Utilisation and Cultivation of Grassland in the Upper Enns Valley: Vegetation and Ecological Classification, Aspects of Plant Production, Internal Resource Flows, Socioeconomics and Case-Studies of Utilisation

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1. Introduction

The Federal Research Institute for Agriculture in Alpine Regions (=BAL Gumpenstein) has scientifically been working on aspects of grassland farming in mountainous regions for more than 50 years. Many interdisciplinary research projects, dealing with aspects of plant and animal production, economic and ecological affairs, have been carried out and worked on by means of exact field experiments, case and model studies. Within the named MAB - project "Changing Agriculture and Landscape: Ecology, Management and Biodiversity Decline in Anthropogenous Mountain Grassland", the departments for grassland management, botany, soil science, animal production systems and applied economics have been involved and have carried out interdisciplinary research activities in the pilot project region "Styrian Ennstal" (*Figure 1*).

2. Material and methods

The pilot project region, which consists of 5 different communities is located in the upper part of Styria and is representative for mountainous grassland in Austria. The project region includes different geological and topographical conditions and ranges from the valley bottom with about 650 m up to an altitude of more than 1100 m. The agricultural used area of about 3.700 ha is mainly used as grassland, which is the basis for dairy cattle production, only less than 2% is arable land (*Figure 2*).

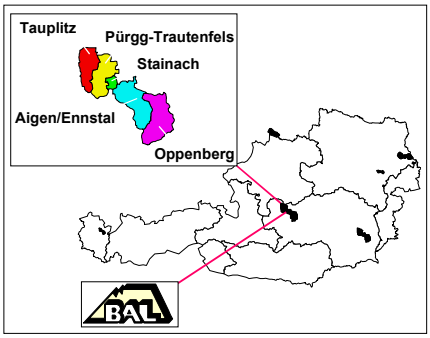

Figure 1: **Location of the pilot project region "Styrian Ennstal", consisting of 5 communities and the location of the Federal Research Institute for Agriculture in Alpine Regions (BAL Gumpenstein)**

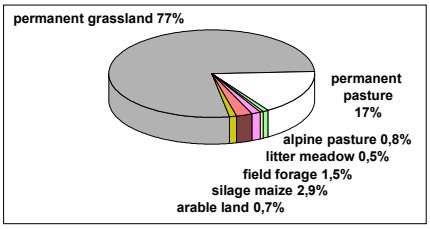

Figure 2: **Structure of the agricultural used area in the pilot project region "Styrian Ennstal"**

The following investigations have been carried out in the pilot project region "Ennstal":

- Comprehensive studies on 65 farms concerning aspects of soil science (262 soil analysis - organic matter, minerals, heavy metals etc.), of botany (more than 180 recordings - plant communities, number of species, floristic biodiversity) and aspects of plant production (forage quality, including energy value, digestibility, crude nutrients etc.).
- Special studies on 6 selected farms regarding plant and animal production (total feed intake, forage intake, feed ration etc.) and economic affairs (costs of mechanization, investments, work load etc.).
- Interrogation studies on 201 farms concerning aspects of farm structure and management intensity (full time farming, part time farming, organic and conventional farming etc.) as well as livestock structure and nutrient fluxes (livestock intensity, nutrient input, nutrient circulation etc.) and socioeconomic aspects (acceptance and statements to the Austrian environmental program for agriculture ÖPUL).

3. Results and discussion

In the BRUNDTLAND-Report (1987) sustainability is discribed as a process, which neither limits the environmental nor the social and economic conditions of future generations. For agriculture this means the reduction of external substances (energy, nutrients, pesticides etc.) and the efficient use of internal resources. On a grassland farm these strategy can mainly be fulfilled by high forage quality (and a therefore high milk amount from forage) and an efficient use of farm manure aiming a well balanced nutrient circulation. From that point of view, aspects of fertilization which strongly influence the interactions between soil, plant and environment are of main interest.

3.1 Origin and use of main nutrients in the pilot project region "Styrian Ennstal"

Regarding the whole federal area of Austria, 58% of the nitrogen that is used in agriculture (arable and grassland farming) comes from farm manure. 42% of the nitrogen comes from artificial fertilizer, which is an external input, that with respect to a well balanced nutrient circulation and an efficient use of internal resources should be reduced. *Table 1* shows the origin of the main nutrients nitrogen, phosphorus and potassium in

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Table 1: **Origin of the main nutrients N,P,K in the pilot project region "Styrian Ennstal" and in total Austria (PÖTSCH, 1999)**

nutrient	manure (kg/year)	total Austria*	mineral fertilizer (kg/year)	total Austria*
N_{tot}	347.828 (91%)	*58%	35.062 (9%)	*42%
P_2O_5	154.590 (77%)	*60%	45.101 (23%)	*40%
K_2O	502.418 (95%)	*82%	27.078 (5%)	*18%

