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Timothy productivity and forage quality

- possibilities and limitations -

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Effect of quality assessment on cultivar performance in timothy variety testing in Finland

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Introduction

Official variety trials are conducted in Finland by the Plant Production Research unit of MTT Agrifood Research Finland. Owners of the variety rights enter varieties into the trials and cover the expenses involved. Forage grass varieties undergo official trials for a minimum of three years or until the variety is withdrawn from testing or is entered in the National List of Cultivars of the Ministry of Agriculture and Forestry. If the variety is accepted on the National Lists of Varieties it will usually continue in trials for a further 2-3 years to provide growers with additional information. Decisions on the inclusion of varieties in the National List of Varieties are made by the Plant Variety Board of the Ministry of Agriculture and Forestry. The principal characteristics used to assess new timothy varieties for inclusion in the National List of Cultivars are dry matter yield, yield at first cut, yield of regrowth and extent of winter damage.

Grasses are predominantly used for silage in Finland. Two or three cuts are taken during the growing season. Successful timing in harvesting the primary growth is critical as grasses develop very rapidly at a day length of >18 hours and a daily mean temperature close to 20°C. The primary growth has to be harvested within a short period to secure a yield of high digestibility. According to Huhtanen (2001), digestibility (D-value) of the silage falls away at 0.5% unit per day during primary growth. For second and third harvests, change in digestibility is much slower than for the first cut. In timothy variety trials all cultivars are harvested at the same date to reduce labour. Although differences in earliness among timothy varieties are relatively small under Finnish growing conditions, there are differences that are likely to lead to quality differences among yields harvested on the same date.

Assessment of quality parameters in forage grass variety trials has been very limited until now because of the high cost of traditional digestibility assessment and fiber fractioning methods. Quality assessment of forage would, however, be particularly useful in Finland as most grass is harvested for silage in two or three cuts. In countries where grasses are grazed during most of the year, quality assessment may not be as useful as quality can be presumed to remain adequately high when the grass is consumed at the vegetative stage.

Forage quality assessment using near infrared spectroscopy (NIRS) has been applied routinely in forage breeding for a long time. It has been used in variety testing in Norway for many years. In Norway samples are taken from all cuts in the first year stands and organic matter digestibility (% DM), protein (% DM), neutral detergent fibre (% DM) and carbohydrate content (% DM) are analysed and also values of milk units (units/kg DM) are recorded (Moltenberg & Engerer 2003).

The aim of this paper is to present preliminary results of quality analyses of timothy varieties tested in Finland and to assess how taking these quality characteristics more into account would affect performance evaluation of cultivars differing in key characteristics.

Material and methods

Yield samples for this study were taken from timothy variety trials in 2000-2004. In 2000, samples were taken only for the reference varieties, but in 2001-2004 samples were taken of all varieties included in the variety testing programme. Experiments were conducted at 10

trial sites in various parts of Finland. Samples were taken from first and second year stands. At least two cuts were taken during each season. In seven experiments of a total of 44 including the variety Tammisto II three cuts were taken in each season. All cultivars in the trial were harvested at the same time. The first cut was taken when 20-30% of ears had emerged from leaf sheaths in the reference variety.

Samples were dried at 100°C for one hour and subsequently at 60°C until completely dry (usually overnight). NIRS analyses were carried out at MTT Agrifood Research Finland laboratory. The NIRS equipment (Braen Luebbe; Infra Analyser 500) was calibrated for samples taken using the same procedure as used in the variety test trials. Quality parameters analyzed by NIRS included digestibility of organic matter in dry matter (D-value), acid detergent fibre (ADF), neutral detergent fibre (NDF), acid detergent lignin and nitrogen content, which was converted to raw protein by multiplying the value by 6.25. Results of D-value, NDF and protein content are presented in this paper.

Results for four various types of variety are presented in this paper. Tammisto II (Boreal Plant Breeding Ltd.) was the reference variety and is commonly sown. Grindstad (Tollef Grindstad), from southern Norway, represents a more southern type of timothy than Tammisto II. Iki (Boreal Plant Breeding Ltd.) is a northern type with less regrowth than the other varieties. Linus (SW Svalof Weibull) represents a slightly later cultivar than Tammisto II. Based on the date of heading, Grindstad is earlier than Tammisto II. Iki is also slightly earlier than Tammisto II.

The set of cutivars varied among experiments. Therefore, the number of trials (one year at one trial site, including results of all cuts) from which quality assessment data are available varied among varieties. In this data set, the reference variety Tammisto II had 44 results, Grindstad 28, Iki 17 and Linus 17. The data were analysed using linear mixed models and the REML estimation method, which take account of all available data in the same analysis. Variety was selected as a fixed effect in the model, and effects of site, year and trial were regarded as normally distributed random effects (Öfversten, J. and Nikander, H. 1996). Analyses were performed using the SAS/MIXED procedure. In the results all cultivars can be compared directly with each other. In Tables 1 and 2, significance levels show how likely a difference between the reference variety (Tammisto II) and the test cultivar was due to chance. The statistical significance levels are: o= significant at 10 % level, *= significant at 5 % level **=significant at 1 % level, ***= significant at 0.1 % level.

A summary of the results during the last eight years is provided. The latest publication covering 1998-2005 was reported by Kangas *et al.* 2006. The quality assessment results used in this preliminary study were not included in that data set.

