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Effect of nitrogen fertilization on the protein quality of timothy grass and silage

LIISA SYRJÄLÄ-QVIST[1], EEVA PEKKARINEN[1], JOUKO SETÄLÄ[1] and TAPANI KANGASMÄKI[2]

[1] *Department of Animal Husbandry,*
[2] *Department of Plant Husbandry, University of Helsinki, SF-00710 Helsinki*

Abstract. Timothy grass given N fertilizer at the rates of 40, 80 and 120 kg N/ha was preserved in 3 glass-fibre silos of 0.4 m^3.

The crude protein content of DM in the grass increased with the increase of N fertilization as follows: N_{40} 14.8 %, N_{80} 18.4 % and N_{120} 22.1 %, but the proportion of true protein in crude protein decreased: N_{40} 82 %, N_{80} 78 % and N_{120} 76 %. The proportion of watersoluble N in the total N in the grass was: N_{40} 27 %, N_{80} 30 % and N_{120} 33 %. The higher was the N fertilization level, the more rapidly was the protein of the grass degraded in the rumen. The amino acid profile of the protein was similar at all the N fertilization levels.

The quality of all the silages was good. The NH_3-N fraction of total N was 2.8—3.9 % and the proportion of water-soluble N in total N was 51—55 %. In silage N_{120} the decrease during ensiling in the proportion of true protein in crude protein and the increase in the proportion of water-soluble N in total N were smaller than in the other silages. The rumen degradability of protein during the first two hours was also lowest in this silage.

Introduction

The protein yields of swards can be increased either by using leguminous plants, e.g. red clover, or by increasing the nitrogen fertilization level of the grass. Little attention has been paid, however, to the quality and the feeding value of the protein in the herbage, when these methods are used. The purpose of this experiment was to study the effect of different nitrogen fertilization levels on the quality and the feeding value of the protein of timothy grass and the changes in its crude protein fraction during ensiling. Corresponding experiments concerning red clover have already been described (SYRJÄLÄ-QVIST et al. 1984).

Experimental procedures

The timothy grass used for this experiment was from second-year sward. Basic nitrogen fertilizer was applied in spring at the rate of

Index words: N fertilization, timothy, protein quality, silage

100 kg N/ha. The first harvest was taken on 18 June and was used for the experiment described earlier (SYRJÄLÄ-QVIST et al. 1984). After the first cutting, the timothy sward was divided into three parts, which received nitrogen fertilizer at three different levels: 40 kg, 80 kg and 120 kg N/ha. The grass used for this experiment was from the second cutting. The harvesting date was 26 July, when the timothy was at the so-called silage stage, or when the ears of the timothy were near emergence or just formed.

Each silage, silage 1 = N_{40}, silage 2 = N_{80} and silage 3 = N_{120}, was preserved in a glass-fibre silo of 0.4 m^3. The grass was chopped and AIV II solution (80 % formic acid and 2 % orthophosphoric acid) was used as preservative, being applied as the silos were filled, at the rate of 5 l/1000 kg fresh grass. The sampling and analyses were as described earlier (SYRJÄLÄ-QVIST et al. 1984).

Results and discussion

Silage raw materials

The dry matter and crude protein yields of the timothy at the different levels of nitrogen fertilizer application were as follows:

Nitrogen kg/ha	Dry matter kg/ha	Protein kg/ha
N_{40}	1927	285
N_{80}	2165	398
N_{120}	2023	447

Table 1. The chemical composition and the digestibility of the raw materials and the silages.

Nitrogen kg/ha	40		80		120	
	Grass	Silage	Grass	Silace	Grass	Silage
Dry matter, %	24.3	21.8	22.3	20.8	20.3	20.2
% of dry matter:						
Ash	7.9	8.2	8.4	8.4	8.7	8.9
Crude protein	14.8	15.2	18.4	18.3	22.1	22.2
Crude fat	3.7	4.9	3.7	5.0	3.8	5.3
Crude fibre	23.5	25.6	23.2	25.5	23.7	24.9
N-free extract	50.2	46.1	46.3	42.8	41.7	38.7
In vitro digestibility of organic matter, %	72.4	72.2	72.3	68.6	74.3	67.8

Table 2. The criteria of the silage quality.

Nitrogen kg/ha	40		80		120	
	Grass	Silage	Grass	Silage	Grass	Silage
pH		4.01		3.99		3.98
% of dry matter:						
Acetic acid		1.51		1.58		2.89
Propionic acid		+		+		—
Butyric acid		—		—		—
Lactic acid		7.58		6.79		5.97
Sugars as glucose	12.3	11.7	10.5	6.2	8.1	3.9
True protein	12.1	8.1	14.1	10.3	16.9	12.3
True protein, % of crude protein	81.5	53.3	78.3	56.1	76.4	55.0
Soluble N, % of total N	27.1	54.2	29.6	54.7	33.4	50.5
NH_3-N, % of total N		2.8		3.3		3.9

The increase in nitrogen fertilization clearly increased the crude protein content of dry matter, the values being 14.8, 18.4 and 22.1 %, respectively (Table 1). Although this increase was evident in the protein yields, the corresponding dry matter yields did not change very much.