Table 2: **Use of mineral fertilizer in the pilot project region "Styrian Ennstal" (PÖTSCH, 1999)**

kg/ha and year	fertilized grassland	total grassland
min. N	Ø 20	Ø 9
min. P_2O_5	Ø 22	Ø 12
min. K_2O	Ø 18	Ø 7

the pilot project region. More than 90% of the total used nitrogen comes from farm manure, only 9% comes from mineral fertilizer. 77% of phosphorus and even 95% of potassium is based on farm manure.

Per ha fertilized grassland area only about 20 kg mineral nitrogen are applied per year (*Table 2*). This amount is exactly corresponding with the official data for Austria, published by EFMA (1995) and this impressively demonstrates the value of farm manure as an important internal resource (*Figure 3*).

On how many farms mineral nitrogen is used in practice? Altogether not only the 57 organic farms, but also 69 conventional farms gave up the use of additional mineral nitrogen. More than half of the farms in the project region did not use any mineral fertilizer at all!

3.1.1 Use of mineral nitrogen and milk production in the pilot project region "Styrian Ennstal"

The hypothesis, that those farms, which produce high amounts of milk per ha forage area, use more external resources

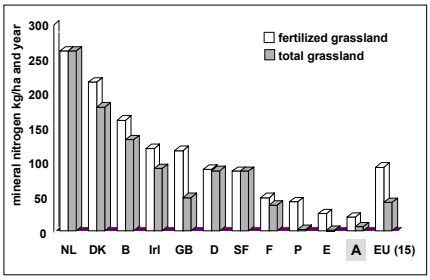

Figure 3: **Use of mineral nitrogen on grassland in Europe (EFMA, 1995)**

for an increase of production, has been also investigated in the project region. *Figure 4* shows, that the named interrelationship only explains about 20% of the variation and either farms with high or low milk production don´t use any mineral nitrogen. This means that the farm manure is not seen as a kind of waste but as a valuable part of the nutrient system on the farm and is therefore used in a very efficient way. On an average about 7.000 kg milk per ha forage area are produced with an input of 20 kg mineral nitrogen per ha and year. A Dutch studie shows that they produce about 13.000 kg milk per ha forage area, but with an input of about 330 kg nitrogen per ha and year, which is fifteen! times more than in the project region.

Table 3 shows the structure of milk production on dairy farms in the project region subdivided in three stages of altitude. Whereas in the bottom of the valley about 65.000 kg milk per farm and year can be produced, only half of this amount can be reached on the very high located farms. This is mainly caused by the lower milk amount per ha forage area for reasons of lower productivity.

Compared to the structure of European dairy farms, the size of Austrian farms and the size of dairy cattle herds is a very small one (*Table 4*). This structure can´t be enlarged easily because of unfavourable climatical and topographical con-

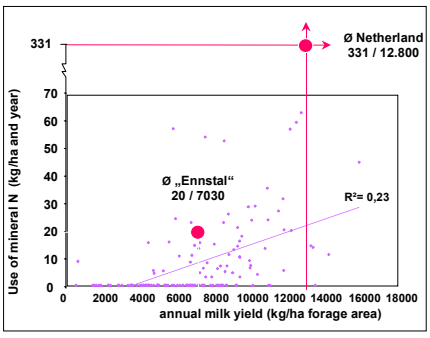

Figure 4: **Use of mineral N-fertilizer on the farms in the pilot project region "Styrian Ennstal", (PÖTSCH, 1999)**

Table 3: **Structure of milk production in the pilot project region "Styrian Ennstal" (BUCHGRABER, 1999)**

altitude	kg milk yield per farm and year		kg milk yield per ha forage area	
< 750 m	65.896	100 %	8.185	100 %
750 - 1100 m	36.934	56 %	6.178	75 %
> 1100 m	34.857	53 %	5.509	67 %

Table 4: **Structure of European dairy farms (BMLF, 1997)**

	A-Quota per farm	dairy cattle/farm
Great Britain	360.000 kg	66,9
Denmark	310.000 kg	50,5
Netherland	268.000 kg	41,6
France	154.000 kg	30,5
Germany	149.000 kg	28,5
Italy	94.000 kg	20,2
Ø EC (15)	143.000 kg	24,3
Austria	36.000 kg	9,2

ditions in most parts of the Austrian grassland region.

