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Importance and Functions of Grasslands

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Abstract

Grasslands, mixture of grass, clover and other leguminous species, dicotyledonous, herbs and shrubs, contribute to a high degree to the struggle against erosion and to the regularizing of water regimes, to the purification of fertilizers and pesticides and to biodiversity and they have aesthetic role and recreational function as far as they provide public access that other agricultural uses do not allow. Grassland will continue to be an important form of land use in Europe, but with increased diversity in management objectives and systems used. Besides its role as basic nutrient for herbivores and ruminants, grasslands have opportunities for an adding value by exploiting positive health characteristics in animal products from grassland and through the delivery of environmental benefits. But even for grassland it is very difficult to create a good frame for its different tasks (1) the provision of forage for livestock, (2) protection and conservation of soil and water resources, (3) furnishing a habitat for wildlife, both flora and fauna and (4) contribution to the attractiveness of the landscape. Nevertheless it is the only crop able to fulfil so many tasks and to fit so many requirements. In this article the focus is limited to the grass and clover components of the grasslands.

Keywords: grass quality, ruminants, EU policy, forage, food, fuel

Introduction

Since mankind, human activities have been influencing grassland management. The most important one are the breeding activities since the early thirties in the last century. Improvement of yield and quality was not only in favour of agriculture, but also a lot of grass species were bred for amenity purposes, parks and sport fields.

Worldwide, grasslands cover about 3500 million ha, more than the double of arable land. On the European continent it is the opposite: only 230 million ha of grassland for 300 million ha of arable land, although, the 27 EU Member States converted about 4 million ha of grassland to arable land in the last twenty years, mostly to grow maize. Besides their natural aspect, grasslands have a pure agricultural destination as a primary food source for wild herbivores and domesticated ruminants. Actually, grasslands, being a mixture of different grass species, legumes and herbs, act as carbon sinks, erosion preventives, birds directive areas, habitat for small animals, nitrogen fixation source. As such, most grassland is in harmony and in balance with the environment, excepted intensively used ones.

No other crop in the world has such a wide range of applications and utilizations. In this paper we will summarise the importance of these different grassland functions: (1) the provision of forage for livestock, (2) protection and conservation of soil and water resources, (3) furnishing a habitat for wildlife, both flora and fauna and (4) contribution to the attractiveness of the landscape.

Although grasslands are a mixture of grass species, clover species and other leguminous, dicotyledonous, herbs and even shrubs, this paper focus only in detail to some characteristics of grass and clover species. Besides, there is only interest for improving yield and quality of a small number of grass and clover species.

Different Roles of Grasslands and Grass Species

Grass for ruminants

In many countries of the world, pastoral rangelands are the primary and only resource on which both wild and domesticated herbivores depend. As the human population has increased, pastures has been converted into cropland, resulting in an overgrazing of the remaining grasslands.

The grassland area decreased in Western Europe with at least 8 million ha since the fifties. In the same period other traditional forage crops, like fodder beets and red clover almost disappeared, while the cultivation of the maize became more popular. Western European dairy farms are nowadays mostly based on the cultivation of two crops: grassland and maize.

Man's understanding of the principles of herbivore nutrition and the laboratory techniques to determine them, together with the plant yield and quality production have advanced significantly and nowadays, in intensive production systems, the dietary requirements are calculated with high precision.

Since World War II, plant breeding, land improvement and the use of fertilisers and pesticides have been applied as means of increasing primary production. In countries where pasture production is highly seasonal, countries with either cold winters or hot dry summers, feeding systems using cereals (especially maize cultivation) and protein-rich supplements (soybean meal), as well as crop by-products (sugar beet pulp, swill) have been developed to meet the nutritional needs of herbivores when there is insufficient grass to graze to meet the animals needs for maintenance, pregnancy and meat and milk production. In countries with plenty of cheap available cereals, pulses and crop by-products, feedlot systems have been developed in which cattle never feel a need to utilise pastoral resources at all. Since the bovine spongiform encephalopathy (BSE) crises an important protein rich by-product, meat and bone meal, is forbidden for incorporation and use in animal feed.

Grasslands and food supply

In the EU, there has been a continuous surplus of food products since 1980 and the common agricultural policy (CAP) has been reviewed and adapted several times. The last reform of 2003 intents:

- to contribute substantially to the stabilisation of the farmers' income and at the same time to the diversification of their farming activities;
- to be a credible answer to the demands of our citizens for healthy food, better quality, and environmentally sound production methods which respect animal welfare principles;
- to help to improve the public image of and support for the common agricultural policy;
- to send a clear message to our trading partners, including in particular the developing countries.

