DRY MATTER AND CRUDE PROTEIN YIELDS IN FERTILIZED GRASSLANDS*

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The effect of graduated rates of nitrogen at constant fertilization with phosphorus and potassium on dry matter (DM) production of above-ground phytomass, content and production of crude protein and PDI was investigated on three types of grasslands (permanent – TTP, reseeded – PTP, temporary – DTP) in locality of Chvojnica (Strážov Mountains) during the years 1992–1997. The lowest DM production on the course of 6 years period was obtained in unfertilized variants of TTP and DTP. Increment of DM yield on DTP in comparison with TTP represented 33% on the average of the years 1992–1994 (the 1st time period of the experiment) and 24.6% (1995–1997 – the 2nd time period) what indicates the positive effect of grassland radical renovation. The highest DM yield (10.02 $t.ha^{-1}$) was achieved at temporary grassland under application of 180 $kg.ha^{-1}$ N and constant PK fertilization on the average of the years 1992–1994, representing increase by 102.8% comparing to unfertilized variant. In the second time period lower DM yield (8.06 $t.ha^{-1}$) was obtained, which was higher by 39.7% in comparison with the control. In PTP DM yields on the 4th variant were 9.47 and 7.74 $t.ha^{-1}$ in the first and the second experimental period, respectively. Fertilization with nitrogen increased uptake of nitrogen by grassland phytomass proportionally to applied N rate. However, utilization of applied nitrogen (in 1992–1994) was decreasing in both TTP and DTP. This tendency was not observed in PTP where the utilization of N was the highest (70.7%) at the highest applied rate of N (180 $kg.ha^{-1}$). Within the 2nd period of the experiment the utilization of N in the 4th variant was higher in comparison to the 1st period fluctuating from 44.7% (PTP) to 70.7% (DTP). Nitrogen rate of 180 $kg.ha^{-1}$ increased content of crude protein and PDI in forage DM in all investigated grassland types in both experimental time periods. The only exception is represented by PDI content in forage DM on the 4th variant of DTP (average of the years 1992–1994), which was not higher in comparison to variants unfertilized with nitrogen, probably as a consequence of intense organic matter mineralization after radical renovation of original grassland by ploughing. Comparing to nitrogen unfertilized variants, the rate of 90 $kg.ha^{-1}$ N increased the content of PDI in forage DM at both TTP and PTP in the first experimental period and at DTP in the second one. Systematic and relatively long-term intense fertilizing with nitrogenous mineral fertilizers was increasing the yields of DM only up to the certain time point (in the case for the first three years), after which the degradation of grasslands and depression of the yields happened and the mineral fertilization ceased to be effective also from economical point of view.

grassland; crude protein; fertilization; nitrogen; PDI; effectiveness

INTRODUCTION

Three farming technologies in grassland pratotechnics system were exploited. The highest intensity of forage production and animal products can be reached on temporary periodically renewed grasslands by utilization of selected and efficient grass and clover varieties. The second technology is based on the grass and clover species reseeding into degraded and less productive grasslands. The third way of natural autochtonic grassland management is related to organic and inorganic fertilization. It is usually realized on the stands, which are suitable from the viewpoint of abiotic and biotic conditions, botanical composition and environmental aspects (Krajčovič et al., 1999). Botanical composition and primary permanent grassland production reflect ecological conditions of a stand, but an application of mineral nutrients, especially nitrogen, can substantially increase their production potential. On the other side, this negatively influences species biodiversity (Holúbek et al., 1997; Nösberger, Kessler, 1997; Gáborčík, 1988; Jančovič, 1999; Vozár, 2003).

Flexible fertilizing according to soil-ecological conditions, type of grassland and its utilization pattern can significantly influence biotechnological value of forage. Recently the introduction of low-input system in grasslands has been propagating in the Slovak Republic and abroad as well. Its implementation and realization ensure permanently sustainable development of grassland ecosystems with regard to standard agroenvironmental requirements (Krajčovič et al., 2004).

The aim of the contribution is to evaluate the effect of graduated nitrogen rates under constant phosphorus and potassium fertilization on the phytomass and crude pro-

* Presented results were achieved within the solution of state project T-95 (No. 5-529-921) and research project 1/0603/03.

tein production in three types of grasslands (permanent, reseeded and temporary).

