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AN ECONOMIC ANALYSIS OF PERMANENT AND OVERSOWN GRASSLANDS BASED ON THE DATA FROM RESEARCH EXPERIMENTS

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Abstract

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Trends in the cost of grassland utilisation were assessed bearing in mind economic, ecological and environmentally friendly management of grassland in mountain regions. The cost calculations were based on the results of long-term trials carried out within the research on grassland management techniques aimed at production, and the quality of hay. A computer program (*MACHDATA www.ktbl.de*) was applied to specify the technological cost of making hay from permanent (PG) and oversown (OG) grasslands. The direct and the total costs of production and quality of hay dry matter (DM) were calculated by a modified specific calculation formula. On the basis of the grassland management technology (permanent and oversown grasslands), the direct and total costs were calculated per ha, per metric tonne of hay DM, per a unit of production of protein and energy nutrients, respectively. The yield of hay DM increased with rising fertiliser rates, the highest yield was recorded at the highest fertiliser rates, namely 7.29 t ha^{-1} at PG and 6.79 t ha^{-1} at OG. The total costs ranged between 139.39 and 409.38 € ha^{-1} at PG and from 174.37 to 444.72 € ha^{-1} at OG fertiliser treatments, respectively. The least efficient production of hay DM and crude protein was recorded at PG with P and K fertiliser application. The application of NPK fertilisers (Treatments 3 and 4) on PG and OG reduced the total costs of production of protein and energy nutrients. The economic effect of oversowing was found at treatments with high fertiliser application rates.

Key words: grassland, low-input management, economy, cost, management techniques

Introduction

Since the nineties of the 20th century, in relation to the problems of global warming, the European grassland research has been aimed at environmentally friendly management, low-input systems, agro-environmental measures and biodiversity conservation. A research project named "Environmentally friendly management of landscape on the basis of grassland"

(Krajčovič, 1991) was established in former Czechoslovakia (now the Czech Republic and Slovakia). The dominant part of this project was research on the permanent (PG), oversown (OG) and temporary (TG) grassland with the objective to study three dominant technologies within one enclosed experiment with a unified methodology at five sites in the Czech Republic and five sites in Slovakia.

A historical development of forage and grassland research in Slovakia shows that the research into the oversowing techniques and conversion of arable land to grassland had been carried out very early (Maloch, 1948; Tomka, 1961; Krajčovič, Ondrášik, 1980; Hrazdira, 1990 and others). However, those research activities were isolated and diverse methods were applied. The complex research project as proposed by Krajčovič (1991) resulted in a wide range of viewpoints and therefore it was substantial.

Over 1992–1999, this research into production, quality and ecosystems was not only assessed in a range of reports, but also synthesised (Holúbek, 2007). Recently, detailed research into the characteristics of grasslands in mountain areas in Slovakia did not pay much attention (Hreško, Bugár, 2001; Bowman et al., 2008; Gallayová, 2008; Halada et al., 2009). Several works mostly evaluate the quantitative change of the use of grasslands for another component of the landscape (Ivanová, 2003; Oťahel et al., 2004; Petrovič, 2005; Olah et al., 2008; Boltižiar, Mojses, 2008; Hronček, 2008; Muchová, Petrovič, 2008; Hreško et al., 2009). Nevertheless, the economic views relating to this theme have been published less frequently thus far (Grznár, 2000; Holúbek, Kuzma, 2003; Holúbek, 2007; Lehmann, Hediger, 2004; Kubánková, Chrastinová, 2006; Kubánková, Burianová, 2007; Petrovič, Bezák, 2004) and mostly in relation to lowland regions. Therefore, we have decided to accomplish an economic analysis of the research site at the highest altitude. We have asked the authors of the production parts of the research (Ilavská et al., 1999, 2002) for their permission to use their experimental data in our economic analysis.

