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Grassland renovation and grassland improvement

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Permanent grassland is a potential, but still not optimal used resource for protein production and meets the new political targets for farmyard protein production without soja perfectly. Possibilities for increasing protein yields from grassland are in general early cutting, the increase of nitrogen fertilisation and an increase of the N-efficiency and an improvement of the botanical composition via higher percentages of legumes. Especially the swards of permanent grassland in South Germany have often high percentages of herbs and weeds with only slight reactions to fertilized nitrogen (Elsaesser, 2005), whereas grasses respond more to N fertilization. Grassland renovation in order to improve the proportion of grasses can therefore be a possibility to increase the grassland productivity. However in spite of the expectation of increased DM yields in the years following the treatment (Taube and Conjin. 2007), reseeding of permanent swards might not always result in net benefits (Soegaard *et al*.. 2007, p. 97). Furthermore, the total costs of renovation with regard to the lack of yield in the first year after treatment were - so far - not calculated exactly. For the evaluation of the success of grassland renovation method, the improvement of the botanical composition has to be taken into account. Furthermore methods used in agricultural practice are to be investigated.

Possibilities for grassland renovation

The comparison of methods for the agricultural practice to increase the N use efficiency in grassland.
An experiment was established in 2009 in a randomized complete block design design with 3 replications on a permanent grassland in Aulendorf (600 m a. sea level; 950 mm annual rainfall; plot size 100 m^2).
Investigated treatments were as follows:

1. untreated control;

2. total renovation at 2nd growth with 4 kg ha^{-1} glyphosate;

3. total renovation at 2nd growth with 1 kg ha^{-1} glyphosate and 10 kg ha^{-1} ammonium sulphate;

4. reseeding with Vredo slot seeder and 25 kg ha^{-1} seed mixture NSF (*Lolium perenne* 48%, *Phleum pratense* 24%, *Poa pratensis* 16% and *Trifolium repens* 12%) at 2nd growth;

5. Over-seeding twice per year with 5 kg ha^{-1} NSF at 2nd and 4th growth;

6. total renovation after tillage with rototiller. Treatments 2, 3 and 6 were sown with 35 kg ha^{-1} of seed mixture GSWI (*Lolium perenne* 59%, *Poa pratensis* 13%, *Phleum pratense* 19%, *Trifolium repens* 9%).

All treatments were mown 5 times per year and were fertilized with 120 (in 2009), 260 (in 2010) and 240 kg ha^{-1} nitrogen (in 2011) as calcium ammonium nitrate per year. DM yields, crude protein contents and net energy yields were investigated and the change of botanical composition was determined (Klapp, 1949). N efficiency was determined as kg DM kg N^{-1} fertilized.

Results and discussion

After three experimental years total renovation of a the permanent grassland sward produced not the highest DM and XP yields. Moreover the losses in yield after total damage of the swards during the first year were too high and could not yet compensated (figure 1). Highest DM yields (analysed for 3 years) could be observed after reseeding, whereas over-seeding resulted in still higher yields than reseeding with slot seeder technique with `Vredo`. Newly sown swards yielded on average 2 t ha^{-1} less than reseeded swards. This was only in the first experimental year related to a statistically significant effect on DM due to the botanical variation of the experimental field. The negative effects for totally renewed grassland could also be observed for the produced crude protein, which was analysed yet for 2 experimental years (table 1). Reseeded grassland had on average 0.3 - 0.5 t ha^{-1} higher yields. Nitrogen efficiency expressed as kg DM produced of kg nitrogen fertilized was highest for treatment no. 5, the frequent overseeding, because the damage of sward was minimally in this treatment. All treatments with total renovation were lower (figure 1). Obviously it was not possible to establish swards with higher proportions of white clover through grassland renovation. Highest percentages of white clover could be obtained with over-seeding (table 1).

