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in

Baumont R. (ed.), Carrère P. (ed.), Jouven M. (ed.), Lombardi G. (ed.), López-Francos A. (ed.), Martin B. (ed.), Peeters A. (ed.), Porqueddu C. (ed.).
Forage resources and ecosystem services provided by Mountain and Mediterranean grasslands and rangelands

Zaragoza : CIHEAM / INRA / FAO / VetAgro Sup Clermont-Ferrand / Montpellier SupAgro
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 109

2014
pages 179-183

Grassland yield variation and botanical composition in mountainous areas of Norway

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Abstract. In Norway, farms in the mountain region need high amounts of conserved forage for the long winter period. The agricultural statistics shows that the grassland yields have stagnated or even decreased in some regions during the last 10-20 years. The farm size and milk production per farm has increased in this period, due to more use of rented land and buying of milk quota. In a new project, we estimate grassland yields to examine yield variations on the field level. The aim of the project is to explain yield variations under practical farming conditions and identify bottlenecks for the grass production. We make registrations of the yield by counting, weighing and sampling big bales. The botanical composition of the fields is examined by the dry weight rank method. Information about soil conditions, land and fertilizer use is gathered from the farmers and the advisory service. In the first year, six farms in three districts have participated in the project. Preliminary results show large yield variations. Poor drainage conditions are common in parts of many fields, limiting grass growth. Heavy traffic in connection with grass harvest and spreading of animal manure might also give yield reductions. The botanical analyses show that coach grass (*Elymus repens*) has a high proportion in many fields compared to other Norwegian investigations. We hope to extend this project the coming years to make a sound basis for good advices in grassland production.

Keywords. Grassland – Agronomy – Yields – Botanical composition.

Composition botanique et variation de la production des prairies dans les zones de montagne en Norvège

Résumé. *En Norvège, les fermes de montagne ont besoin de grandes quantités de fourrages conservés pour la période de l'hiver. Les statistiques agricoles montrent que les rendements des prairies ont stagné ou même diminué dans certaines régions au cours des 10-20 dernières années. La taille de l'exploitation et la production de lait par exploitation a augmenté durant cette période, en raison de l'utilisation de terres louées et l'achat de quotas laitiers. Dans un nouveau projet, nous mesurons les rendements des prairies pour examiner les variations de rendement sur le terrain. Le projet vise à expliquer les variations de rendement dans des conditions de pratique agricole et à identifier les verrous pour la production d'herbe. Nous enregistrons les rendements par comptage, pesée et échantillonnage des grosses balles de fourrage. La composition botanique des prairies est examinée par la méthode de classement de poids sec. Des informations sont collectées sur les conditions du sol, l'utilisation des terres et les engrais auprès des agriculteurs et des services de conseil. La première année, six fermes dans trois districts ont participé au projet. Les résultats préliminaires montrent de grandes variations de rendement. Les mauvaises conditions de drainage sont fréquentes dans certaines parties de nombreuses parcelles, ce qui peut limiter la croissance de l'herbe. La circulation des machines de récolte de l'herbe et d'épandage de fumier peut aussi être la cause des baisses de rendement. Les analyses botaniques montrent que le chiendent (*Elymus repens*) représente une forte proportion dans beaucoup de parcelles par rapport à d'autres enquêtes réalisées en Norvège. Nous espérons étendre ce projet dans les prochaines années pour développer une base solide de conseils pour la production des prairies.*

Mots-clés. *Prairies – Agronomie – Rendements – Composition botanique.*

I – Introduction

Grassland farming makes the basis of mountain agriculture in Norway. With a snow cover lasting from October-November until April-May, the yield of conserved grass for winter fodder is very important for the farmers. Traditionally, the grass was conserved as hay. However, during the last 50-year period silage has become the preferred method due to unstable weather conditions and technological development. Today, 75-80% of the grass is conserved in round bales with a short period of wilting between cut and baling. A two-cut system is most frequently used with a first cut in late June/early July and a second cut in late August/early September. At the highest altitude areas (900-1000 m a.s.l.), only one cut is taken. In addition, some of the silage meadows are grazed in spring, especially on sheep farms. Grazing in autumn is common for both sheep and cattle.