Material and methods

The research trials were established at Liptovská Teplička site located in a mountain region of Slovakia. The basic characteristics of grassland ecosystems was as follows:

Soil ecological region: the Nízke Tatry mountain range (47.04.03), altitude 960 m; longitude (λ) 20° 06´; latitude (φ) 48°55´. Climatic conditions (as long-term averages): global solar radiation 1881 kWh m^{-2}; mean daily air temperature per growing season 9.5 °C; total annual rainfall 900 mm; rainfall over growing season 500 mm. Edaphic conditions: geological substratum – carbonate rock; soil type – rendzina; soil texture – loamy. Landscape type: montane landscape, temperate region.

The assessment comprised two types of grasslands, namely permanent grasslands (PG) and oversown grasslands (OG). A range of grass and clover cultivars was oversown into PG at 29 kg ha^{-1} sowing rate. Identical rates of fertilisers were applied (as ammonium nitrate with lime, superphosphate and 60 % potassium salt) to each of the grassland types at the following treatments (kg ha^{-1}): treatment 1(T1): $N_0 P_0 K_{0;}$ treatment 2 (T2): N0 $P_{30} K_{60;}$ treatment 3 (T3): $N_{3 \times 30} P_{30} K_{60}$ and treatment 4 (T4): $N_{3 \times 60}$, $P_{30} K_{60.}$ The sward was utilised by three cuts. Herbage production and quality were assessed (ø = 7 years), and the data are given in Tables 1 and 2.

The total costs of grassland management techniques were investigated using a calculation formula (Kubánková, Chrastinová, 2006) with the following specific modifications:

– direct costs per ha (DC ha^{-1}) based on labour and material costs,
– overhead costs of production and administration,
– total costs per ha (TC ha^{-1}) = direct costs per ha including overhead and its structure according to the cost items,

T a b l e 1. The costs of hay production per tonne of DM and per tonne of basic nutrients at permanent grasslands (mean of 7 years) – Liptovská Teplička site.

Parameters	PG-meadow				
	The work operation cost and main parameters				
	Units	T 1	T 2	T 3	T 4
Sward treatment	€ ha $^{-1}$	5.95	5.95	5.95	5.95
Fertiliser loading by a tractor set	€ t $^{-1}$	0.00	0.13	0.25	0.50
Fertiliser transport by a tractor set	€ t km $^{-1}$	0.00	0.83	1.25	2.50
Fertiliser application	€ t ha $^{-1}$	0.00	5.28	5.28	5.28
Sward cutting at the 1st, 2nd and 3rd cuts	€ ha ^{1}	51.27	51.27	51.27	51.27
Tedding hay DM at the 1st, 2nd and 3rd cuts	€ ha $^{-1}$	10.50	10.50	13.50	13.50
Raking hay DM at the 1st, 2nd and 3rd cuts	€ ha $^{-1}$	10.50	10.50	10.50	10.50
Harvesting hay DM by a trailer-harvester at the 1st, 2nd and 3rd cuts	€ ha $^{-1}$	24.17	24.17	24.17	24.17
Transporting hay DM by a transporting set at the 1st, 2nd and 3rd cuts	€ t km $^{-1}$	5.85	10.47	14.50	16.95
Loading hay DM inside a hay-shed at the 1st, 2nd and 3rd cuts	€ t $^{-1}$	9.68	17.34	24.01	28.06
Purchased fertilisers	€ ha $^{-1}$	0.00	82.14	141.32	200.50
Purchased seed	€. ha $^{-1}$	-	-	-	-
Ploughing at PG	€ ha $^{-1}$	-	-	-	-
Soil treatment for sowing	€ ha $^{-1}$	-	-	-	-
Grass/clover mixture sowing	€ ha $^{-1}$	-	-	-	-
Total direct costs	€ ha $^{-1}$	117.92	218.58	292.00	359.18
Overhead costs of production and administration	€ ha $^{-1}$	21.47	39.61	44.11	50.20
Total costs	€ ha $^{-1}$	139.39	258.19	336.11	409.38
Hay DM yield	t ha $^{-1}$	2.20	3.84	5.69	7.29
Total costs per tonne of hay DM	€ ha $^{-1}$	63.36	67.23	59.07	56.15
Crude protein (CP) proportion per tonne of hay DM	CP t $^{-1}$	0.1384	0.1426	0.1340	0.1539
Total costs per tonne of crude protein	€ t $^{-1}$	8.77	9.58	7.91	8.64
Total costs per ha	€ ha $^{-1}$	19.29	36.78	45.00	62.98
∑ costs of machinery operation	€ ha $^{-1}$	117.92	136.44	150.68	158.68
Proportion of as GJ NEL	GJ t $^{-1}$	0.00589	0.00607	0.00587	0.00597
Total costs per GJ NEL	€ GJ NEL $^{-1}$	0.37	0.41	0.34	0.33
Total costs per hectare (GJ NEL t ha of hay DM)	€ ha^{-1}	0.81	1.57	1.93	2.40
Proportion of PDIN as tonnes per tonne of hay DM	t PDIN t $^{-1}$ DM	0.0915	0.0940	0.0934	0.0981
Total costs per tonne of PDIN	€ ha^{-1}	5.79	6.32	5.51	5.51
Total costs per hectare (EUR t PDIN t ha of hay DM	€ ha^{-1}	12.74	24.27	31.35	40.16