Table 1: Percentages of grasses and white clover (2011)

White clover %	5.0 abc	5.3 ac	5.3 ac	5.3 abc	9.7 c	2.3 ab
Grasses %	58.3 b	44.3 a	70.7 c	55.7 ab	58.3 abc	55.3 ab

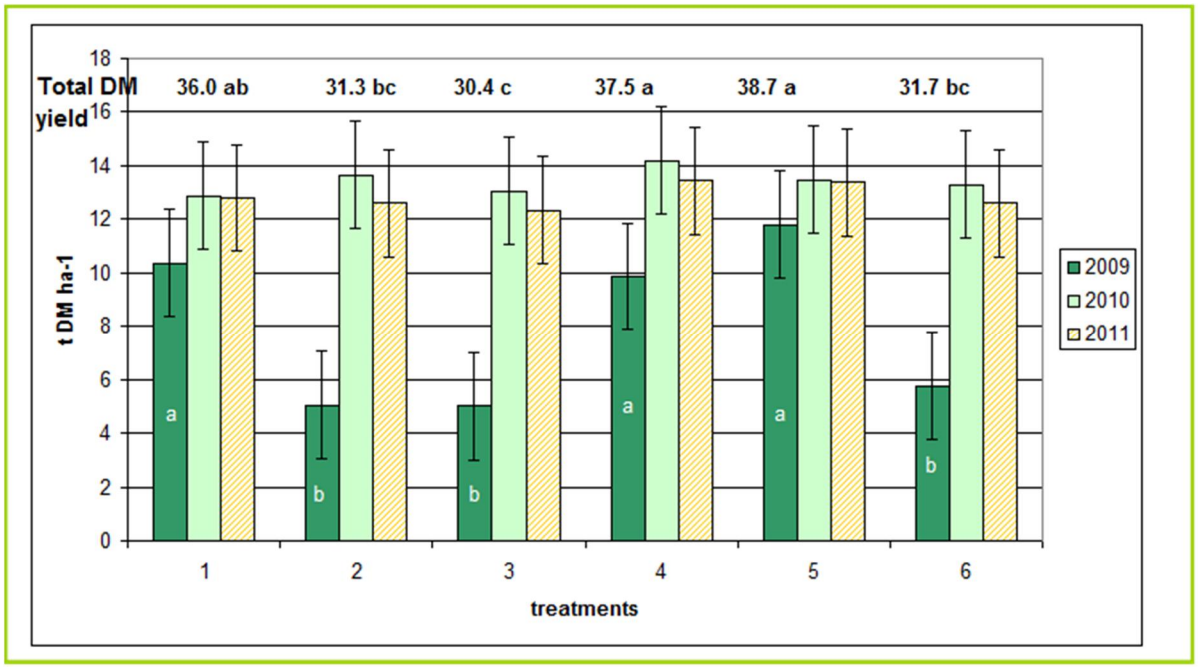

Figure 1: DM yields (average 2009 – 2011) of different renovation and reseeding technics

Conclusions

Methods of grassland renovation can improve botanical composition as well as DM- and protein yields. However, as expected, these effects are not guaranteed. Reseeding seems to be more successful than total renovation under the experimental conditions. Yield losses during the first year after total damage of grassland swards were very high and could not be compensated. With regard to the yield losses, methods of grassland reseeding seem to be the best and most economic treatment for improving DM-yields and for protein production. Moreover, this methods prohibit nitrogen leaching and are also to use for biological agriculture.

References

Elsaesser, M. (2005) Performance of a reseeded grassland (Trisetetum) in Germany. *Grassland Science in Europe*. Tartu. Vol. 10. 477-480.

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Taube, F. and Conjin, J. (2007) Grassland renovation in Northwest Europe: current practices and main agronomic and environmental questions. In: *Grassland resowing and grass-arable crop rotations*. Third and fourth workshop of the EGF working group. Report 148. Wageningen Plant Research International. 35-38.

Specific grassland management for horses

Horses on pastures are often considered the epitome of animal welfare. Simultaneously many horses graze on rather pure areas which serve not necessarily the proper diet of grazing animals. This is due to the fact that horse pastures are partly more extensive forms of grassland use. And there are some typical differences to cattle pastures.