MATERIAL AND METHODS

Experimental investigations were realized on the semi-natural grasslands in locality of Chvojnica during the years 1992–1997. Experimental stand is situated at altitude of 600 m above sea level (latitude 48° 53´; longitude 18° 34´). Declination of the stand is represented by the value of 12°.

Within agroclimatic partitioning the experimental area belongs to mildly cold agroclimatic region, subregion mildly wet with prevailingly cold winter. Average year air temperature reaches 7.4 °C and the sum of annual precipitation amounts to 805 mm.

Agrochemical characteristics of experimental stand soil analyzed before trial establishment are stated in Table 1. Soil reaction was extremely acid, total N content was medium, contents of available phosphorus and magnesium were very low and the content of available potassium very high.

The trial was established in three regular blocks. The first one represented permanent grassland (TTP) with orginal semi-natural cover of Lolio-Cynosuretum cristati R. Tx. 1937, order Arrhenatheretha (Pawlowski et al., 1982). Within the second block the grass-clover mixture of the following composition was reseeded into the original semi-natural cover by drilling machine SE 2-024 in the spring 1992:

Lolium multiforum x *Festuca arundinacea* (hybrid *Felina*) – 12 $kg.ha^{-1}$
Lolium perenne, variety *Metropol* – 8 $kg.ha^{-1}$
Dactylis glomerata, variety *Rela* – 4 $kg.ha^{-1}$
Trifolium pratense, variety *Sigord* – 3 $kg.ha^{-1}$
Trifolium repens, variety *Huia* – 2 $kg.ha^{-1}$

In the third block the radical renovation of original cover was realized by deep autumn ploughing and subsequent seeding of grass-clover mixture (of the same composition as in the second block) in the spring of next year resulting in temporary grassland formation.

In all three blocks the same treatments of mineral nutrition (arranged randomly in four replications) and nitrogen rate distribution to respective cuts were realized (Table 2). Phosphorus was applied in the form of triple superphosphate, potassium in 60% potash salt and nitrogen as ammonium nitrate with limestone (calcium carbonate). The first rate of nitrogen and PK fertilizers were applied early in spring and the further nitrogen rates 10 days after respective mowings at the latest. Grasslands of all three blocks were utilized by 3 cuttings for hay making.

The content of nitrogen in DM of grasslands was determined by Kjeldahl´s method and content of crude protein (CP) as follows:

$$CP = \text{content of N} \times 6.25$$

The content of protein resorbed in small intestine (PDI) was calculated on the basis of the following relations (Sommer et al., 1994):

$$PDI = PDIA + PDIMN \; (g.kg^{-1} \; DM)$$

$$PDIA = CP \times 1.11 \times (1 - deg/100) \times 1 \times dsi/100 \; (g.kg^{-1} \; DM)$$

where: CP – content of crude protein ($g.kg^{-1}$ DM)
PDIA – undegraded CP really digested in small intestine
PDIMN – microbial protein of forage which can be synthetized in rumen from degraded crude protein of forage when contents of utilizable energy and nutrients are not limited
deg – effective degradability of CP (%)
dsi – real digestibility of undegraded CP in small intestine (%)

On the basis of recommended values of degradability and small-intestine digestibility of crude protein the values for deg = 65% and for dsi = 74% were applied (Sommer et al., 1994).

Effectiveness of investigated grasslands fertilization was expressed by means of coefficient of economic effectiveness (K_{EE}) and coefficient of natural effectiveness (K_{NE}). Agrochemical equivalent (AChE) and profit (Z)

Table 1. Agrochemical characteristics of soil

Depth of sampling (mm)	pH_{KCl}	C_{OX} (%)	N_{TOT} (%)	Content of available nutrients ($mg.kg^{-1}$)		
				P	K	Mg
50–100	4.13	2.58	0.204	15.8	696	68
200–300	3.83	1.36	0.095	9.70	604	23

Table 2. Nutrient rates and their distribution

Treatment	Number of cuttings	Rate of nutrients ($kg.ha^{-1}$)			Distribution of nitrogen ($kg.ha^{-1}$)		
		P	K	N	In spring	After the 1st cut	After the 2nd cut
1	3	–	–	–	–	–	–
2	3	30	60	–	–	–	–
3	3	30	60	90	30	30	30
4	3	30	60	180	60	60	60

were used for K_{NE} evaluation as a criterion. Calculations were done according to the following formulae:

$$K_{EE} = \Delta P / \Delta N$$

where: ΔP – increment of DM yield in consequence of fertilization (Sk.ha^{-1})
ΔN – increment of fertilization cost expressed in Sk.ha^{-1} (costs for fertilizers purchase, transport, application and harvest of yield increment)