– total costs per metric tonne of dry matter (TC t $^{-1}$) = (TC ha^{-1} : DM yield ha^{-1}),
– total costs per metric tonne of crude protein (CP) according to a proportion in the content of basic nutrients given as kg t $^{-1}$ (1000 g TC t $^{-1}$) of dry matter in €, and at the same time also total costs in € t $^{-1}$ of protein digested in the small intestine (PDI) and total costs per GJ of net energy for lactation (NEL).

The material costs comprised fertilisers as well as grass and clover seeds used for overdrilling into permanent grasslands (29 kg ha^{-1}).

T a b l e 2. The costs of hay production per tonne of DM and per tonne of basic nutrients at oversown grasslands (mean of 7 years) – Liptovská Teplička site.

Parameters	OG-meadow				
	The work operation cost and main parameters				
	Units	T 1	T 2	T 3	T 4
Sward treatment	€ ha $^{-1}$	5.95	5.95	5.95	5.95
Fertiliser loading by a tractor set	€ t $^{-1}$	0.00	0.13	0.25	0.50
Fertiliser transport by a tractor set	€ t km $^{-1}$	0.00	0.83	1.25	2.50
Fertiliser application	€ t ha $^{-1}$	0.00	5.28	5.28	5.28
Sward cutting at the 1st, 2nd and 3rd cuts	€ ha ^{1}	51.27	51.27	51.27	51.27
Tedding hay DM at the 1st, 2nd and 3rd cuts	€ ha $^{-1}$	10.50	10.50	13.50	13.50
Raking hay DM at the 1st, 2nd and 3rd cuts	€ ha $^{-1}$	10.50	10.50	10.50	10.50
Harvesting hay DM by a trailer-harvester at the 1st, 2nd and 3rd cuts	€ ha $^{-1}$	24.17	24.17	24.17	24.17
Transporting hay DM by a transporting set at the 1st, 2nd and 3rd cuts	€ t km $^{-1}$	5.85	10.47	14.50	16.95
Loading hay DM inside a hay-shed at the 1st, 2nd and 3rd cuts	€ t $^{-1}$	9.68	17.34	24.01	28.06
Purchased fertilisers	€ ha $^{-1}$	0.00	82.14	141.32	200.50
Purchased seed	€. ha $^{-1}$	14.70	14.70	14.70	14.70
Ploughing at PG	€ ha $^{-1}$	-	-	-	-
Soil treatment for sowing	€ ha $^{-1}$	-	-	-	-
Grass/clover mixture sowing by overdrilling	€ ha $^{-1}$	20.64	20.64	20.64	20.64
Total direct costs	€ ha $^{-1}$	153.26	253.92	327.34	394.52
Overhead costs of production and administration	€ ha $^{-1}$	21.47	39.61	44.11	50.20
Total costs	€ ha $^{-1}$	174.73	293.53	371.45	444.72
Hay DM yield	t ha $^{-1}$	2.34	4.19	5.81	6.79
Total costs per tonne of hay DM	€ ha $^{-1}$	74.67	70.05	63.93	65.49
Crude protein (CP) proportion per tonne of hay DM	CP t $^{-1}$	0.1361	0.1494	0.1342	0.1436
Total costs per tonne of crude protein	€ t $^{-1}$	10.16	10.46	8.58	9.40
Total costs per ha	€ ha $^{-1}$	23.77	43.82	49.85	63.82
∑ costs of machinery operation	€ ha $^{-1}$	153.26	157.08	171.32	179.32
Proportion of NEL as GJ NEL	GJ t $^{-1}$	0.00601	0.00595	0.00601	0.00615
Total costs per GJ NEL	€ GJ NEL $^{-1}$	0.45	0.41	0.31	0.40
Total costs per hectare (GJ NEL GJ ha $^{-1}$ of hay DM)	€ ha^{-1}	1.05	1.74	2.20	2.71
Proportion of PDIN as tonnes per tonne of hay DM	t PDIN t $^{-1}$ DM	0.0921	0.0945	0.0937	0.0977