3.1.2 N-regional balance (black box balance) for the pilot project region "Styrian Ennstal"

The calculation of nutrient or energy balances is generally considered as a practicable instrument for the documentation of long term ecological impacts, but also as an indicator for the evaluation of environmental measures. The horizon of a nutrient balance can be very different and reaches from a global to an international and regional dimension, down to an area or plot related balance of nutrients and substances. On a farm scale, mainly the so called black-box-balance (only input that goes to and output that leaves the farm is calculated) or an area balance are used.

By means of input and output components, a regional balance for nitrogen, which is of main interest considering ecological and environmental aspects, has been set up. *Table 5* points out and quantifies several parts of that balance. It can be seen, that by means of biological N-fixation the double amount of nitrogen compared to that from mineral fertilizer and concentrate together is brought into the pilot region. About 80.000 kg N are exported by milk and meat, about 85.000 kg N are lost by am-

Table 5: **N-regional balance (black box balance) for the pilot project region "Styrian Ennstal" (PÖTSCH, 1999), data in kg N**

Input components		Output components	
Mineral fertilizer:	35.060	29.200	livestock
litter:	4.560	52.500	milk
concentrate:	42.370	2.870	plant products
other feed:	6.300	85.000	unavoidable losses of NH_3
livestock:	2.670		
biol. N - fixation	142.000		
N - deposition	37.400		
total Input	270.360	169.570	total Output
⇨ balance:	+ 100.790 kg N	⇨ 27 kgN/ha	

monia volatilization from the storage up to the application of farm manure on the field. Denitrification losses as well as mineralization and accumulation in the soil have not been considered. For the total project region a surplus of about 100.000 kg N has been calculated. This results a surplus of 27 kg N per ha, which compared to data of other European countries can be tolerated.

3.1.3 Use of concentrates on dairy farms in the pilot project region "Styrian Ennstal"

As another external nutrient resource, concentrate and its use has to be considered on grassland farms (*Figure 5*). The interrelationship between the use of concentrate and the milk production was also a rather weak one in the pilot region. On an average of all dairy farms 560 kg concentrate was used per cow and year for the production of Ø 7.030 kg milk per ha forage area.

This indicates that beside the efficient use of farm manure, there is another important farm resource, namely forage from meadows and pastures. The forage quality plays an important role for the feeding strategy - the higher the forage quality, the more the amount of (external) concentrate can be reduced. The named Dutch studie shows, that the average input of concentrate amounts to about 2.000 kg per cow and year, which in addition to the high input of mineral nitrogen an area independend kind of production.

3.2 Forage quantity and forage quality in the pilot project region "Styrian Ennstal"

The forage yield of extensive used grassland amounted from 20 to 60 dt DM per ha and year with nearly no influence

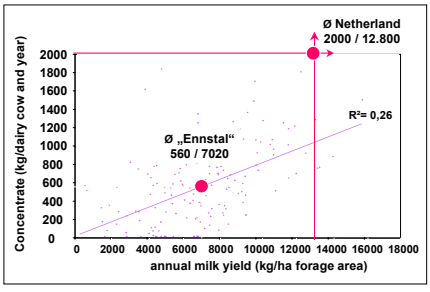

Figure 5: **Use of concentrates on the farms in the pilot project region "Styrian Ennstal" (PÖTSCH, 1999)**

Table 6: **Yield amount of different types of agricultural used grassland in the pilot project region "Styrian Ennstal" (BUCHGRABER, 1999)**

altitude	extensive areas one cut areas extensive pastures, litter meadows	two cut areas +/- pasture	three cut areas +/- pasture	cultivated pasture mowing pasture ley farming areas
< 750 m	37,9 +- 15,0	70,2 +- 19,9	89,4 +- 13,8	94,1 +- 14,6
750 - 1100 m	32,3 +- 14,8	65,1 +- 11,1	80,3 +- 8,4	68,3 +- 14,1
> 1100 m	37,6 +- 12,3	68,0 +- 13,5	(78,0 +- 1,0)	48,7 +- 13,1

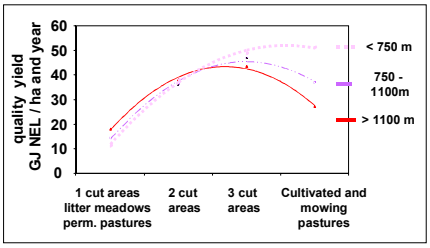

Figure 6: **Quality yield amount of different used grassland in the pilot project region "Styrian Ennstal" (BUCHGRABER, 1999)**

by different altitude (*Table 6*). Extensive pastures showed the lowest, litter meadows the highest yield amounts. The forage yield of areas with two and three cuts per year amounted from 65 to 80 dt DM per ha and year.