In relation to plant products, animal products account for a relatively small proportion (< 10%) of food consumed by the human population of the world. However, if the people in the Third World attempt to obtain also 30% of their calories from animal products, like we do, only a population of 2.5 billion people could be sustained. This is because of the low efficiency (conversion ration of 0.068 as estimated by Vitousek *et al.*, 1986) of conversion plant material into human food by livestock. Despite the relatively low contribution that herbivores make directly to the diet of the human population of the world, herbivores do have the ability to convert sources of protein and energy into food products that would otherwise be unavailable to humans. About a quarter of the total global land resource (13 billion ha, Morris 1995) is represented by pastures suitable for utilisation by herbivores. From the 3500 million ha classified as grasslands, half of his area is indicated as natural grasslands. In the EU 15 we had in the year 2000 about 55 million ha of grasslands.

Since 1990 (the reference year in the Kyoto Protocol) some 3 million hectares of grassland are converted to arable land, especially for maize cultivation (Carlier *et al.*, 2003). The EU enlarged its grassland area with about 20 million ha (+ 36%) and with 45 million ha of arable land (+ 53%), since the new membership of 12 CEEC countries.

Genetic developments in grasslands

The development of new varieties, better adapted to biotic and abiotic stress situations (diseases, climate) and the application of new technologies in pasture management with high fertiliser (nitrogen) input has resulted in a substantially increased output in yield and quality. Breeding work resulted in tetraploid varieties with some specific characteristics (Carlier 1974) and interspecific crossing (cisgenese) grass species (e.g. *Festulolium* varieties). The possibilities of the characteristic pathways for C4 *Gramineae* for a more efficient water use, a higher dry matter production per unit of time and area and a higher N efficiency are only exploited in maize cultivation in temperate regions. Nevertheless productions of 10.000 litres of milk or 1000 kg of weight gain per ha of grassland are not exceptional (Ernst *et al.,* 1980). However, impacts of these technologies also cause problems of excessive manure (Ten Berge *et al.*, 2002), of air and water pollution and of perceptions with regard to the reductions in animal welfare. Problems with too high nitrate contents in water sources (> 50 mg/liter), too excessive N, P and K balances on dairy farms (Verbruggen and Carlier, 1996) and unnatural veterinarian help with "caesarean section" for high muscled cows at calving, drove dairy farming far away from the original sustainable production system. Moreover, the disappearance of the complex grass-clover-herbs mixtures by converting native grasslands into monocultures of perennial ryegrass results in a deterioration of the biodiversity. Some specific forage crops like red clover, alfalfa, vetches, fodder beets, etc. disappeared on the much specialised dairy farms. Intensively managed grassland for grazing (summer time) and maize for silage (winter feeding) are almost the two only pillars of the modern dairy farming system in the EU. These negative impacts are no longer politically acceptable and statutory regulations (specific EU regulations and directives) are progressively being introduced to control them.

In July 2002 the European Commission recommended guidelines (2003/556/EC) for the development of national strategies and best practices to ensure the coexistence of genetically modified crops with conventional and organic farming. Up to now there seems to be no interest in changing grasses by genetic engineering (Puia *et al*., 2001), may be because of the difficulties with the interspecific crossing possibilities and the permanent character of grass species (the more permanent and persistent the variety, the less renovation is needed).

Grassland composition

Two types of grass species dominate grasslands at the global scale: C_3 and C_4 species; depending on the first carbohydrate synthesised during the photosynthesis. In Europe most of the grass species belong to the C_3 group. Their optimal temperature for photosynthesis, on average 20°C, is much lower than for C_4 grass species (on average 30°C) and they still have photosynthetic activity above 5°C. Therefore C_3 grass species are much more adapted to grow and to develop in the colder regions. The most important grass species in natural and renovated grassland in Europe is perennial ryegrass (*Lolium perenne* L.). Other important grass species, especially because of their production and/or quality characteristics are Italian ryegrass (*Lolium multiflorum* Lam.), tall fescue (*Festuca arundinacea* L.), meadow fescue (*Festuca pratensis* Hudson), cocksfoot (*Dactylis glomerata* L.), timothy (*Phleum pratense* L.), rough-stalked meadowgrass (*Poa trivialis* L.), smooth-stalked meadowgrass (*Poa pratensis* L.) and bent (*Agrostis spp*).