Pastures for horses are not only used as forage area, the horses need grassland for running and other movement. There are a lot of bad developments in the botanical composition. Claims of the horses and the requirements of pasture plants do not agree with each other. Horses need fibre-rich feed, only little protein and especially enough space for movement. This is contrary to the requirements of the grassland sward, where only frequent uses allow dense swards and low weed infestation. Therefore horse pastures have special objectives, which are the more considered, the more variety and use of the horses underline their attributes as a fast moving animal.

Main objectives of horse pastures
1. The pasture size must allow enough movement of the horses
2. The grassland sward must be dense
3. The grass growths should be of good forage quality
4. The grasses shall be sustainable and long lasting

It is difficult to fulfil these various objectives in the practice. Very often are the pastures much too small for the number of grazing horses. Also there is often no change of grazed areas in order to reduce the parasites and to protect the grasses. In addition the typical selective grazing of the horses and their attitude not to eat defecated areas lead to not avoidable effects with different grazed areas on pastures. Young grass is not the demand of horses, old grasses are much better for the horse nutrition, but has difficult attributes in grazing (Tab. 1).

Tab. 1: Requirements on energy and digestible protein of horses *(Raue, 1997)*

Horse 600 kg LW	Digestible Protein g	Digestible Energy MJ	Proportion
3. – 6. month	**680**	**73**	**9:1**
7.-12. month	**610**	**74**	**8:1**
19.-24. month	**505**	**79**	**6:1**
Riding horse (1 h work)	**365-455**	**73-91**	**5:1**
Lactating mare (3. month)	**1185**	**142**	**8:1**
Young grass			**15:1**
Pasture 1. growth before ear emergence	**118**	**12,1**	**10:1**
Very old grass	**52**	**8,7**	**6:1**

Over and under grazing are mistakes in the pasture management

Over grazing: Higher demand on feed then the grassland offer.
Effect: too long grazing period on the same grassland area. Too short grazed grasses with too low resistance
Under grazing: Feed offer is much higher than the demand of grazing animals.
Effects: Partially too old grasses with only low input and high grazing residuals.

Selection of horses protect single plants, the grassland sward switches to an increase of not grazed plants which have the possibility to generative reproduction. As a result the botanical composition of the grassland changes. From this high plants like thistles, docks, *Urtica dioica* or grasses like *Deschampsia caespitosa* have advantages. But also more precious plants like *Dactylis glomerata* or *Festuca arundinacea* are not or only less eaten.

Another effect takes place. Already deep grazed areas will be more and more short grazed. Due to an imbalance between the grazing area and the number of horses grazing on it, the grazing period is very much prolonged in some areas and the phase of rotation is shortened. Therefore the necessary recreation periods for important plants were shortened as well and the grass swards has not enough reserves for a good and quick regrowth. Only good grassland management can help to avoid such effects.

Picture 1: Favourable areas for horse pastures are to find in calcareous and dry soils without any high soil humidity.

A good grassland management has the obligation to understand how management faults work

Over grazing occurs

Over grazing can adjust itself even if the actual grazing area is limited by increase of rank patches or by aging of grassland growth. The animals bite continously the regenerating and new plants. Bald patches develop, in which annual herbs or grasses can immigrate (f.e. *Capsella bursa pastoris, Stellaria media, Poa annua, Camomilla spec*.). Additionally an increase of foot traffic and bite-resistant species (plants with thorns, dense hair or with toxins eg *Holcus lanatus species* or *Ranunculus*) and not detectable plants in rosettes (daisy or common plantain) will take place. At the same time existing weeds (eg *Rumex obtusifolius*, thistles) will find ideal conditions and spread even more closely .

Under grazing happens for example, if the start of grazing is too late in too old and too far developped swards or if there are too little horses per area. This occurs when the horses have enough or even too much space for movement.

What to do?