Total costs per tonne of PDIN	€ t $^{-1}$	6.87	6.62	5.99	6.40
Total costs per hectare (EUR t PDIN t ha of hay DM	€ ha $^{-1}$	16.07	27.73	34.80	43.45

The labour costs of two PG management techniques covered the sequence of working procedures as performed by a line of machinery (Tables 1 and 2).

The technological costs of mechanised work at permanent grassland management were defined by the computer program MACHDATA available at *www.ktbl.de*. The final analyses of production parameters were evaluated by the method of comparison and structural analysis. The parameters of PG and OG quality were assessed in detail and in compliance with the specific methods (Krajčovič, 2006; Holúbek, 2007).

Results and discussion

The research site (altitude 960 m) is located in a rather extreme area on the north-eastern slopes of the Nízke Tatry mountain range. However, the carbonate substratum with the rendzina soil type mitigates the harsh mountain conditions as indicated by *Festuco-Cynosuretum* sward type that is in between the semi-natural and the productive type. For the first three research years, a markedly high proportion of legumes was found at all the treatments (including those with N fertiliser applied). At permanent grasslands, the legume ground cover was 40 – 52 – 44 – 35% for the first three research years, and 23 – 41 – 30 – 0% for the second three, respectively. At the oversown grasslands, the legume ground cover was 40 – 46 – 43 – 36% for the first three research years and 25 – 49 – 5 – 0% for the second three years of research. Consequently, the effects of PK fertiliser application were more notable – this is a well known fact, but it is exceptional for the proportion of legumes in sward.

The production was studied at grasslands utilised as meadows by three cuts, because this enabled making objective comparisons.

The costs were determined from a common sequence of work operations with a minimum share of treatment, but with more detailed parameters of forage harvesting and storage.

The diversification of intensity was achieved by fertiliser application, putting emphasis on nitrogen.

The direct and the total costs specified as euro (€) for PG and OG are given in Tables 1 and 2, respectively. The following survey illustrates a relative increase in the costs, including a comparison given as the absolute values:

Treatments	T 1	T 2	T 3	T 4
PG – total labour cost	1.00	1.85	2.47	3.04
– total cost	1.00	1.85	2.41	2.93
OG – total labour cost	1.00	1.65	2.13	2.57
– total cost	1.00	1.68	2.12	2.54

All the differences within and between the technologies indicated a tendency decreasing with the intensity of fertilisation. There is a surprisingly lower increase in the total costs, however, it starts from a higher basis at the control treatments.