The content of dry matter and water-soluble carbohydrates (sugars) decreased with the increase of nitrogen fertilization (Tables 1—2), but the content of the other chemical constitutents was fairly similar in the different grasses. Corresponding results have been obtained in some other experiments (see e.g. McDONALD 1981, SALO and SORMUNEN 1976).

In the other criteria describing the quality there were some differences between the grasses (Table 2, Figures 1—2). Although the proportion of true protein in crude protein was relatively high in all the samples, it decreased as the N fertilization level increased, as follows: N_{40} 82 %, N_{80} 78 % and N_{120} 76 %. The proportion of watersoluble nitrogen in total nitrogen increased with the increase in N fertilization, from 27 to 30 to 33 %.

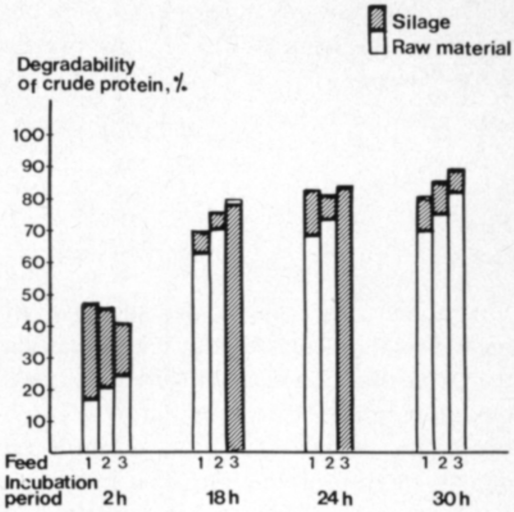

Fig. 1. The rumen degradability of the protein of the raw materials and the silages.

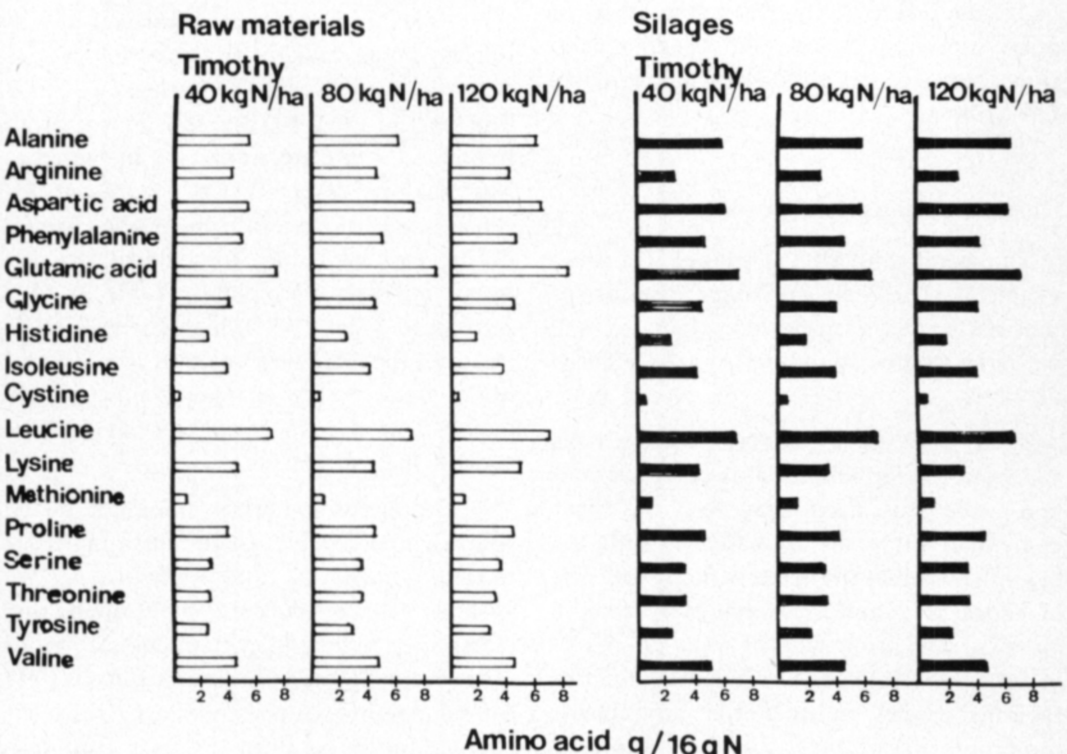

Fig. 2. The amino acid contents of the raw materials and the silages.

