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EFFECTIVE GROWING DEGREE DAYS AS A CRITICAL FACTOR FOR YIELD AND QUALITATIVE VALUES OF TIMOTHY IN SUBARTIC GROWING CONDITIONS.

O. Nissinen

Agricultural Research Centre of Finland, Lapland Research Station, Tutkijantie 28, FIN-96900 Saarenkylä, Finland, e-mail: oiva.nissinen@mtt.fi

Abstract

The yield and forage quality of timothy (*Phleum pratense* L.) leys at different stages of development were studied in 1991-1999 at the Lapland Research Station of the Agricultural Research Centre of Finland in Rovaniemi (66°35´N). The aim of the study was to determine the optimal time for the first cut with respect to yield and qualitative values. In timothy the first heads were visible on 25 June on average and full heading was seen on 5 July, i.e. some ten days later. During this period the dry matter yield increased from 2769 to 4945 kg/ha, crude protein content decreased from 16.6 to 11.7%, crude fibre increased from 27.1 to 33.9% and organic matter digestibility decreased from 74.4 to 65.1% in dry matter. There was, however, a significant ($P<0.05$) correlation between effective growing degree days (GDD, base +5°C) and growth rate, dry matter yield, crude fibre content and organic matter digestibility at the very beginning of heading. Effective GDD lower than 280°C delayed the heading of timothy by 7 days but increased the dry matter yield by 27% compared to effective GDD higher than 280°C. Simultaneously, higher temperature accumulation decreased the

crude protein content by 0.6 percentage points, increased crude fiber by 2.3 percentage points and decreased organic matter digestibility by 2.3 percentage points in dry matter.

Keywords: timothy, effective degree days, dry matter yield, crude protein, crude fibre, organic matter digestibility

Introduction

Agriculture in northern Finland relies heavily on livestock, and nearly 80% of the cultivated area is used for growing grass forage. The most important and the major ley plant for silage is timothy (*Phleum pratense* L.) (Nissinen and Hakkola, 1995; Nissinen, 1998). Close to the arctic circle the growing period (mean daily temperature above +5^{o}C) begins within 1-2 weeks after melting of the snow in the middle of May and averages 136 days and 883^{o}C effective degree days. Only about 100 days of summer can, however, be exploited for yield production. When the primary aim is to exploit the intense growth of grass in early summer, the right timing of the first harvest is important both for the quantity and the quality of yield. There is, however, great variation between years in the development of yield and qualitative values of timothy swards. There is seldom drought due to rich water from melting snow. Thus, the purpose of this study was to determine whether there are significant correlations between yield features and temperature conditions, e.g. effective degree days, during a period of six weeks preceding the first harvest.

Material and Methods

The present investigation is based on field trials carried out during 1991-1999 at the Lapland Research Station of the Agricultural Research Centre of Finland in Rovaniemi (66°35´N). The study included first-to-third-year timothy (*Phleum pratense* L., cv. Iki) stands. The spring yield was fertilized with 100 kg nitrogen per hectare. The development of the first yield and forage quality was followed over a period from before the first visible heads to flowering of timothy. The swards were harvested by a forage plot harvester (Haldrup) and crop samples were taken every 3-5 days to measure yield size and to analyse dry matter, crude protein and fibre contents, as well as organic matter digestibility. At harvesting, the stage of development of timothy was visually observed. For total nitrogen, the plant samples were analysed with the Kjeldatherm system (Gerhardt, Germany) and for fibre content with the Fibertec system (Tecator, Sweden). The digestibility of the organic matter was tested in vitro by the cellulase-enzyme method of Friedel (1990). This paper presents the results of three samplings from the very beginning of heading to full heading. The effective growing degree days (GDD, base +5°C) measured at the Lapland Research Station were used to test the correlation between temperature conditions and yield features in the first cut. Their interactions were determined using the analysis of variance and the SAS software.