Besides dicotyledonous plant species (*Taraxacum officinale, Capsela bursa pastoris*), white clover is normally a big part of the botanical composition, especially in natural grasslands and in renovated grassland depending to the sown grass-clover mixture the grassland management (nitrogen fertilisation, cutting regime, grazing density) and season (white clover develops best in summer, while grass species grow better in springtime). The interest for white clover in grassland is renewed since the last decades for its nitrogen symbiosis capacity, due to the limited nitrogen fertilisation of grassland in EU member states, because of the problems caused by nitrate in the soil (Nitrate Directive 91/676/EEC). A good and stable balance between grasses, clover and dicotyledonous species is difficult to reach and to maintain during the whole grazing season. A lot of research data and an enormous quantity of literature about the role of white clover in grassland are available.

In old permanent pastures in Europe, America and Canada one can find grasses infected with endophytes. The most common endpophyte is (*Acremonium) Neotyphodium coenophialum* L. in ryegrass and festuca grass species. Grasses infected with this endophyte produce more alkaloids, like perloline, loline and lolitrem and show a better resistance against stress (drought and diseases) (Carlier and Andries 1984). Publications from American, Canadian and New Zealander authors prove negative animal behaviours (higher temperature, fescued foot, ergotisme) of cattle grazing infected grass, while European researchers never concluded to such negative effects.

The last couple of years there is a lot of interest for the nutritive role of grassland in producing conjugated linoleic acid (CLA) and ω fatty acids. Grasses contain linoleic acid and over half of the total fatty acids consist of ω-3 linoleic acid C 18 : 3n-3). Substantial bio hydrogenation occurs in the rumen, but some of this linoleic acid is absorbed from the digestive tract and appears in ruminant products (Wilkins and Vidrih, 2000). Studies by Dewhurst and King (1998) show substantial differences in contents of ω-3 linoleic acids between grass species and cultivars. There is obvious potential to exploit this finding in marketing products from grass-based cattle breeding. More research is needed to establish the factors determining the extent of bio hydrogenation of these fatty acids in the rumen and to develop methods for minimising these changes. Conjugated linoleic acid (CLA) is a potent anticarcinogen. Linoleic acid has 2 unsaturated positions: position 9 and 11. This unusual structure is associated with remarkable characteristics: the fat and protein metabolism of the body is regulated by an increased muscle formation and a decreased fat content. Milk and meat produced by grazing cattle contain this CLA and have in this respect a much higher nutritive value for mankind.

Grass on dikes, verges and nature reserves

Grasses are the main plant species in verges along roads, railways and on river dikes. It is difficult to get an idea how many hectares are involved in this type of land cover. Along highways, main and small roads, along railways and rivers, strips of some meters of width all over hundreds of kilometres are overgrown with grass, herbs, shrubs and trees. One may count some 3000 m^2 of verges per running km, giving an enormous capacity for carbon sequestration, mostly for a long period of time. Besides the presence of grass species in fallow terrains are also an enormous carbon sink, although in these sites the situation lasts for a long period so that C balance does not change.

In the frame of the EU Directive 2078/92 "Farming practices compatible with the requirements of protection of the environment and natural resources, as well as maintenance of the countryside and the landscape", the member states may conclude agreements with farmers for sowing grass or another cover crop after a main crop (cereals, maize) to prevent the leaching of nitrates and minerals and to prevent wind and water erosion during winter time. In Flanders, the Government contracted 4.240 farmers with about 50.000 hectares for this arrangement in 2006. Under the same Directive, the authorities can make a long term agreement (5-10 years) with farmers for the management of buffer zones (5 m width) between arable land along small streams or a wood for an increasing biodiversity. In Flanders, it means a total area of 1.600 ha under this management system.

In more modern times (1950s) the sugar industry used vetiver grass quite widely as contour conservation hedges and for the stabilization of road sides and embankments. Vetiver once thought to be confined to wetlands thrives over a range of ecological conditions.

In cases, set-aside and riparian buffer zones and woods, concern arable land converted to grassland. But this is only a small fraction of the grassland area lost in Europe during the last decades.

It is clear that these types of grasslands respond very much to the new EU policy for maintaining and enlarging the biodiversity, animal welfare, development of the countryside, etc., directed in the respective regulations and directives.