Results

Characteristics of the four example varieties used in this study are given in Table 1 and are presented according to the traditional variety testing scheme. In heading Grindstad and Iki were slighly earlier and Linus later than Tammisto II (Table 1). The higher DM content of the first cut of Grinstadt illustrate earliness as well as lower DM content compared with Tammisto II. The high yield of the second cut and high percentage of regrowth yield of Grindstadt indicate that it is a southern type. Iki and Linus have reduced regowth capacity, indicating early preparation for winter typical of northern types.

In Table 2, D-value, NDF and raw protein content of cultivars for the first and second cuts are given. At the first cut the D-value of Grindstad was significantly lower that that of Tammisto II and the D-value of Linus was significantly higher that that of Tammisto II. At the second cut the D-value of Grindstad was significantly lower than that of Tammisto II. The D-values for Linus and Iki were significantly higher that for Tammisto II at the second cut.

Table 1. Characteristics of timothy varieties based on data from traditional variety descriptions. The data set includes all results for the variety in the variety data bank 2000-2004. Statistically significant differences between the means of a test variety and the reference variety Tammisto II are indicated with asterisks.

Variety	Results	Winter damage %	Days to heading from 1.5.	DM 1st cut %	DMY 1st cut kg ha^{-1}	DMY regrowth kg ha^{-1}	DMY total kg ha^{-1}	Regrowth of total DMY %
Tammisto II	73	4.9	46.0	21.6	5289	5072	10361	49
Grindstad	54	5.5	44.4***	23.1***	5258	5866***	11124***	53
Iki	64	4.5	45.6***	21.7	5284	4684***	9968***	47
Linus	33	4.1	46.7***	21.0***	5165	4614***	9779***	47

For protein content at the second cut it is likely that the lower value for Grindstad resulted from high yield and the higher protein content for Linus and Iki resulted from their low yield at the second cut. The higher lignin content for the second cut of Grindstad (43.9 g kg^{-1} DM), compared with the value for Tammisto II (41.7 g kg^{-1} DM) may explain the lower D-value for Grindstad although NDF content was similar for Tammisto II and Grindstad. The difference in lignin content was statistically significant. Lignin content of Linus at the second cut was 40.1 g kg^{-1} DM, which was significantly lower than for Tammisto II.

Table 2. D-value, NDF and protein content of timothy varieties at the first and second cut in the test study. The data set was compiled from data from 2000-2004. Statistically significant differences between the means of a test variety and the reference variety Tammisto II are indicated with asterisks.

		Quality parameters for the 1st cut			Quality parameters for the 2nd cut		
Variety	Results	D-value %	NDF g kg^{-1}	protein g kg^{-1}	D-value %	NDF g kg^{-1}	protein g kg^{-1}
Tammisto II	44	68.4	649	116	68.1	638	101
Grindstad	22	67.7**	639*	112*	66.6***	637	91**
Iki	17	68.7	648	115	69.8***	629	110
Linus	17	69.4***	634***	120*	70.3***	629	112***

Table 3 represents a summary of results for yield at first and second cuts when total yield is given as dry matter yield (DMY) and as digestible yield (DIY), which is obtained using the D-value to calculate DIY from dry matter yield. The earlier Grinstad performed better in the traditional DMY in comparison with Tammisto II (106***) than in the DIY comparison (104***). However, the DIY of Grindstad remained significantly higher that that of Tammisto II. Iki and Linus benefited from the use of DIY. The relative figures for DMY and DIY of Tammisto II improved from 98 to 99 and from 95** to 97^{o} for Iki and Linus, respectively.

Table 3. Dry matter yield (DMY) and digestible yield (DIY) of timothy varieties for first and second cut and for total yield. Digestible yield was calculated from DMY and the D-value. The data set was compiled data from 2000-2004 including only trials where the quality was analysed. Statistically significant differences between the means of a test variety and the reference variety Tammisto II are indicated with asterisks.

		Yield of 1st cut		Yield of 2nd cut		Total yield		Total	Total
Variety	Re-sults	DMY kg ha^{-1}	DIY kg ha^{-1}	DMY kg ha^{-1}	DIY kg ha^{-1}	DMY kg ha^{-1}	DIY kg ha^{-1}	DMY rel	DIY rel
Tammisto II	44	5307	3642	5080	3447	10701	7310	100	100
Grindstad	22	5181	3510^{o}	5792***	3845***	11361	7626	106***	104***
Iki	17	5477	3763	4656**	3241*	10469	7248	98	99
Linus	17	5202	3606	4632**	3237*	10146	7068	95**	97^{o}

Discussion

Significant differences in quality parameters among varieties were recorded for yields of both the first and second cuts (Table 2). Differences in D-values reflected the differences in earliness of varieties and differences in protein content reflected differences in the yield of a particular cut. When D-values were taken into account in calculating digestible yield from dry matter yield the performance of Linus was improved. Iki also performed better when the D-value was taken into account. The D-value for Iki was higher, particularly for the regrowth, than that of Tammisto II. Performance of the early variety Grinstad was not as good when the D-value was taken into account as when only dry matter yield was considered. Quality assessment of yield in variety trials would provide valuable evaluation information. In addition, it would provide useful data to study the effects of other factors (climate, cutting regime) on quality of timothy.

Quality assessment in cultivar trials would motivate breeders to enhance their efforts in quality improvement. A decision has been made in Finland to include quality assessment in the forage cultivar testing programme. The sampling procedure has been modified so that drying will be done at a constant 60^{o}C. The quality characteristics to be recorded and analysed are being discussed.

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