Cultivated meadows and mowing pastures showed the highest yield amounts in the bottom of the valley but a strong depression with increasing altitude. The reason is, that the favourable areas in the bottom of the valley are exclusively used by mowing, whereas the steeper areas are more and more used by grazing.

The line graph in *Figure 6* indicates the development of the quality yield amount (MJ NEL per ha) - this is the product of yield quantity (kg DM per ha) and yield quality (MJ Net Energy Lactation per kg DM) - in different altitude. It can be seen, that there is a reduction of the quality yield amount with increasing altitude beginning from a utilization frequency of two cuts per year. This reduction is mainly influenced by a decrease of the yield quantity (short vegetation period, deeper temperatures, longer time of snow blanket etc.). So mountain farmers not only have higher work load (GREIMEL, 1999), higher costs of mechanization etc., but they also have more unfavourable conditions in plant production.

3.3 Botanical aspects in the pilot project region "Styrian Ennstal"

Comprehensive botanical investigations and recordings have been carried out in the pilot project region. The results have been structured into three main groups: more intensive grassland, extensive grassland on moderate dry to fresh locations and extensive grassland on moist to wet locations (BOHNER et.al, 1999). At all 16 different plant communities on agricultural used grassland could be named out and 416 different vascular plant species could be found and determined, including about 20 red book species!

Table 7 shows the amount of vascular plants in different types of grassland subdivided in three altitude levels. Concerning the overall number (right columne) and the total number (last line), a reduction of species can be notized with higher altitude as well as with intensive utilization. Nevertheless, even three cut areas or cultivated pastures should a relatively high number of different species compared to the poor bio-diversity on intensive grassland in some European countries with high input systems.

3.4 Acceptance of the Austrian environmental program for agriculture in the pilot project region "Styrian Ennstal"

In most of the EU-countries, environmental programs according the EU regulation 2078/92, have been set up. In

Table 7: **Number of vascular plant species on meadows and pastures in pilot project region "Styrian Ennstal"**

	meadows			pastures		
altitude	1 cut	2 cuts	3 cuts	cultiv.	perm.	overall
< 750 m	167	137	143	103	106	293
750 - 1100 m	167	177	111	59	191	321
>1100 m	52	115	60	101	137	212
total number	254	230	167	141	254	416

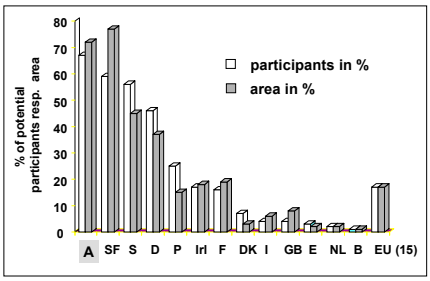

Figure 7: **Acceptance of environmental programs for agriculture in different countries of the EU**

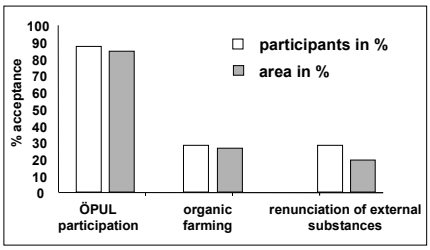

Figure 8: **Acceptance of ÖPUL in the pilot project region "Styrian Ennstal"**

opposite to other countries, the Austrian program "ÖPUL" is offered to the farmers over the total Austrian area. The acceptance for such programs can be seen as a kind of indicator for the readiness to change into more sustainable farming systems, which take increasing care of the sensitive interrelationship between agriculture and environment.

The bar charts in *Figure 7* demonstrate the high acceptance of the environmental program in Austria with a participation of about 70%, which is much higher than the European average!. In the project region, the acceptance even reached more than 85%, with a share of nearly 30 % of organic farmers and about 30 % farmers with a renunciation of external substances for example mineral nitrogen or herbizides (*Figure 8*).

4. Abstract

Due to the presented data and results, the pilot project region "Ennstal" can be called an agricultural production area, where the idea of sustainability is fulfilled on most of the farms. The strategy of decreasing external input and efficient use of internal ressources is practiced, considering aspects of interactions between soil, plant and environment. This is also demonstrated by a very high acceptance of the Austrian environmental program for agriculture. The data and results of the MAB-project are not only useful for the evaluation of this program and as a basis for decisions of agricultural policy, but are beyond that important for a sustainable management of mountainous and alpine regions in Europe. Nevertheless high workload and high costs of mechanization caused by unfavourable climatical and topographical conditions lead to a disadvantage in management and production. Therefore special frameworks have to be set up by the agricultural policy to preserve this sensitive and multifunctional system of nature and agriculture.

5. References

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