The following percentage values were obtained for the degradability of crude protein in the rumen:

	Incubation period			
	2 h	18 h	24 h	30 h
N_{40}	17	63	69	70
N_{80}	21	71	73	76
N_{120}	24	79	84	82

Although the rumen degradability of crude protein increased with the increase in the N fertilization level (Figure 1), it was quite low in all the samples during the first two hours. An increase in the rumen degradability of grass protein with an increasing N fertilization level has also been noted in another experiment (Møller 1981 ref. Setälä 1983).

The N fertilization did not affect the amino acid composition of the crude protein of timothy grass, which was similar to that in grasses in other studies (Andersen 1980, Salo et al. 1982). Mo (1977) and Andersen (1980) observed that nitrogen fertilization had some effect on the free amino acids of grass, especially aspartic and glutamic acid, whose content increased with increasing N fertilization.

Changes during ensiling

The quality of all the silages was good (Table 2). The chemical composition of the dry matter of the silages corresponded well with the composition in the raw material (Table 1).

There were slight differences between the silages in the fermentation of carbohydrates and crude protein. In silage N_{40}, the sugar content of the grass decreased by only 0.6 %-units, whereas the corresponding decrease in silages N_{80} and N_{120} was more than 4 %-units. The proportion of water-soluble N in total N was lower in silage N_{120} than in the other silages. In some other experiments the proportion of water-soluble N increased as the nitrogen fertilization level increased (Ettala et al. 1974), Poutiainen and Rinne 1976).

The rumen degradability of crude protein was higher in the silages than in the corresponding grasses, especially during the first two hours of incubation (Figure 1). These results confirm the earlier findings (Syrjälä-Qvist et al. 1984) that the higher is the proportion of true protein in crude protein and the lower the proportion of watersoluble N in total silage N, the slower is the degradation of crude protein in the rumen. The increase of the ammonia-N fraction of total N in silage has also been found to be reflected in increased degradation of protein in the rumen (Setälä 1983). In this experiment the proportion of ammonia-N was rather low and similar in all the silages (3—4 %), so that its effect on the rumen degradability of protein is difficult to evaluate. N fertilization seemed to increase also the level of degradation of crude protein in silage (Figure 1). The amino acid profile of protein did not change very much during ensiling (Figure 2).

The total amount of inorganic substances in timothy increased with the rising level of N fertilization (Table 1). As the N fertilization level of timothy rose, the content of all the minerals that were analysed increased at least slightly, except that of Ca. As no effluent was formed in the silages, the changes during ensiling in the contents of the different minerals were small (Table 3). According to Varis (1983), high N fertilization increases the total amounts of K, Ca, Na and Mg in grass, but the changes in the amounts mainly depend on the availability of the minerals in the soil.

The total ensiling losses amounted to the following percentages of the fresh material: silage N_{40} 8.2 %, N_{80} 8.8 % and N_{120} 4.1 %. Although the dry matter content of the raw materials was no higher than 20—24 %, no effluent was formed. The ensiling losses were caused mainly by surface spoilage, which accounted for the following losses of fresh material: N_{40} 7.8 %, N_{80} 8.5 % and N_{120} 3.5 %.

Table 3. The inorganic constituents of the raw materials and the silages.

Nitrogen kg/ha	40		80		120	
	Grass	Silage	Grass	Silage	Grass	Silage
Ca g/kg Dm	5.0	5.4	4.8	4.9	4.7	4.9
P »	2.6	2.9	2.9	3.2	2.9	3.2
Mg »	1.3	1.4	1.4	1.5	1.6	1.6
K »	26.2	28.0	30.6	31.9	31.4	34.2
Na mg/kg DM	170	110	170	110	200	120
Fe »	101	107	102	113	123	141
Mn »	34	37	45	46	48	52
Zn »	39	40	49	49	53	54
Cu »	8	7	9	8	9	8

The fermentation losses made up a very small proportion of total losses. The losses of the different nutrients mainly paralleled the total ensiling losses of the different silages (Table 4).

Table 4. The ensiling losses, % of the ensiled amounts.

Nitrogen kg/ha	40	80	120
Total	8.2	8.8	4.1
Dry matter	16.0	13.1	2.5
Organic matter	16.3	13.1	2.7
Ash	12.2	13.3	—0.1
Crude protein	13.5	13.6	2.2
Crude fat	—11.5	—17.6	—34.9
Crude fibre	8.4	4.4	—2.4
Sugars as glucose	19.8	49.3	53.0

The palatability to sheep was good in all the silages, the average daily voluntary intake being 2.6—2.7 kg DM/100 kg liveweight. In the grass the *in vitro* digestibility of organic matter was little higher at fertilization level N_{120} than at the other levels. Conversely, in the silages the *in vitro* digestibility of organic matter decreased with increasing N fertilization level (Table 1). In an earlier experiment the *in vitro* digestibility of organic matter decreased slightly with increasing N fertilization level in both silage and its raw material (Salo 1978).