Considering a lot of interactions in the total productive and economic system, the cost items were distributed into groups of direct costs, which show more objectively the reasons of influence. This is presented in Table 3, including a proportionate structure of direct costs.

The direct cost structure in relation to the trial treatments of both technologies is equal only in the cost of operations for sward management and oversowing; these are identical for all the trial treatments. Fertiliser application is the only parameter of intensification which keeps increasing. The costs of harvesting are also rising, but only due to the marked effects of fertiliser application. A prevalence of direct and evoked intensification factors resulted also in an increase in total direct costs.

A proportionate analysis has got a different character, because it deals with the proportions of operations within the research treatments, and therefore there is a change in the

T a b l e 3. The direct costs (€ ha^{-1}) at PG and OG under 3-cut utilisation. Experimental solutions (Liptovská Teplička site).

Parameters of operations	PG (€ ha^{-1})				OG (€ ha^{-1})			
	T 1	T 2	T 3	T 4	T 1	T2	T 3	T 4
Sward treatment	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
Fertiliser application	-	88.38	148.10	208.78	-	88.38	148.10	208.78
Hay DM making at meadow	72.27	72.27	75.27	75.27	72.27	72.27	75.27	75.27
Hay DM harvesting and storing	39.70	51.98	62.68	69.18	39.70	51.98	62.68	69.18
Overdrilling	-	-	-	-	35.34	35.34	35.34	35.34
∑ Total direct costs (€ ha^{-1})	117.92	218.58	292.00	359.18	153.26	253.92	327.34	394.52
Sward treatment (%)	5.0	2.7	2.0	1.7	3.9	2.3	1.8	1.5
Fertiliser application (%)	-	40.4	50.7	58.1	-	34.8	45.2	52.9
Hay DM making at meadow (%)	61.3	33.1	25.8	20.9	47.1	28.5	23.0	19.1
Hay DM harvesting and storing (%)	33.7	23.8	21.5	19.3	25.9	20.5	19.2	17.5
Overdrilling (%)	-	-	-	-	23.1	13.9	10.8	9.0
∑ Total direct costs (%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Note: The data given in Tables 1 and 2 are processed here.

cost development between the treatments at both technologies, as well as between the technologies themselves. The only operation with an increase in costs was the application of fertilisers, because it had the function of herbage production and was the decisive operation in the experiment.

As to the operations related to hay DM making in the meadow and harvesting with storage, the trend is changing direction towards more intensive treatments and becomes gradual, more markedly, only for both intensive treatments. At both intensive treatments, the shares of fertiliser application are dominant, but especially the high costs per tonne of hay DM (53.6 and 56.9 € t^{-1} at PG , and 65.5 and 60.6 € t^{-1} at OG). It resulted from the 3-cut utilisation system at low DM yield, which would be difficultly applied in practical terms. Therefore, the structural analysis continued in the first phase by simulating one cut at Treatment 1 and two cuts at Treatment 2, but it was not appropriate for this treatment either. Thus, a simulation of one cut was used for extensive Treatments 1 and 2, but the three-cut system was still applied at intensive Treatments 3 and 4. The results (Table 4) show a decrease in Σ DC (direct costs) at permanent grassland Treatment 1 to 36.7 and 62.1% respectively, and at oversown grasslands to 51.3 and 67.3% in comparison with the original values. The relationships between the costs of operations were balanced. There was a special case, namely the twofold increase in the share of overdrilling at the treatment with zero fertiliser application, but the decrease in the share of costs of overdrilling accelerated at the other treatments. **The economic effect of oversowing** was found at intensive treatments. The application of a one-cut system requires more explanation here. The one-cut system also includes aftermath grazing with cattle or sheep, which is a common practice in the Slovak Carpathians. The significance of this practice lies in the prolonged grazing season and improved biodiversity. There is not any increase in costs, because the costs of staff looking after livestock are fully covered, even without the proposed change.