There is a need to bring the number of animals and their demands on forage and the sward yield in a good balance. Because of much more available feed in spring and early summer than in the autumn, it can be very helpful to give smaller grazing areas at the beginning of the grazing season. There are positive effects of interval cuttings and additional available areas for dry seasons, which are mowed firstly and then productive with new grass.
After grazing the grass needs urgently time for recreation, until the sward is again in the right condition for new grazing. In this time, the horses should not have the possibility to graze in that parts of the pasture.

Necessary recreation time for good grassland regrowth:

- In spring 25 days,
- In summer 35 days
- In autumn 40 days.

Fructan can be a problem

Grasses store their reserve materials depending on species- and variety-conditions differently as fructan (see Tab. 2). In particular, perennial ryegrass often superimposed a fructan. The risk of high fructan contents is particularly high when sunny days in spring limit the growth by cold nights or lack of water growth. Would the grasses grow well, then there would be a dilution effect of the fructan. If the conditions for the inhibition are good, the grazing period should be limited and structurally rich hay is to feed additionally.

Tab. 2: Fructan contents in grasses

High
English raygrass (*Lolium perenne*)
Italian raygrass (*Lolium multiflorum*)
Timothy (*Phleum pratense)*
Medium
Cocksfoot (*Dactylis glom.)*
Kentucky bluegrass (*Poa pratense*)
Meadow fescue(*Festuca pratense*
Low
Meadow foxtail (*Alopecurus pratensis*)
Red fescue (*Festuca rubra*)

The objective is a uniform nutrient distribution

Grazing animals withdraw only small quantities of minerals on pastures. By far the greatest amount of nutrients from feed returns via feces and urine back to the pasture. When grazing the nutrients from excreta are selectively distributed on the surface. At the urine patches a portion of the nitrogen is released as ammonia in the air, the remaining nutrients are taken quickly from the grassland sward. On the other hand, the plant nursery in rank patches is initially inhibited. The high amounts of nutrients in the excreta promote the growth of such plants that require or tolerate high nutrient doses. Because horses avoid the lining rank patches, unevenly grazed areas incurred. As a result, up to 30 % of the pastures are not used as fodder area and it comes to local nutrient-enrichment. The same effects occur in the immediate vicinity of fixed pasture installations like potions or feed racks. So in particular,

unregulated grazing management in extensive and continuously grazed pastures, there is a nutrient transport within the grazing area. As well as unfavorable for pastures is, due to the parasite load, the fertilization of pastures with horse manure. This should be avoided urgently especially if the area or the paddocks are to be grazed immediately after.

Tab. 3: Nutrient redelivery of horses and sheep on pastures in kg (Angaben nach DLG)

Animals	**N**	**P_2O_5**	**K_2O**
Horse 550 kg LW	82	38	73
Horse 450 kg LW	68	32	61
Horse 200 kg LW	32	13	35
Mare with foal	86	37	88

LW = Live weight

What to do?

Collecting the manure on small horse pastures is a need, but it is work intensive. Cutting after grazing seems to be easier and in addition forage intake from rank patches is higher in following growths. If this is done with a mulcher, a better distribution of manure takes place. Mixed grazing of horses and cattle or grazing consecutively with different animals can reduce the percentage of rank patches significantly. Attention please: If *Rumex obtusifolius* exist on a pasture only very early mulching or only mowing is considered (distribution of seeds)!

Short grazing

Horses bite grasses and grassland swards much deeper than cattle. In general not all plants were eaten during the grazing process with the same intensity like with cutting. In consequence on horse pastures mainly plants with different growth stages exist due to the extensive grazing. Mostly the animals prefer young and only less fertilized forage. If the number of horses in specific parts of a pasture is so little, that only best plants are taken, the rest of other plants getting older and their forage values and attractivity decrease significantly. Some plants are even not touched and partially they are able to flower and build seeds. In consequence, weeds spread out.

What to do?

Weed protection

Urtica dioica and *thistles* were only avoided as standing plants. Wilted or dried plants are eaten. Mowing after grazing or periodical cuts can help to make a good balance.