Grass for amenity purposes

There are a lot of small, varying to very large, grass fields without any agricultural function. More and more agricultural land is used for the urbanisation and the construction of public buildings and private houses. Part of it is reserved for parks and lawns. The private garden and especially the "green grass of home" is in many countries for families the identification of their good feelings. People try to keep their lawn in good condition and even to make it better looking. For private and public organisations parks, sport fields and open areas are mainly composed of different grasses. Mostly specific grass species are bred for these purposes, giving a strong dense green sward, composed of slow growing grasses with good carrying capacity. These grass fields are frequently renovated and the most appropriate species and varieties are used to fit with the requested goal. Besides its amenity role, this type of grassland has almost no other side functions; just its water holding capacity and erosion protection effect are positive factors. For carbon sequestration, development of the biodiversity and improvement of fauna and flora, amenity grass fields seem not be very useful.

In well developed countries, the production of ornamental plants (azaleas roses) is big business, while in other parts of the world drug crops (tobacco, cannabis) are grown. To survive, in Africa and other poor countries, the production of food and feed is the most important. A discussion about the possibility to produce the 5 Fs (food, feed, fibre, fuel and/or fun) is only speculative in rich and well developed areas.

Grass as energy and fuel crop

At the end of 2010 the minimum proportion of bio fuels or other renewable fuels on the market of EU member states must be 5.75% by Directive 2003/30/EC. Research and industry are looking for crop production systems that give biomass productions transferable to bio energy: bio fuels from cell walls (Möller *et al*., 2007).

Poplar, willow, perennial grass species *Miscanthus* and wheat straw, recognized as energy crop for the second generation fuel, are the main sources of biomass relevant to the member states of EU. The currently available biomass for non-food use could be increased by proper selection of the plant species taking in consideration the specificities of particular region. The development of breeding programs for the energy crops based on the scientific findings of plant system biology will allow economically more efficient plants to be selected. Plant genetic modification of these plants via gene transfer methods, is an option for the development of new forms possessing valuable traits such as resistance to biotic and abiotic stress, lower inputs of fertilizers and higher yield of biomass. Obviously this approach has a future, but presently as a whole, the public opinion especially in some countries of the European Union is not positive towards the GMO's.

Poplar tress are transformed in Plant Genetic Systems (Ghent University, Belgium) with a much better cell wall digestibility (lower lignin content); but the Belgian policy didn't allow to grow them outside up to now. Nevertheless the genetically modified crops for energy purposes will be more easily accepted from all stakeholders than transgenic food crops.

Grass for carbon sequestration and for charcoal

Other specific characteristics give grassland more importance. The capacity to store carbon and to act as a carbon sink, in comparison to arable land, its role in the prevention of erosion, the immobilisation of leaching minerals are interesting additional effects in the frame of a sustainable agriculture and development of the countryside.

Grasslands are able to sequester about the double quantity of C in the soil in comparison to arable land (Guo and Gifford, 2003; Mestdagh, 2003; Sleutel, 2003).

In this context is worthwhile to notice that permanent grasslands are sinks for carbon sequestration in comparison to arable land. Although livestock enteric fermentation, manure and the use of inorganic fertilizer account for the major share of agricultural greenhouse gasses (GHG) in most developed countries. In the EU, the contribution of agriculture in the total main GHG, carbon dioxide CO_2 is only about 2%, it accounts for over 50% of total nitrous oxide N_2O and nearly 45% of methane CH_4 emissions. Besides, the global warming potential of CH_4 and N_2O are respectively about 20 and 300 times higher than that of CO_2. So some agricultural activities, especially well fertilised grazed grassland and grassland renovation by ploughing the old sward may lead to high GHG emissions and transform grassland from a carbon sink to a carbon source.

In some countries, especially in C&E European countries (Romania, Bulgaria), farmers have the tradition to burn the stubbles after the harvest. Under this uncontrolled burning, black parts of stems remain. Under controlled anaerobe combustion of plants (300 to 600°C, depending of the technology), volatile components (oils) are collected. The remaining ash is called charcoal. This can be used to improve soil characteristics. Depending of composition of the mixture of grass species, herbs and shrubs, the nature of volatile components will change and so also the composition and characteristics of the charcoal.

Grass for perfumes, alcohols and beverages

Well known is the kind of brandy "Zubrowka bison grass wodka" from Poland with a stem of bison grass (sweet grass: *Hierochloe odorata* L.) as a characteristic in the bottle.

Other coumarin rich grass species are used in the same way, like sweet vernal grass (*Anthoxanthum odoratum* L.) used in tobacco and herb pillows.