T a b l e 4. The direct costs (€ ha^{-1}) at PG and OG at different utilisation. The simulation made for practical terms (Liptovská Teplička site).

PG	T 1	T 2	T 3	T 4	OG	T 1	T 2	T 3	T 4
Sward treatment	5.95	5.95	5.95	5.95	Sward treatment	5.95	5.95	5.95	5.95
Fertiliser application	-	88.38	148.10	208.78	Fertiliser application	-	88.38	148.10	208.78
Hay DM making at meadow	24.09	24.09	75.27	75.27	Hay DM making at meadow	24.09	24.09	75.27	75.27
Hay DM harvesting and storing	13.23	17.32	62.68	69.18	Hay DM harvesting and storing	13.23	17.32	62.68	69.18
Overdrilling	-	-	-	-	Overdrilling	35.34	35.34	35.34	35.34
∑Direct cost (€)	43.27	135.74	292.00	359.18	∑ Direct cost	78.61	171.08	327.34	394.52
PG (%)	T 1	T 2	T 3	T 4	OG (%)	T 1	T 2	T 3	T 4
Sward treatment	13.7	4.3	2.1	1.6	Sward treatment	7.6	3.5	1.8	1.5
Fertiliser application	-	65.2	50.7	58.2	Fertiliser application	-	51.6	45.2	52.9
Hay DM making at meadow	55.7	17.7	25.7	20.9	Hay DM making at meadow	30.7	14.1	23.1	19.0
Hay DM harvesting and storing	30.6	12.8	21.5	19.3	Hay DM harvesting and storing	16.8	10.2	19.1	17.7
Overdrilling	-	-	-	-	Overdrilling	44.9	20.6	10.8	8.9
∑Direct cost %	100.0	100.0	100.0	100.0	∑ Direct cost %	100.0	100.0	100.0	100.0

Note: The data given in Tables 1 and 2 are processed here.

The objective of our work was not only to study the economy of production costs, but also to assess the costs for the parameters of quality. It should be said that not very much attention is paid to this topic. We tried to apply a method that had not been published yet (Krajčovič, 2006 – 2007). The method is based on the evaluation of nutritive components of organic matter, namely crude protein (CP), fat, ash, fibre, nitrogen-free extractives (NFE). These are all included in the sum of 1000 g kg^{-1} or kg t^{-1} and the following simple formula is used:

$$PC_{NU}\ t^{-1}DM = \frac{NU\ kg.t^{-1}}{1000} \text{ x } PC\ t^{-1}\ DM\ .$$

In this formula,

PC_{NU} t^{-1} = total costs per nutrient (NU) in one tonne of herbage DM,

NU kg t^{-1} DM = nutrients from organic matter,

PC t^{-1} DM = total costs per tonne of herbage DM (i.e. total costs per ha divided by DM yield per ha).

Thus, the total costs are specified as SKK (Slovak crown) or € (euro) for all the organic matter nutrients and their sum equals the total costs per tonne of DM as SKK or €. This

T a b l e 5. The quality parameters (g kg $^{-1}$ DM) at permanent and oversown grasslands. Liptovská Teplička site (Ilavská et al., 2002).

Nutrients	PG				OG			
	T 1	T 2	T 3	T 4	T 1	T 2	T 3	T 4
Crude protein (CP)	138.4	142.6	134.0	153.9	136.1	149.4	134.2	143.6
Fibre	211.2	227.0	231.1	233.0	226.5	221.2	240.7	236.4
Fat	46.1	44.2	44.3	44.9	43.1	42.8	44.4	45.9
Ash	89.7	95.7	90.6	86.1	87.6	89.3	86.8	87.0
Nitrogen-free extractives (NFE)[x]	514.6	490.5	500.0	482.1	506.7	497.3	493.9	487.1
PDI g.kg^{-1}	91.5	94.0	93.4	98.1	92.1	94.5	93.7	97.7
NEL MJ	5.9	6.0	5.8	5.9	6.0	5.9	6.0	6.1
PDI/NEL	15.5	15.5	19.9	16.4	15.3	15.9	15.6	15.9