$$K_{NE} = \Delta U / Z$$

where: ΔU – increment of dry matter yield (kg.ha^{-1}) as a consequence of fertilization
Z – rate of pure nutrients (kg.ha^{-1})

$$AChE = \Delta N / D \times C$$

where: D – rate of pure NPK nutrients (kg.ha^{-1})
C – price of 1 kg grass mass dry matter (Sk.kg^{-1})

$$Z = \Delta P - \Delta N \text{ (Sk.ha}^{-1}\text{)}$$

Computation was done by using current prices of fertilizers and hay (1 t of hay DM = 1294 Sk, 1 kg N = 15 Sk, 1 kg P = 43 Sk, 1 kg K = 12 Sk).

RESULTS AND DISCUSSION

Results of six-year experiment with 3 types of grasslands are subdivided for two equal time periods with an aim to evaluate effect of fertilization on DM yield and CP production.

Dry matter yields, content of CP and N-balance in two time periods (1992–1994, 1995–1997) by grassland type are stated in Table 3.

Table 3. Yields of above-ground phytomass of grasslands and nitrogen balance

Type of grassland	Year	Variant	DM yield		Content of N in DM	Nitrogen balance		
						Offtake by yield	$E - E_0$**	V_N***
			t.ha^{-1}	Rel.(%)	g.kg^{-1}	kg.ha^{-1}	kg.ha^{-1}	%
TTP	1992–94	1	3.74	100.0	25.01	93.5	–	–
		2	4.92	131.6	25.00	123.0	–	–
		3	6.86	183.4	25.78	176.9	83.4	92.7
		4	7.72	206.4	28.99	223.8	130.3	72.4
		Average	5.81		26.56*	154.3		
	1995–97	1	4.63	100.0	26.62	123.3	–	–
		2	5.37	116.0	27.76	149.1	–	–
		3	6.34	136.9	26.48	167.9	44.6	49.6
		4	7.59	163.9	29.30	222.4	99.1	55.1
		Average	5.98		27.70*	165.7		
PTP	1992–94	1	5.58	100.0	27.95	156.0	–	–
		2	5.46	97.8	28.42	155.2	–	–
		3	7.39	132.4	28.75	212.5	56.5	62.8
		4	9.47	169.7	29.91	283.2	127.2	70.7
		Average	6.98		28.92*	201.7		
	1995–97	1	5.64	100.0	28.97	163.4	–	–
		2	6.46	114.5	29.32	189.4	–	–
		3	6.98	123.8	28.62	199.8	36.4	40.4
		4	7.74	137.2	31.43	243.3	79.9	44.4
		Average	6.71		29.68*	199.0		
DTP	1992–94	1	4.94	100.0	24.83	122.7	–	–
		2	5.35	108.3	25.40	135.9	–	–
		3	8.29	167.8	23.80	197.3	74.6	82.9
		4	10.02	202.8	24.86	249.1	126.4	70.2
		Average	7.15		24.65*	176.2		
	1995–97	1	5.77	100.0	26.67	153.9	–	–
		2	5.87	101.7	26.48	155.4	–	–
		3	7.52	130.3	27.83	209.3	55.4	61.6
		4	8.06	139.7	34.89	281.2	127.3	70.7
		Average	6.81		29.38*	200.0		

* weighted average, **E – export of N by yield in fertilized variants, E_0 – export of N by yield in unfertilized variants, ***V_N – utilization of N from fertilizers (%)

Level of production on grassland under optimum conditions is in essence the function of applied nutrients and increasing of yield is even considered to be a linear function of applied nitrogen up to the rate of 300 to 400 kg.ha^{-1} (Míka, 1982).

Initial production level of grasslands under regular mowing can be evaluated by means of unfertilized treatment. The lowest dry matter yield within six-year experimental period was found at unfertilized variants of both TTP and DTP. Increment of DM yield in DTP comparing with TTP was 33% on the average of 1992–1994 period and 24.6% for 1995–1997 period. This indicates a positive effect of radical renovation of original grassland.

Fertilizing with mineral fertilizers in TTP increased DM yield relatively to larger extend than in DTP and PTP, however at the lower level of absolute yields in both time periods of the experiment. In the second time period the yield increments were lower in general (Table 3).

