to graze? – that is the question" is still very important in grassland management (Van den Pol-van Dasselaar et al., 2008). Current trends in livestock farming in Europe are causing a decline in the popularity of grazing systems for dairy cows. Especially in the last few years the number of dairy cows which are kept indoors for all or part of the summer has increased considerably. This trend has been observed not only in Finland, Netherlands, Germany, Belgium and the UK (Van den Pol-van Dasselaar et al., 2008), but in Central Europe as well (Stypinski et al., 2009). Grazing affects both grass yield and grass utilization. Grazing has a relatively low gross dry matter production compared to cutting only. Unrestricted grazing results in the lowest intake of net energy available for lactation due to the combination of relatively low production and relatively large grazing losses (Van den Pol-van Dasselaar et al., 2008). On the other hand, however, grazing has many advantages: for example, it provides a much broader scope for natural behavior compared with conventional cubicle sheds.

Effect of grazing on fatty acid composition of milk

High-fat diets, especially those rich in saturated fats, can elicit detrimental effects on cardiovascular disease risk factors e.g., blood low density lipoprotein cholesterol (LDL) (Elgersma et al., 2006). Milk fat contains approximately 70% saturated, 25% monosaturated and 5% polyunsaturated fatty acids but this can be modified by changing the animal diet. Milk plays a key role in the fatty acids balance and content in

the human diet and it should be underlined that milk FA composition is mainly related to the FA composition of the animals' feed, and the effect of forage and feeding systems.

Results of many studies indicate that milk and meat produced from grassland, particularly from botanically diverse pastures, have higher concentrations of fatty acid and antioxidants which are considered to be a benefit to human health (Moloney, 2008). The grazing system affects the fatty acid composition of milk. The content of unsaturated fatty acids in milk increases when cattle are grazed, as has been shown by Elgersma et al. (2003) and Moloney et al. (2008). The World Health Organization (WHO, 2003) recommends that total fat, saturated fatty acids (SFA), ω -6 polyunsaturated fatty acids (PUFA), ω -3 PUFA and trans fatty acids should contribute, 15–30%, < 10%, 5–8%, < 1.2 and < 1% of total energy intake by humans, respectively (Moloney et al., 2008). Reducing the intake of SFA and increasing the intake of ω -3 PUFAs are particularly recommended. Meat, fish, fish oil and eggs are important sources of ω -3 PUFA, while beef and other ruminant products such as milk are dietary sources of conjugated linoleic acid (CLA). Feeding fresh grass or grass silage (rich in linolenic acid) compared to concentrates (rich in linoleic acid) results in higher concentrations of ω -3 PUFA and CLA in ruminant milk (Elgersma et al., 2006; Moloney et al., 2008). Linoleic acid (C18:2) and linolenic acid (C18:3) in feed are the precursors of conjugated linoleic acid (CLA) in milk and meat. Moreover, the linolenic acid content in forage also increases the content of ω -3 fatty acids in these products (Wyss et al., 2006).

Quantifying the concentration and composition of fatty acids in grasses in response to environmental factors could help farmers and advisors to design management strategies to increase precursors for beneficial FA in products from ruminants (Elgersma et al., 2006). Dewhust & King (1998) studied the effect on ensiling on the fatty acids in the feed content. Wilting prior to ensiling reduced the content of total fatty acids by almost 30%, and for linolenic acid, even 40%. Haymaking reduced the total FA by over 50%, resulting in an even higher percentage of loss of linolenic acid, and similar observations were seen in haylage (Elgersma et al., 2008; Elgersma et al., 2003). It has been well documented that nitrogen fertilization has a positive effect on FA concentration in grass. A significant relationship was observed between the nitrogen application dose and contents of C16:0, C18:2 and C18:3 in the herbage. Strong positive overall linear relation was also found between the concentration of total FA and C18:3 with the N concentration in the herbage (Witkowska et al., 2011). According to many previous studies (Elgersma et al., 2006) cows grazing the fresh grass on pastures with a high herbage allowance produce milk with the highest concentration of PUFAs (ω -6 polyunsaturated fatty acids). Experiments showed a quick response of the CLA content in milk by changing cows from indoor feeding to pasturing and *vice versa*.

The concentration of five major fatty acids in forage depends on the botanical composition of grassland sward. It is however not so easy to prove the direct effect of plant species on the chemical composition of milk, especially on the fatty acid profile of milk fat. On the basis of three years of trials with different grass-clover mixtures, Wyss et al. (2006) concluded that it was difficult to see any differences between grasses and that legume and fatty acid composition of the three mixtures was similar.

Human intake of FA is related to milk production and total milk consumption; ruminant products are the main source of CLA intake. The beneficial effect of unsaturated fats in commonly accepted, and it could be predicted that in the future a special premium will be paid to those farmers who produce milk from grazed grass. This kind of premium has been already paid to small dairy cooperatives in the Netherlands and producers obtain a special price for good quality milk with higher CLA concentration (Elgersma, 2006).