[x] The data on NFE total cost per tonne are processed both in Tables 1 and 2 (in their bottom parts) and in full detail within the Results and discussion.

method can be used not only for the calculation of main nutrients, but also for their fractions (e.g. amino acids from crude protein, minerals from ash, energy values from N-free extractives, etc.) as a concrete proportion of their values (g kg^{-1} or mg kg^{-1}) in the basic value of total costs. The presented cost analysis is based on the research data recorded at Liptovská Teplička site (Table 5).

Table 6 presents a balance of changes in direct costs and in total costs when permanent and oversown grasslands were managed as meadows utilised by two cuts.

The highest differences in the total costs between the technologies were recorded in the control treatments under the 3-cut experimental system, the difference was only in the value of overdrilling. At permanent grasslands, 95% of costs were produced by harvesting, the most risky procedure in mountain regions; but also, 72% for oversown grasslands is a high number. The same increase in the costs of fertiliser application started from Treatment 2 at both technologies, and consequently, the intensive Treatments 3 and 4 were getting closer, though the costs of overdrilling were higher by 10.5 and 8.4% , respectively, when specified as the absolute values. An input to only these treatments might have some justification. Oversowing into grasslands without fertiliser application is not efficient, because there is either a decrease in yield or weed infestation coming over the years.

As to the option of reducing the number of cuts on the more intensive treatments, this is advantageous in practical terms, especially if the 1-cut system includes aftermath grazing. In Slovakia, this is a common practice with permanent grasslands. However, we have not realised that the change in utilisation of oversown sward will result in a 50 or 20% increase in the total costs in comparison to PG, and this should be carefully taken into consideration. The simulation of total costs for the basic organic nutrients, ash, and also for the feeding ration parameters showed interesting data, enabling the possibility to search for a more detailed relationship of nutrients in the economy of forage production and in animal husbandry.

T a b l e 6. A balance of changes in the direct and the total costs of permanent and oversown grassland management at two systems of utilisation (Liptovská Teplička site).