There are twelve known varieties of vetiver grass; the most important is *Vetiveria zizanioides* Linn. For centuries the oil extract from the roots of *V. zizanioides* has been used in the perfume trade. Indigenous peoples have recognized vetiver for its medicinal uses, for thatching, mulch, and feed, and for soil and moisture conservation. It grows both on highly acidic (< pH 4) and alkaline soils (pH 11). Its roots will grow to depths of 3 - 4 meters. It is not affected seriously by pests or diseases. Each clump of vetiver is extremely dense, so dense that if con*Fig.*d correctly will act as a near perfect filter. The generic name Vetiver is a Tamil word meaning "root that is dug up" and zizanioides means "by the riverside".

The genus *Cymbopogon* accumulates different kinds of essential oils. The essential oil of *Cymbopogon validus*, which chemical composition is reported by Chagonda *et al*. (2000), has been used as an astringent skin toner and anti-ageing for men and has anti fungal and anti septic properties. The predominant compounds, properties and uses of *Cymbopogon* species are described by Naidoo (2007).

The essential oil of lemon grass *Cymbopogon citratus* (West Indian lemon grass) consists mainly of citral. Further terpenoids in lemon grass oil are nerol, limonene, linalool and β-caryophyllene. The content of myrcene is low, but still enough to make the oil susceptible to oxidative polymerization.

East Indian lemon grass *Cymbopogon flexuosus* oil consists of alcohols citronellol, geraniol) and aldehydes (geranial, neral, citronellal). This species is dominantly used in the perfume industry as it contains less myrcene and, therefore, has a longer shelf life.

Two further species have considerable relevance for the perfume industry: The so-called palmarosa oil is distilled from Cymbopogon martini (Roxb.) J.F. Watson var. martini (native to India, cultivated also in Jawa) and contains mainly geraniol and geranyl acetate. Also worth mentioning is citronella grass (Cymbopogon winterianus Jowitt) which also stems from India, but is today grown throughout the tropics; its main constituents are citronellal, geraniol and citronellol plus minor amounts of geranyl acetate.

EU policy and grasslands

The EU policy has always stimulated intensive farming without encouraging employment. For some cops yield per ha doubled since 1960, but in the meantime the number of farmers has decreased drastically to about 2% of the active population. It is difficult to understand the logic that the former CAP favoured the production of one ha of silage corn to one hectare of grassland ten times more aid. The challenges we had in the West to face at the end of World War II, being cut from our traditional wheat sources, located at the other side of the "Iron Curtain" are disappeared. Between 2004 and 2007, 12 new countries got the EU membership. Most of these countries have a less intensively developed agriculture than the EU 15 with on average about 15% of their people, being active in agriculture. Hopefully the newest CAP vision of the EU, promoting and supporting a less intensive agriculture with a multifunctional task for the farmer will fit with the development of these CEEC countries so that within a decade all members of the CEEC will aim the same goal: a good balance between the social, environmental and economic aspects of agriculture.

The renewed and actualised CAP of the EU (Council Regulation EC No 1782/2003, implemented by the Commission Regulation (EC) No 1973/2004) makes grasslands nowadays more attractive for farmers than before. Article 5.2 of this Council Regulation obligates Member States to ensure all that land which was under permanent pasture at the date provided for the area aid applications for 2003 to be mentioned under permanent pasture. In annex IV the standards for "Good agricultural and environmental conditions" (GAEC) are mentioned with special attention for permanent pasture. The Member States themselves must introduce their own policy in the development of these GAEC, so that the farmers will receive direct payments in return for their responsibilities towards the protection of the environment, animal health and welfare and public health (so called "Cross Compliance").

Conclusions

Grassland will continue to be an important form of land use in Europe, but with increased diversity in management objectives and systems used. There are opportunities for adding value by exploiting positive health characteristics in animal products from grassland and through the delivery of environmental benefits. In fact grasslands contribute to a high degree to the struggle against erosion and to the regularisation of water regimes, to the purification of fertilizers and pesticides and to biodiversity. Finally they have an aesthetic role and recreational function as far as they provide public access that other agricultural uses do not allow.

The evolution of policies that seek to enhance the environmental performance of agriculture will present major challenge to farmers, the agro-food industry, trade relations and policy makers. This will involve reconciling the trade-offs between the need to increase agricultural production to provide food and other agricultural products and services at affordable prices, addressing the social concerns of rural communities, while enhancing environmental conditions in agriculture and expanding trade. The European agricultural policy is not simple and needs to accommodate also social and environmental requirements. Even for grassland it is very difficult to create a good frame for its different tasks (1) the provision of forage for livestock, (2) protection and conservation of soil and water resources, (3) furnishing a habitat for wildlife, both flora and fauna and (4) contribution to the attractiveness of the landscape. Nevertheless, it is the only crop able to fulfil so many tasks and to fit so many requirements.

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