The highest DM yield (10.02 t.ha^{-1}) was achieved at a temporary grassland (DTP) under the application of 180 kg.ha^{-1} N with parallel PK fertilization on the average of the years 1992–1994, what represents a yield increase by 102.8% in comparison to unfertilized variant. In the second time period the lower DM yield (8.06 t.ha^{-1}) was obtained representing increase by 39.7% to control variant. In reseeded grassland DM yields were 9.47 t.ha^{-1} and 7.74 t.ha^{-1} for the first and second time period, respectively. Furthermore, the differences in the yields among types of grasslands were lowering in the 4th variant during the period 1995–1997.

By the yield of grassland a considerable amount of nutrients per annum is removed from the soil and fertilizers owing to the good uptake ability of grassland communities. One ton of meadow yield DM under the medium intensity of fertilizing takes off 19–21 kg N, 2.5–2.8 kg P, 20–22 kg K, 5–8 kg Ca and 2–3 kg Mg (Lichner et al., 1983).

Effect of grassland fertilization by mineral fertilizers unambiguously resulted in increased uptake of nitrogen. The highest uptake of nitrogen was found in 4th variant, where the highest rate of N was applied. In this variant the highest amount of N was taken up by whole-year yield on PTP (200 kg.ha^{-1}) and the least amount on TTP (160 kg.ha^{-1}) on the average of six years. Temporary grassland (DTP) took up by the whole-year yield 188 kg.ha^{-1}N (Table 3).

Graduated rates of nitrogen increased the yield of dry matter, however efficiency of applied nitrogen was decreasing in permanent and temporary grassland on the average of 1992–1994 time period. This tendency did not manifest in reseeded grassland where the efficiency of nitrogen utilization was the highest (70.7%) at the highest rate of nitrogen (180 kg.ha^{-1}). Higher efficiency of nitrogen utilization was found on the 4th variant in the second time period of the experiment fluctuating from 44.4% (PTP) to 70.7% (DTP). Although the achieved values only approximately reflect the nitrogen utilization efficiency from mineral fertilizers, they are commonly accepted in agricultural practise. Efficiency of nutrient utilization is not only influenced by the rate of applied fertilizers but also with content of available nutrients in soil, various weather conditions in respective experimental years and pedo-ecological factors of the stand (Hanáčková, 1995; Slamka, 2002).

The content of nitrogen in complexity with other characteristics creates the general picture about grassland forage quality. The content of crude protein in grassland forage DM is required to be 150–200 g.kg^{-1} (Holúbek, 1994). Labuda et al. (1975) state that forage would contain 120–150 g.kg^{-1} CP in DM to cover the nitrogen requirements even for high-performing dairy cows.

Evaluating effect of fertilization on CP content in grassland forage, it can be concluded that higher CP content in forage DM was found out in the second investigated time period (1995–1997) on the variants fertilized with the highest rate of nitrogen in all 3 types of grasslands (Table 4). It is supposed that this is a consequence of systematic intensive fertilizing of the grassland as well as the phytocenological changes in botanical composition of the cover. Grasses as nitrophilic and dominant species in grassland communities under nitrogen fertilization can maintain high content of PDI, that is protein, which is resorbed in small intestine.

Nitrogen rate of 180 kg.ha^{-1} (variant 4) increased the content of PDI in forage DM of all investigated types of grassland in both analyzed time periods. The only exception was the content of PDI in the 4th variant of DTP in period 1992–1994 (99.4 g.kg^{-1}), which was not higher in comparison to variants unfertilized with nitrogen. This was probably in the consequence of intense organic matter mineralization after radical original cover renovation by ploughing. There was probably released higher amount of mineral nitrogen into the rhizosphere of plants, which reduced the expected differences between N-fertilized and N-unfertilized variants.

In comparison to N unfertilized variants (1, 2), the rate of 90 kg.ha^{-1} N (3rd variant) increased content of PDI in forage DM at TTP and PTP in the first time period and at DTP in the second time period (Table 4). In the first time period (1992–1994) in DTP under both N fertilized variants the content of PDI was similar to that of with N unfertilized variants resulting from already above-mentioned mineralization effect after radical renovation.

The differences of PDI content in DM of grassland forage between two investigated time periods were not statistically significant on both TTP and PTP. However, the content of PDI in forage from DTP was significantly higher (117.7 g.kg^{-1}) in the second investigated time period in comparison to the first one (98.6 g.kg^{-1}) – Table 5.