Deschampsia caespitosa is sensible against deep cutting and therefore deep cutting reduce this plants mainly if during mowing the direction changes. *Thistles* are best to mow after flowering, because at this time the reserves of the plants are used and stored in above ground plant material.

Picture 2. Too short grazed plants reduce the storage reservoir of grasses. There is a need to change grazing areas early enough

Damages by trampling

Trampling of horses damage the grassland swards much more than other animals do. Damages are depending of weight, horseshoeing and mobility of the horses. It is visible that e.g. young thoroughbreds move and run much more than old cold blood horses. Mainly running and sudden stops destroy swards and soil markedly and on wet and loamy soils the damages by trampling are mostly high. Areas at pasture entrances or at water places are completely destroyed.

Grassland plants have specific reactions on trampling, which is expressed by the nine point scale of Briemle and Ellenberg. For example *Poa annua* and *Plantago media* or *major* tolerate trampling better than other plants. E.g. *Lolium perenne* takes profít of slightly pressed soil. *Festuca pratensis* and *Dactylis glomerata* or *Festuca rubra* have problems with soil compaction. Frequent compaction reduces percentages of these plants. Soil compaction on wet and humid soils lead to the rise of *Juncus* species.

Picture 3: Trampling destroys the grassland sward and mechanical grassland improvement is necessary

What to do?

In order to avoid or reduce damages of trampling, the gaps should equalized with a pasture harrow and can closed by re- or overseeding. You can use this trampling in a positive way if you overseed 5 kg/ha seed of English Raygrass at the last grazing days and if you use the flock of horses as a living roller. At rainy days or steep slopes grazing on larger areas can reduce damages (at least 150 m^2 per horse and day seems to be necessary).

Pasture Management in horse pastures

The aim of grazing management is to provide throughout the grazing season a high quality and sufficient food offer. Therefore, proper grazing management requires good planning. The horse owners must for this purpose know the following data:

- The performance and yield predictability of the sward,
- the size and location of pastures and
- the number of horses to be grazed.

The choice of grazing method depends on the operating conditions mainly the available work and land capacity. In general, horses graze mostly in extensive on permanent paddocks. It occurs often, that a constant number of grazing animals are fed through the entire vegetation period on the same area without any adaptation to the productivity of the sward. This leads to a "forage mountain" in early summer and shortness of forage in summer and autumn. The advantage of continuous pastures lies in the calmness of the herd and the relatively low work load.

At farms with only little pasture areas pastures are grazed usually „rotational“. Following the principle of "short grazing time - long protection time" the total pasture area should not exceed a grazing time of 5-7 days. Thus, at least 4 or at a maximum 8 paddocks for a proper grazing management are necessary. This is especially important with regard to avoid high parasites pressure. Strip grazing, with a daily allocation of forage area, does not match to horses due to their demand for moving areas.

Demand on forage area

The necessary partition of grazing areas and retention time of horses can roughly be made according to Table 3. Trampling effects decrease in parallel with the decrease of stocking rate. On the other hand, feed selection increases and this continues in unequal distribution of feces. The result is old and avoided feed material, which can be used only to a limited extent. Regarding the forage acceptance there are specific differences depending on species. While cattle accept growing crop from the time of flowering only with difficulties, horses e.g. robust small horses enabled to eat also significantly older feed (Tab. 4).

Picture 4: Divide grassland areas in units of same structure and yield, otherwise specific areas are grazed very short and other areas stay without any uptake

Tabelle 4: Estimated forage area per horse in m^2/day on rotational pastures
(The given values vary widely according to forage quality and grazing length; horses with high need for movement need sometimes much larger areas)

		Details of the grassland sward			
Sward height		15 cm	25 cm	35 cm	45 cm
Yield (t DM/ha)		1	2	3	4
Fresh matter kg/m^2		0,5	1	1,5	2
Grazing residuals at least		20 %	25 %	30 %	40 %
Feed intake*)	DM kg/day	**Grazing area per horse and day in m^2**			
Horse 200 kg live weight	5	60	32	22	18
Horse 400 kg live weight	6	72	38	27	22
Horse 600 kg live weight	9	108	57	40	32
Horse 800 kg live weight	13	156	82	58	47