CONCLUSIONS

Milk production per 1 ha of agricultural land is generally related to the share of grassland in total agricultural lands; the best milk productivity in Europe is observed in the Atlantic zone. Grasslands in Europe have a huge potential for dry matter productivity and could be an important source of good and cheap forage for ruminants.

In some regions of Europe farmers have tried to reduce production costs by a better use of grazing and grass silage, but, in contrast, milk production is based on maize and concentrates in some other areas of Europe. Especially in the last few years the number of dairy cows which are kept indoors for all or part of the summer has increased considerably. That could be changed, however, if farmers apply animal welfare standards and pay more attention to food safety and environmentally friendly management.

One of the key factors of the future milk market should be milk quality. It is a challenge for farmers because milk quality can be changed by feeding strategy and there are long-term strategies for animal breeding and husbandry. Results of many studies indicate that milk and meat produced from grassland, particularly from botanically diverse pastures, have higher concentrations of those fatty acids and antioxidants which are considered to benefit human health. The grazing system affects the fatty acid composition of milk but still more research must be done to explain, for example, the effects of the botanical composition or forage conservation on milk quality. Primary milk producers should be interested in improving milk quality because they are able to obtain special benefit from the higher market value at the end of the food chain.

REFERENCES

Coulon, J. B. & Priolo, A. 2002. Influence of forage feeding on the composition and organoleptic properties of meat and dairy products, bases for “terroir” effect. *Grassland Science in Europe* **7**, 513–524.

Dewhurst, R. J. & King, P. J. 1998. Effect of extended wilting, shading and chemical additives on the fatty acids in laboratory grass silage. *Grass and Forage Science* **53**, 219–224.

Elgersma, A., Tamminga, S. & Ellen, G. 2003. Comparison of the effect of grazing and zero grazing of grass on milk fatty acid composition of dairy cows. *Grassland Science in Europe* **8**, 271–274.

Elgersma, A., Tamminga, S. & Ellen, G. 2006. Modifying milk composition through forage. *Animal Feed science and Technology* **131**, 207–225.

Elgersma, A., Wever, A. C. & Nalecz-Tarwacka, T. 2006. Grazing versus indoor feeding: effect on milk quality *Grassland Science in Europe* **11**, 419–427.
EUROSTAT 2008. htpp//www.eurostat.ec.europa.
Huyghe, C., Baumont, R. & Isselstein, J. 2008. Plant diversity in grassland and feed quality *Grassland Science in Europe* **8**, 75–386.
Kristensen, T., Soegard, K. & Kristensen, I. S. 2005. Management of grasslands in intensive dairy livestock farming *Livestock Production Science* **96**, 61–73.
Laidlaw, A. S., Nesheim, L., Frame, J. & Pineiro, L. 2006. Overcoming seasonal constraints to production and utilization of forage in Europe *Grassland Science in Europe* **11**, 29–43.
Moloney, A. P., Fievez, V., Martin, B., Nute, G. R. & Richardson, R. L. 2008. Botanically diverse forage–based rations for cattle: implication for product composition, product quality and consumer health. *Grassland Science in Europe* . **13**, 361–374.
Peeters, A. 2008. Challenges for grassland-based systems and their production potential in Europe *Grassland Science in Europe*, **13**, 9–24.
Roeder, N., Hennesy, T. & Stilmant, D. 2007. Impact of CAP reform on the use of pastoral land in Europe. *Grassland Science in Europe* **12**, 445–463.
Smit, H. J., Metzger, M. J. & Ewert, F. 2008. Spatial distribution of grassland productivity and land use in Europe.*Agricultural Systems* **98**, 208–219.
Stypinski, P., Hejduk, S., Svobodova, M., Hakl, I. & Rataj, D. 2009. Development, current state and changes in grassland in the past year. In *Grassland Science in Europe* **14**, 1–10.
Stypinski, P., Mastalerczuk, G. & Sienkiewicz-Paderewska, D. 2006. Grassland production, biodiversity and stability in *Grassland – part of mountains agriculture and landscape*. GMARI Banska Bystica, Slovakia, pp. 186–191.
Van den Pol-van Dasselaar, A., Vellinga, T. V., Johansen, A. & Kennedy, E. 2008. To graze or not to graze, that's the question. *Grassland Science in Europe* **13**. 706–716.
Witkowska, I. C., Wever, A. C. & Elgersma, A. 2006. Factors affecting the fatty acid patterns of *LoliumpPerenne* L. *Grassland Science in Europe* **11**, 454–456.
Wyss, U., Morel, I. & Collomb, M. 2006. Fatty acid content of three grass/clover mixtures. *Grassland Science in Europe* **11**, 348–350.