Results and Discussion

A summary of dry matter yields and forage quality is shown in table 1. Dry matter yield and its qualitative values were highly related to the stage of development of timothy. Within a period of ten days from the beginning of heading to full heading, dry matter yield increased from 2769 to 4945 kg/ha, crude protein decreased from 16.6 to 11.7 %, crude fibre

increased from 27.1 to 33.9% and organic matter digestibility decreased from 74.4 to 65.1% in dry matter on average. The growing period from the beginning of the growing season , 14th of May, to the date of the first visible heads, 25th of June, averaged 42 days (range 30-53) and 280^{o}C effective GDD (range 229-333^{o}C). There was a significant ($P<0.05$) correlation between effective GDD and growth rate, dry matter yield, crude fibre content and organic matter digestibility at the very beginning of heading. However, the temperature sum had only a slight effect on the crude protein content in dry matter. There was no significant correlation between yield size and qualitative values either. Effective GDD lower than 280^{o}C delayed the heading of timothy by 7 days compared to effective GDD higher than 280^{o}C. However, at the developmental stage of the first visible heads, in these cooler conditions the dry matter yield was 665 kg/ha higher, crude protein content 0.6 percentage points higher, crude fibre content 2.3 percentage points lower and organic matter digestibility was 2.3 percentage points higher than in the summers with high effective GDD and very rapid growth. High temperatures in May decreased significantly the amount of dry matter measured by the beginning of heading. The amount of dry matter excluded, the annual differences in forage quality had levelled off by the time of full heading.

The significant correlation between early heading and low dry matter yield in first cut is due to low shoot density of timothy stands. In 24-hour photoperiod, higher temperatures accelerated already fast generative development of main shoots and lower also the forage quality in relation to amount of dry matter. In such cases, when harvested at a very early stage of development, some of the late lateral shoots remain uncut and weaken the qualitative values of aftermath. High organic matter digestibility is the most important qualitative criterion for roughage. However, in practice, heading is the only visible sign in timothy indicating when to cut the first harvest. Although the yield increases until flowering of timothy, cutting should be done earlier for the sake of quality. On average, the time for

harvest in relation to dry matter yield and forage quality is the best when about half of the shoots of timothy have come into ear, which takes about 5 days from the first visible heads. During these days the dry matter yield increases by more than half, but organic matter digestibility is still about 70%. However, at this stage of development of the stands the changes in forage quality are very rapid, e.g. digestibility decreases 0.9 percentage points in a day. This means that harvesting should be started somewhat earlier and must be completed within one week. Although effective GDD had a significant effect on the date of the first visible heads and at that time also on the amount of dry matter and organic matter digestibility, changes in yield and forage quality occurring during the actual heading stage are not influenced by weather conditions.

References

Friedel, K. (1990). Die Schätzung des energetischen Futterwertes von Grobfutter mit Hilfe einer Cellulasemethode. Wissenschaftliche Zeitschrift der Wilhelm-Pieck-Universität, Rostock. Matematische-naturwissenschaftliche Reihe. **39:** 78-86.

Nissinen, O. (1998). Timotei Lapin rehukasvina. Abstract: Timothy as a herbage grass in Lapland. Maatalouden tutkimuskeskuksen julkaisuja. Sarja A. **40:** 50-56.

Nissinen, O. and Hakkola, H. (1995). Effects of plant species and harvesting system on grassland production in northern Finland. Agricultural Science in Finland **4:** 479-494.

Table 1 - Dry matter yields and qualitative values of timothy at different stages of development in different temperature conditions at the Lapland Research Station in Rovaniemi during 1991-1999.

Variables and growth stages [1)]	Mean in 1991-1999	Effective degree days at growth stage I 229-278°C	288-333°C
Dry matter, kg/ha			
I	2769	3101	2436
II	4096	4403	3788
III	4945	5191	4698
Crude protein, %			
I	16.6	16.9	16.3
II	13.4	13.6	13.2
III	11.7	11.8	11.5
Crude fibre, %			
I	27.1	26.0	28.3
II	30.9	30.7	31.1
III	33.9	34.0	33.9
Organic matter digestibility, %			
I	74.4	75.6	73.3
II	69.5	69.8	69.3
III	65.1	65.1	65.1

1) Growth stage: I- first visible heads; II- half of shoots are heading; III- full heading