Grassland yield is difficult to measure precisely under practical farming conditions, and thus the official yield statistics for grassland is more uncertain than for cash crops like cereals or potatoes. The statistics indicate that the grass yield in Norway has levelled off during the last 10-20 years. The farm size in the mountain district is generally smaller than in the lowlands. Many farms have increased their milk or meat production during the past years, and most of their increased forage production comes from rented land. This leads to longer transport distances both for forage to the farm and for animal manure back to the fields. Many farmers want to increase their forage production on the closest fields to reduce the transport costs. This leads to more intensive cultivation of fields close to the farm and more extensive cultivation of fields far away from the farm.

In Norway, the goal is to increase the agricultural production by 20 % before 2030 to maintain the degree of self-sufficiency in food production (Landbruks- og matdepartementet, 2011). An increased production in the mountain district must be based on higher yields per area, or on a higher utilization of the pastures. The average farm size is increasing rapidly, and in many districts winter forage is limiting production. More knowledge on factors restricting forage production is needed to give better advice for the farmers. Therefore, this project was initiated measuring yield and botanical composition on farmer's fields to obtain better knowledge of grassland production.

II – Materials and methods

Forage yield and botanical composition in meadows was measured in 30 fields at six farms in the mountain district of southern Norway in 2013, three farms in Nord-Østerdalen, two farms in Valdres and one farm in Ottadalen. The majority of fields were cut twice; five high-altitude fields were cut only once, and in two fields the regrowth was grazed by sheep after the first cut. At all fields, the forage was conserved as round bales. All bales per field were counted, and three representative bales were weighed and sampled after conservation. The samples were dried at 60°C for 48 hours to determine the dry matter content. The area of each field was measured from digital maps. Dry matter yield per hectare was calculated by multiplying the number of bales with average bale weight and dry matter content, and dividing it with the field area. The method of estimating yield by counting and sampling grass bales worked out well. Counting the bales is simple, and sampling three bales per field for weight and dry matter content is not very labour intensive. The bales can be put aside and sampling and weighing can be done simultaneously for all cuts and fields from a farm. The measurement of bales gives a good estimate for the whole field together, both productive parts and less productive parts. This is difficult to address with other methods.

Botanical composition of the fields was examined using the dry weight rank method (t'Mannetje and Haydock 1963) with dominance factors of 70, 20 and 10 for the three most frequent species within each subplot. 15-20 subplots were registered within each field at random using a 50x50 cm frame. The fields were divided into three groups after age (1-3 yr, 4-7 yr, > 7 yr) to examine changes in yield level, tested by one-way analysis of variance. Botanical composition was test-

ed with a general linear model: Proportion = μ + Age + Field within Age + Species, with field as random variable. In addition, information about each field about soil quality, cropping history, fertilization, drainage conditions and machinery use were collected from farmers.

III – Results and discussion

The botanical composition of the meadows changed as the age of the meadows increased; there was a significant interaction between age and species (P<0.001, Table 1). Almost all meadows were seeded with a mixture of *Phleum pratense*, *Festuca pratensis* and *Trifolium* species, often with *Poa pratensis* included. Two fields in the oldest group were seeded with *Dactylis glomerata* and *Bromus inermis*.

The newly reseeded fields showed as expected a very high proportion of the sown species with a dominance of *Phleum pratense*. The proportion of clover was rather low, which is probably due to high application of nitrogen fertilizers.

The 4-7 year old fields showed a declining content of the sown species *Phleum pratense and Festuca pratensis*. However, the content of *Poa pratensis* increased. The content of coach grass (*Elymus repens*) was high, and in five out of ten fields coach grass was the most frequent species in this group.