References

Andersen C.E. 1980. Dyrkningsfaktorerens indflydelse på planteres indhold af organiske og uorganiske kvaelstofforbindelser. Dyrkningfaktorer og planternes kemiske sammansaetning. København. 261 p.

Ettala E., Takala M. & Lampila M. 1974. Typpilannoitustasot lypsylehmien säilörehuruokinnassa. Kehittyvä Maatalous 18: 51—59.

McDonald P. 1981. The Biochemistry of Silage. Chichester, John Wiley and sons Ltd. 261 p.

Mo M. 1977. Studies on protein quality of gass silage. Quality of forage. Lantbrukshögskolan, Inst. för husdjurens utfodring och vård, Rapport 54: 79—90.

Møller P.D. 1981. Personal communication. Ref. Setälä J. 1983.

Poutiainen E. & Rinne K. 1976. Typpilannoituksen vaikutus säilörehun ravintoarvoon. Kehittyvä Maatalous 29: 14—21.

Salo M.-L. 1978. Kasvuasteen ja typpilannoituksen vaikutus säilörehunurmen rehuarvoon. Kehittyvä Maatalous 38: 3—9.

Salo M.-L. & Sormunen R. 1976. Nurmisäilörehukokeita maatilasiiloissa. 1. Rehuarvon muutokset ja säilöntätappiot. J. Sci. Agric. Soc. Finl. 48: 109—127.

Salo M.-L., Tuori M. & Kiiskinen T. 1982. Rehutaulukot ja ruokintanormit. 70 p. Helsinki 1982.

Setälä J. 1983. Lypsylehmien valkuaisen tarve ja sen ruokinnalle asettamat vaatimukset. Lypsylehmien ruokinnan ja rehuntuotannon talous. Työtehoseuran julkaisuja no. 252: 5—60.

SYRJÄLÄ-QVIST L., PEKKARINEN E., SETÄLÄ J. & KANGASMÄKI T. 1984. Effect of red clover/timothy ratio on the feeding value of protein and the quality of silage. J. Sci. Agrig. Soc. Finl. Vol. 56: 193—198.

VARIS E. 1983. Typpi kasvien sadon ja määrän säätelijänä. Maataloustieteen päivät. Suomen maat. tiet. seuran tiedote 3: 16—20.

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SELOSTUS

Typpilannoitustason vaikutus timotein ja siitä valmistetun säilörehun valkuaisen laatuun

Liisa Syrjälä-Qvist[1], Eeva Pekkarinen[1], Jouko Setälä[1] ja Tapani Kangasmäki[2]

[1] Kotieläintieteen laitos, [2] Kasvinviljelytieteen laitos, Helsingin yliopisto, 00710 Helsinki 71

Vertailtavana oli timotein kolme N lannoitustasoa: 40, 80 ja 120 kg N/ha. Näistä valmistettiin säilörehut 0.4 m^3:n lasikuitusiiloihin.

Typpilannoitustason noustessa timoteiruohon kuiva-aineen raakavalkuaispitoisuus nousi seuraavasti: N_{40} 14.8 %, N_{80} 18.4 % ja N_{120} 22.1 %. Raakavalkuaissato oli eri N lannoitustasoilla N_{40} 285, N_{80} 398 ja N_{120} 447 kg/ha ja kuiva-ainesato vastaavasti N_{40} 1927, N_{80} 2165 ja N_{120} 2023 kg/ha.

Typpilannoitustason noustessa puhdasvalkuaisen osuus raakavalkuaisesta laski timoteiruohossa seuraavasti: N_{40} 82 %, N_{80} 78 % ja N_{120} 76 % ja vastaavasti liukoisen typen osuus kokonaistypestä nousi, N_{40} 27 %, N_{80} 30 % ja N_{120} 33 %. Myös timotein valkuaisen pötsihajoavuus lisääntyi timotein typpilannoitustason noustessa. Valkuaisen aminohappokoostumuksessa ei näillä typpilannoitustasoilla ollut eroja.

Säilörehut olivat laadultaan hyviä. Rehujen pH oli $\leq$ 4, ammoniumtypen osuus oli 2.8—3.9 % ja liukoisen typen osuus 51—55 % kokonaistypestä. Säilönnän aikana puhdasvalkuaisen osuus raakavalkuaisesta laski ja liukoisen typen osuus kokonaistypestä nousi vähiten N_{120} säilörehussa. Myös valkuaisen pötsihajoavuus oli 2 ensimmäisen tunnin aikana matalin tässä rehussa.