The effect of fertilization on PDI content in DM of forage is indicated in Table 6. It results from this table that statistically significant effect of fertilization on PDI content was obtained only at the rate of 180 kg N + PK (4th variant) in both TTP and DTP.

Table 4. Content of crude protein and PDI in forage DM of grasslands

Type of grassland	Year	Variant	Crude protein (CP)			
			Content of CP	Whole–year yield	Natural production	PDI
			g.kg^{-1}	kg.ha^{-1}	kg DM. kg^{-1} N	g.kg^{-1}
TTP	1992–1994	1	156.3	584.6	–	100.0
		2	156.3	769.0	–	100.0
		3	161.1	1105.1	5.8	103.1
		4	181.2	1398.9	4.5	115.9
		Average	166.0*	964.4		106.2*
	1995–1997	1	166.4	770.4	–	106.4
		2	173.5	931.7	–	111.0
		3	165.5	1049.3	3.1	105.9
		4	183.1	1389.7	3.4	117.1
		Average	173.1*	1035.2		110.7*
PTP	1992–1994	1	174.7	974.8	–	111.8
		2	177.6	969.7	–	113.6
		3	179.7	1328.0	3.9	115.0
		4	186.9	1770.0	4.4	119.6
		Average	180.7*	1260.6		115.6*
	1995–1997	1	181.1	1021.4	–	115.9
		2	183.3	1184.1	–	117.3
		3	178.9	1248.7	2.5	114.4
		4	196.4	1520.1	2.8	125.6
		Average	185.5*	1243.6		118.7*
DTP	1992–1994	1	155.2	766.7	–	99.3
		2	158.8	849.6	–	101.6
		3	148.8	1233.6	5.2	95.2
		4	155.4	1557.1	4.4	99.4
		Average	154.1*	1101.8		98.6*
	1995–1997	1	166.7	961.9	–	106.6
		2	165.5	971.5	–	105.9
		3	173.9	1307.7	3.8	111.2
		4	218.1	1757.9	4.4	139.5
		Average	183.6*	1249.8		117.5*

* weighted average

Intense grassland fertilization with nitrogen increases the content of CP on one side, but it causes the depression of energy components content represented by non-nitrogenous compounds, fibre and water-soluble sugars on the other side (K o l á ř, 1983; H o l ú b e k, 1991).

Increase of CP content and its digestibility leads to increase of PDI content, which however does not result in nutritional effect (relative deficiency of energy), but to increased excretion of nitrogen by urine in full extend of increased intake (B r a u n et al., 1996). It means that high rates of nitrogen fertilizers (both organic and mineral) in spite of the fact that increase DM yields, do not earn required economical effect.

In the context of new viewing on the solution of CP problematic, this criterion (CP, PDI) is not sufficient, because it does not respect the processes running in digestive tract of polygastric animals during digesting taken fodder. In new systems evaluating crude protein, digesting and metabolism of nitrogen are considered together with identification and quantification of nitrogen losses,

Table 5. Effect of two time periods on PDI content (g.kg^{-1}) in DM of grasslands (Tuckey test)

Period	TTP	PTP	DTP
1992–1994	106.6 a	115.9 a	98.6 a
1995–1997	110.9 a	118.4 a	117.7 b

LSD = 13.4 (α = 0.05)
LSD – least significant difference
The same letters at average values indicate statistical insignificance

which are caused by its inappropriate intake (Sommer, Čerešňáková, 1995). Utilization of N-fertilizers is considerably influenced by crude protein production in unfertilized variant caused by presence of legume species. For this reason it is needed to count off the crude protein production in the control (unfertilized) variant from crude protein production in respective fertilized variants.

In the first time experimental period the production of CP increased in all variants (Table 4) due to the reseeding of grass-clover mixture as well as the radical renovation of original grassland cover. Within unfertilized (control) variant CP production was higher by 55.7% in PTP and 31.1% in DTP compared to TTP. Respective types of grasslands responded to regular intense fertilizing differently. It was found out that CP production of reseeded grassland (PTP) decreased in comparison with TTP and oppositely in temporary grassland (DTP) increased (in 4^{th} variant for instance by 26.5%) comparing to TTP on the average of 1995–1997 years.

Increment of CP was increasing with graduating nitrogen rate, the effect of which was relatively the highest in TTP and the lowest in PTP. Achieved results are in harmony with the data published by Morháč (1991).