A. Solution according to the research results								
Grassland types	PG				OG			
Parameters	$T\ 1_A$	$T\ 2_A$	$T\ 3_A$	$T\ 4_A$	$T\ 1_A$	$T\ 2_A$	$T\ 3_A$	$T\ 4_A$
Total costs (€ ha^{-1}) at 3 cuts	139.39	258.19	336.11	409.38	174.73	293.53	371.45	444.72
Total costs € relative	1.00	1.85	2.41	2.93	1.00	1.68	2.12	2.54
OG / PG comparison	1.00	1.00	1.00	1.00	1.25	1.13	1.10	1.08
B. Solution at different utilisation of extensive and intensive treatments								
Number of cuts	1 cut		3 cuts		1 cut		3 cuts	
Parameters per ha of hay DM	$T\ 1_B$	$T\ 2_B$	$T\ 3_B$	$T\ 4_B$	$T\ 1_B$	$T\ 2_B$	$T\ 3_B$	$T\ 4_B$
Total costs € at different utilis.	64.74	175.35	336.11	409.38	100.08	210.69	371.45	444.72
Total costs € relative	1.00	2.70	5.19	6.32	1.00	2.10	3.71	4.44
OG / PG comparison	1.00	1.00	1.00	1.00	1.54	1.20	1.10	1.08
C. Simulation of the proportions of main organic nutrients and ash in total costs t^{-1} of hay DM for the solution B								
Treatments	$T\ 1_B$	$T\ 2_B$	$T3_B$	$T\ 4_B$	$T\ 1_B$	$T\ 2_B$	$T\ 3_B$	$T\ 4_B$
Hay DM yield (t ha$^{-1)}$	2.20	3.84	5.69	7.29	2.34	4.19	5.81	6.79
Total costs per tonne	29.42	45.66	59.07	56.15	42.77	50.28	63.93	65.49
Total costs CP t^{-1} hay DM €	4.07	6.51	7.91	8.64	5.82	7.51	8.58	9.40
Total cost – fibre t^{-1} hay DM €	6.21	10.36	13.65	13.08	9.68	11.12	15.38	15.48
Total costs – fat t^{-1} hay DM €	1.35	2.02	2.61	2.58	1.84	2.15	2.83	3.00
Total cost – NFE t^{-1} hay DM €	15.14	22.39	29.53	27.07	21.67	25.00	31.57	31.69
Total cost – ash t^{-1} hay DM €	2.63	4.37	5.35	4.83	3.74	4.49	5.55	5.69
∑ Total costs t^{-1} hay DM €	29.40	45.65	59.05	56.20	42.75	50.27	63.91	65.26
D. Simulation of the proportions of feeding ration nutrients in total cost t^{-1} of hay DM for the solution B								
Nutrients	$T\ 1_B$	$T\ 2_B$	$T\ 3_B$	$T\ 4_B$	$T\ 1_B$	$T\ 2_B$	$T\ 3_B$	$T\ 4_B$
Total costs – PDI t^{-1} hay DM €	2.69	4.29	5.51	5.51	3.94	4.75	5.99	6.40
Total cost- NEL GJ^{-1} hay DM €	0.17	0.27	0.34	0.33	0.25	0.30	0.38	0.40

Conclusion

The economic assessment of mountain meadows (*Festuco-Cynosuretum* association) under long-term fertiliser application, and at two main technologies of management and utilisation, revealed a range of stimuli for further research into these problems. The direct costs of the fertiliser treatments were rising from 117.92 € ha^{-1} (Treatment 1) to 359.18 € ha^{-1} (Treatment 4) at permanent grasslands, and from 153.26 € ha^{-1} (Treatment 1) to 394.52 € ha^{-1} (Treatment 4) at oversown grasslands. Fertilisers had a dominant part in increased direct costs; in relative values it was 37.5–55.82% at permanent grasslands and 32.34–50.82% at oversown grasslands. The machinery operation was the second highest part in direct costs of hay DM making. When given as absolute values, it ranged between 117.92 € ha^{-1} (Treatment 1) and 158.68 € ha^{-1} (Treatment 4) at permanent grasslands, and from 153.26 € ha^{-1} (Treatment 1) to 179.32 € ha^{-1} (Treatment 4) at oversown grasslands.

The lowest statistically significant differences in the total costs per tonne of DM were recorded at the treatments with fertiliser N + PK application at both grassland management technologies. It was 59.07 € ha^{-1} (Treatment 3) and 56.15 € ha^{-1} (Treatment 4) at permanent grasslands, and 63.93 € ha^{-1} (Treatment 3) and 65.49 € ha^{-1} (Treatment 4) at oversown grasslands. The highest total costs per hay DM (67.23 € ha^{-1}) were found at PG meadows with PK fertiliser application. The economic effect of grassland overdrilling was found at the intensive treatments. Grassland oversowing into the swards without fertiliser application is not efficient, because usually either the dry matter yield decreases or the swards are infested with weeds over the years.

A decrease in the direct costs by reducing the number of cuts at the more extensive treatments (Treatments 1 and 2) is advantageous under practical terms, especially if this 1-cut system is combined with aftermath grazing. At oversown grasslands, the change in the system of utilisation increased the total costs by 50 and 20%, respectively, when compared with permanent grasslands. This is worth taking into consideration.

A simulation of the total costs for organic nutrients, as well as for the parameters of feeding rations contributed to presumptions of more detailed nutrient relationships in the economy of forage production and in the nutrition of ruminants.

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