Table 1. Proportion (%) of different species in cut meadows of different age in the mountain districts of southern Norway

Number of fields	1-3 yr N = 11	4-7 yr N = 10	>7 yr N = 9
Phleum pratense	56	21	3
Festuca pratensis	21	15	2
Poa pratensis	5	14	16
Trifolium repens	5	<1	1
Trifolium pratense	2	1	<1
Elymus repens	3	27	36
Poa annua	2	5	4
Taraxacum officinale	<1	4	2
Dactylis glomerata	<1	2	6
Agrostis capillaris	1	1	8
Deschampsia cespistosa	1	2	6
Alchemilla spp	<1	1	6
Other grasses	<1	1	4
Other herbs	3	7	6
Standard error mean	6.4	8.4	9.7
P value	<0.001	<0.001	<0.001

In the oldest fields, *Elymus repens* had the highest proportion, with *Poa pratensis* on second place. Coach grass was the most frequent species on five out of nine fields. Here, there was a higher diversity between fields in species composition, and typically, the content of herbs was higher than in younger grasslands.

The content of coach grass was high compared with older Norwegian investigations (Nesheim 1986, Lundekvam and Gauslaa 1986), although this species was present under different conditions. In the

mountain districts, herbicide treatment with glyphosate against coach grass has not become common practice before renewal. With a continuous grassland production, coach grass is usually not considered as a problem weed. Many farmers think they grow sown grasses although they have a high proportion of coach grass in their meadows. When the proportion of sown species, especially *Phleum pratense* and *Festuca pratensis*, decreases after two-three years, coach grass fills gaps in the sward and is well adapted to fertilization practice, harvest- and grazing regimes in the mountain district.

The yield investigation showed average yields of about 6 tons dry matter per hectare (Table 2). This figure is rather low compared with grassland experiments (e.g. Bakken *et al*. 2009). However, compared with the official yield statistics it is high (Statistisk sentralbyrå 2013). There are big losses in the process between grass cutting and silage feeding. When measuring silage bales, dry matter losses in the field and in the conservation process were included. However, losses during feeding and disposal of badly preserved bales were not considered.

Table 2. Average yields of dry matter (t ha^{-1}) in two cuts in grassland of different age

Number of fields	1-3 yr N = 8	4-7 yr N = 8	>7 yr N = 3
Yield 1st cut	3.2	3.7	2.9
Yield 2nd cut	3.1	2.6	2.6
Total yield	6.3	6.3	5.5
SE (total yield)	1.7	0.6	1.0
Minimum	3.6	5.8	4.4
Maximum	9.0	7.8	6.5

The average total yield did not differ between different grassland age groups (P = 0.54) (Table 2). The 4-7 year old grasslands yielded at the same level as the 1-3 year old ones. However, one should not conclude about this from one year and a small material. Differences in harvest times and elevation might influence the dry matter yield considerably, but the groups were quite similar in this respect. In the permanent meadow group (age >7 years) there were five fields in addition from high altitude fields (about 900 m a.s.l.). Here, only one late cut was taken with average yield 4.1 t DM ha^{-1}.

One goal of the project is to get a better understanding of yield variation between fields. Although the material is yet too small to draw clear conclusions at this point, we could see that some of the lowest yielding fields were poorly drained. The connection between botanical composition and yield still is not clear, and there seems to be no clear effect of the content of *Elymus repens* on dry matter yield. The project continues and hopefully, more clear conclusions may be achieved later. Connections between yields, botanical composition, soil conditions and agronomical practice will be examined. From the first year we conclude that the high content of *Elymus repens* is important. Many grasslands with age above three years have a high content of this species and we need a better understanding of the effects of coach grass. Forage quality will be included in the project in 2014. The methodology of measuring yields by counting and sampling grass bales worked out well and will be continued.

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