Comparing two investigated time periods it is evident that in the first period CP production was higher only in PTP (1261 kg.ha^{-1}). In TTP and DTP CP production was higher in the second time period on the average of the years 1995–1997.

Table 6. Effect of fertilization on content of PDI in DM of grassland forage (g.kg^{-1}) (Tuckey test)

Variants of fertilization	TTP	PTP	DTP
1	103.2 a	113.3 a	103.4 a
2	105.8 ab	114.9 a	103.7 a
3	104.1 a	114.3 a	106.7 a
4	116.8 b	123.6 a	120.3 b

LSD = 12.1 (α = 0.05)
LSD – least significant difference
The same letters at average values indicates statistical insignificance

Table 7. Economical characteristics of grassland fertilization (average of the years 1992–1994 and 1995–1997)

Type of grassland	Years	Variant	Increment of DM yield		K_{NE}[1]	K_{EE}[2]	Profit Sk.ha^{-1}	AChE[3]
			t.ha^{-1}	Sk.ha^{-1}				
TTP	1992–1994	1	–	–	–	–	–	
		2	1.18	1527	13.11	0.69	–683	
		3	3.12	4037	17.33	1.02	77	
		4	3.98	5150	14.74	0.97	–160	
	1995–1997	1	–	–	–	–	–	
		2	0.84	1087	9.33	0.49	–1 123	
		3	1.81	2342	10.06	0.59	–1618	
		4	3.06	3960	11.33	0.75	–1350	
PTP	1992–1994	1	–	–	–	–	–	
		2	–0.12	–155	–1.33	–0.07	–2055	18.98
		3	1.81	2342	10.06	0.59	–1618	17.00
		4	3.98	5034	14.41	0.95	–276	13.48
	1995–1997	1	–	–	–	–	–	
		2	0.82	1061	9.11	0.48	–1149	
		3	1.34	1734	7.44	0.44	–2226	
		4	2.10	2717	7.78	0.51	–2593	
DTP	1992–1994	1	–	–	–	–	–	
		2	0.41	531	4.56	0.24	–1679	
		3	3.35	4335	18.61	1.09	375	
		4	5.08	6574	18.81	1.24	1264	
	1995–1997	1	–	–	–	–	–	
		2	0.10	129	1.11	0	–2081	
		3	1.75	2265	9.72	0.57	–1695	
		4	2.29	2963	8.48	0.56	–2347	

K_{NE}[1] – coefficient of natural effectiveness
K_{EE}[2] – coefficient of economical effectiveness
AChE[3] – agrochemical equivalent – indicates what should be natural effectiveness of 1 kg pure nutrients (K_{NE}) to reach equilibrium between the price of DM yield increment and fertilization cost increment, that is K_{NE} = 1

Fertilization with phosphorus and potassium also increased CP production, but in substantially less extent than nitrogen fertilizing.

Buchgraber and Gindl (2004) consider as satisfied if 1 kg of nitrogen is converted to 4.5–5.0 kg of CP in grassland forage. After counting CP production in unfertilized variant off this condition is fulfilled in both with nitrogen fertilized variants on TTP and the 3rd variant on DTP on the average of 1992–1994 years.

It results from Table 7 that PK fertilization (variant 2) in investigated grasslands was ineffective within both experimental time periods. The values of coefficient of natural effectiveness (K_{NE}) were deeply under the value of agrochemical equivalent (AChE), which is considered to be a criterion for assessing K_{NE}. Calculated coefficient of economical effectiveness (K_{EE}) in this variant indicates (Table 7) that input of 1 Sk to the fertilizing cost resulted in yield increment less than 1 Sk. It means that fertilization was ineffective from the economical point of view and resulted to financial loss fluctuating from –683 $Sk.ha^{-1}$ (TTP) up to –2 081 $Sk.ha^{-1}$ (DTP).

Addition of 90 $kg.ha^{-1}$ N to PK fertilizers substantially increased increment of DM yields in both TTP and DTP in comparison with the control variant on the average of 1992–1994. Consequently, K_{NE} was higher than AChE and $K_{EE} > 1$ resulting in profit of 77 $Sk.ha^{-1}$ (TTP) and 375 $Sk.ha^{-1}$ (DTP). Reseeded grassland was not capable effectively to utilize applied nitrogen for yield formation which was reflected in low value of K_{NE} and financial loss (–1618 $Sk.ha^{-1}$). Another increase of nitrogen rate by 90 $kg.ha^{-1}$ to total 180 $kg.ha^{-1}$ acted positively on DM yields in the first time period of the experiment. The highest value of K_{NE} was achieved on DTP (18.81). From the viewpoint of economical effectiveness only DTP was capable to utilize this nitrogen rate for yield and profit formation (K_{NE} = 1.24; profit = 1264 $Sk.ha^{-1}$).