*) after Gesellschaft für Ernährungsphysiologie, 1994 (data modified): daily work included
See also: https://www.landwirtschaftskammer.de/landwirtschaft/tierproduktion/pferdehaltung/pdf/tabellen-futterrationen-berechnen.pdf

Special features of the fertilization of pastures
Nutrients that remain as excrement on the corresponding surfaces while grazing, must be taken into account in determining the amount of fertilizer (Table 5) in each case. Related to the required nitrogen fertilization of cut grassland, pastures can be fertilized with the following approximate proportions of the quantities given in Table 6.

- All-day grazing (24 h / day): 45 %
- Half day at pasture (11 h / day): about 65 %
- Short-day grazing (max. 7 h / day): 80 %

Fertilisation with P and K

The nutrients (P, K) given with farm yard manure were fully considered for the fertilization calculation.

Table 5: Nutrients in manure and excretions of horses (kg per unit)

Nutrients in 10 t stable manure [1)]	**N kg**	**P_2O_5 kg**	**K_2O kg**
DM-content 25 %	57[2)]	34	97
Nutrient excretions of horses			
200 kg LW	32	13	35
450 kg LW	68	32	61
Rearing 5-36 months	56	25	50
Mare with foal	86	37	88

Explanation:
1) it is to assume that 1 LU = 550 kg LW, bring in average **11 dt stable manure with a DM content of 25%**.
2) 25 % of total N are already taken into account as storage losses. At the fields nitrogen losses are not avoidable even in case of fertilization in a proper way. These losses are mainly caused by ammonia emissions.

Table 6: Demand on nitrogen, phosphorus, potassium and magnesium (kg/ha and year) **in class C** of the soil with exclusive cutting. The nutrient delivery via excrements is to take into account (Elsaesser, 1999)

Use	**Net yield**	**N**	**P_2O_5**	**K_2O**	**MgO**	**If other soil classes exist, the values are to adapt**
	Soil class	**)	**C**	**C**	**C**	
Fertilisation demand on „favourable“ grassland sites (in kg/ha)						**for P and K**
2	**6,0** t DM/ha	55	40	150	20	If class **A**: add 80 kg/ha
3	**7,5** t DM/ha	120	70	220	35	If class **B**: add 40 kg/ha
4	**9,0** t DM/ha	195	90	270	45	If class **D**: half fertilisation
5	**11,0** t DM/ha	245	110	330*)	80	If class **E**: no fertilisation
Fertilisation demand on „un-favourable“ grassland sites (in kg/ha)						**for magnesia**
1	**4,0** t DM/ha	20	25	60	10	If class **A**: add 60 kg/ha
2	**5,5** t DM/ha	70	40	140	15	If class **B**: add 30 kg/ha
2-3	**6,5** t DM/ha	85	50	175	20	If class **D**: half fertilisation
3	**7,0** t DM/ha	115	65	200	35	If class **E**: n fertilisation
3-4	**8,0** t DM/ha	145	80	240	40	

*) withdrawl can be higher, but in order to avoid „luxuray consommation“ oft he plants, the demand is set the same as the withdrawl
**) no soil classes for nitrogen

Fertilisation with horse manure on grassland is unfavourable, even if it is not to avoid in agriculture. If possible take the manure to fields. Manure on areas fresh to graze should be neglected because of parasites.

Picture 5: The lack of minerals in grassland feed should be equalized with different and planned portions of mineral concentrates

Parasites

The best pasture and the best horses are useless if the grazing animals cannot grow up free of gastrointestinal and tapeworms. For pastures the treatment of horses against stomach and intestinal worms should be self-evidently. The same applies to the end of grazing season. A control especially of young animals on necessary treatments should become routine during the grazing months.
In addition, a change of the paddocks is also important, particularly for grazing in times of humidity, which carries the risk of contamination with liver fluke and require treatment. In the fight against parasites, it is recommended to change the medicaments in order to avoid resistances.

What to do?

Continuous change of paddocks and fertilization with calcium cyanamide (300 kg/ha in spring) reduce contamination with parasites. Calcium cyanamide seems to be expensive, if you focus only on nitrogen contents. The application can be profitable, if also the effect as an herbicide, as an anti-parasite and the calcium content are taken into account.

Year round continuously grazing

Due to the need of movement of the horses, pastures are partially grazed the whole year round. At low grazing intensity and extensive areas with mature grass stock such grazing does not necessarily damage the plant sward. Old and high plants decrease the trampling effects. However, the important parts for the regrowth of plant must not be damaged by too deep bites in the stubble of the grasses. The result would be an increase of *Poa trivialis* or *Elymus repens*. Mostly winter grazing is connected almost inevitably to the destruction of the sods. Winter pastures must therefore be restored immediately in the spring by reseeding.

Requirements for winter-grazing:

- Robust and well prepared horses;
- Suitable climate in winter;
- Grazing areas should not have humidity and sites should be not too steep;
- There is a urgent need for additional feeding and care for the animals;
- Presence of frost free water troughs and shelters for wind protection
- Balance between grazing area and amount of horses;
- Protection hut or barn.

What to do?

Year round grazing of horses is only suitable for robust horses and on pastures which are well drained. Use high points for the feed of additional forage and pave these areas. Grazing of horses in wet areas may affect the hooves also.

Avoid rank patches

Since grazing animals mainly avoid the rank patches of their own species, mixed stocking of cattle and a few horses can (about 20 to 30 percent of the total stocking density) can help to decrease the proportion of rank patches. An even better option would be the feeding on pastures during the subsequent boost with other species, if the operational requirements are met them. Collecting the feces is also recommended on small horse pastures. An aftermath gives better feed intake of the regrowth. A mulcher distributes the feces at the same time very finely.

Weed control on horse pastures

Non chemical weed control in grassland is possible, if it happens under regard of the location of plant reserves for regrowth at cutting time. It is most important, that weeds are mowed when the reserves could taken together with the cut plant material. This effect is mostly reached if you cut just before flowering, when the nutrient reserves are not stored in the roots.

If the pasture areas are small or the percentage of weeds is low, plants can taken by hand or pricked-out with equipment easy to handle (e.g. „Fiskars lawn weed puller“ or „Ampferstecher“ see picture). More methods of weed elimination are described in www.gruenland-online.de under the point „Grünlandverbesserung und Pflanzenschutz).

Picture 6: „Ampferstecher“ for mechanical elimination of *Rumex* and a scorcing equipment. The last is not of high benefit acc. to our own experiences.

After all chemical treatment of *Rumex* seems to be best and the most sustainable method if the farmer do this control continuously and only with the allowed substances under regard to the rules of spraying.

Picture 7: Chemical single plant weed control seems to be very effective against *Rumex*

Summary: Successful pasture management for horses

- Start early with grazing and bring the horses on pastures at any time if there is grass to eat. But: Avoid too long stays outside if there is no grass anymore
- Think at this: Short grazing time and long recreation time for the pastures are a need
- Graze regularly with system
- Adapt the number of horses to available grass and make a suitable balance
- Grassland with weeds or herbs are to graze first in spring
- Tolerate grazing residuals, but mow grassland with weeds early
- Reserve extensive pastures for rainy weather
- If you don´t need the pastures for grazing, than use the fields immediately for preparing hay or silage
- If the pastures have steep slopes, avoid high fertilisation with nitrogen.

Picture 7: Robust horses need fiber rich feed from older growths during the winter period

Picture 8: Too short grazed areas reduce the potential for grassland regrowth. Horses should taken away from these areas.

More informations:

Elsaesser, M., 1999: Pferdeweiden Anforderungen - Maßnahmen – Pflege. Merkblätter für umweltgerechte Landbewirtschaftung. Herausgeber: Landwirtschaftliches Technologiezentrum, Baden-Wuerttemberg.
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