As far as the second period of the experiment (1995–1997) is concerned, fertilization with nitrogen and PK was not effective and showed financial losses in all types of grasslands as well as in all fertilized variants on the average of 3 years (Table 7).

On the basis of achieved results, it can be concluded that systematic relatively long-term intense fertilizing with nitrogen fertilizers (+ PK) increased the increments of yields only for certain time period (in this case for the first three years of the experiment). After the first three years degradation of grasslands and decline of yields have happened and fertilization with mineral fertilizers ceased to be economically effective.

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Received for publication on August 17, 2005
Accepted for publication on October 19, 2005

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Vplyv hnojenia trávnych porastov na úrodu sušiny a dusíkatých látok.

Scientia Agric. Bohem., *37*, 2006: 49–56.

V lokalite Chvojnica v Strážovských vrchoch sa v rokoch 1992 až 1997 sledoval vplyv stupňovaných dávok dusíka pri konštantnom hnojení fosforom a draslíkom na produkciu fytomasy a dusíkatých látok a na efektívnosť hnojenia pri troch typoch trávnych porastov (trvalom, prisiatom a dočasnom). Najnižšia produkcia sušiny za 6-ročné obdobie bola zistená na nehnojenom variante TTP a DTP. Prírastok úrod sušiny na DTP v porovnaní s TTP v priemere rokov 1992–1994 (1. etapa pokusu) činil 33 %, za obdobie rokov 1995–1997 (2. etapa pokusu) 24,6 %, čo poukazuje na pozitívny vplyv radikálnej obnovy trávneho porastu. Najvyššia úroda sušiny (10,02 $t.ha^{-1}$) bola dosiahnutá na dočasnom trávnom poraste pri aplikácii 180 $kg.ha^{-1}$ N pri súčasnom PK hnojení v priemere rokov 1992–1994, čo je zvýšenie o 102,8 % v porovnaní s nehnojeným variantom. V druhej časovej etape bola dosiahnutá nižšia úroda sušiny (8,06 $t.ha^{-1}$), čo však reprezentuje zvýšenie oproti kontrole o 39,7 %. Na prisiatom poraste bola úroda sušiny 9,47 $t.ha^{-1}$, resp. 7,74 $t.ha^{-1}$ v 2. časovej etape. Hnojenie dusíkom zvyšovalo príjem dusíka trávnym porastom úmerne jeho dávke. Využiteľnosť aplikovaného dusíka (v rokoch 1992–1994) sa však znižovala na TTP aj DTP. Táto tendencia sa neprejavila na PTP, kde využiteľnosť dusíka bola najvyššia (70,7 %) pri najvyššej dávke dusíka (180 $kg.ha^{-1}$). V druhej etape pokusu bola využiteľnosť dusíka na 4. variante vyššia a pohybovala sa v rozmedzí od 44,7 % (PTP) do 70,7 % (DTP). Dávka dusíka na úrovni 180 $kg.ha^{-1}$ zvyšovala obsah NL i PDI v sušine krmu na všetkých skúmaných typoch trávnych porastov v obidvoch časových obdobiach. Výnimkou bol obsah PDI v krme na 4. variante DTP v rokoch 1992–1994, kde nebol obsah PDI vyšší v porovnaní s dusíkom nehnojenými variantmi, pravdepodobne v dôsledku intenzívnej mineralizácie organickej hmoty po radikálnej obnove pôvodného porastu orbou. V porovnaní s dusíkom nehnojenými variantmi dávka 90 $kg.ha^{-1}$ zvyšovala obsah PDI v krme pri TTP a PTP v 1. časovej etape a na DTP v 2. etape pokusu. Systematické a relatívne dlhodobé intenzívne hnojenie dusíkatými priemyselnými hnojivami zvyšuje úrody sušiny trávnej hmoty len do určitého časového obdobia (v našom prípade prvé tri roky), po ktorom nasleduje degradácia porastu, pokles úrod a hnojenie prestáva byť efektívne aj z ekonomického hľadiska.

trávny porast; dusíkaté látky; hnojenie; dusík; PDI; efektívnosť

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