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Nutrition value of Bromus marginatus and possibilities to regulation of fermentation in ensilage process

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ABSTRACT

Results in ours study shown that mountain brome (Bromus marginatus Nees ex Steud, cv. Tacit) is grass with high content of fibre complex. At the end of elongation phase was content of crude fibre 278.7 g, and in phase full heading 342.8 g/kg DM. Content of crude protein decreased with maturation from 160.9 to 89.8 g/kg DM. The optimal cut time of this grass is end of elongation phenophase. Application of biological and biological-enzymatic additives markedly improved all fermentation parameters compared to untreated silage. In inoculated silages were lower losses of dry matter, pH value, content of alcohol, NH3 – N of total N, and higher acid concentrations than in untreated silage. The application of bacterial additives caused a decrease in the contents of crude fibre, ADF, and NDF. This positive effect was higher in silage treated with the biological-enzymatic additive as in silages treated with biological additives.

Keywords: mountain brome, phenophases, nutrition value, bacterial additive, fermentation, silage quality

INTRODUCTION

Mountain brome (Bromus marginatus Nees ex Steud.) belongs to the secondary forage grasses not only in Slovakia (Krajčovič et al., 1968) but also in abroad (Holmes et al., 1980; Heath et al.,1985). The role of this species is still increasing especially due to higher drought resistance, good adaptation to the low rainfall and higher temperatures. It is more tolerant of heat and drought than perennial ryegrass and /or timothy. Its drought tolerance is related to its extensive root system (Míka and Řehořek, 2004).

Bromus marginatus is grass with higher drought resistance, and good adapted to low rainfall, high summer temperatures, and severe winters. It is more tolerant of heat and drought than perennial ryegrass, timothy. Its drought tolerance is related to its extensive root system.

Mountain brome cv. Tacit which was released recently in Czech Republic (Míka and Řehořek, 2004) possesses an extraordinary yield potential (e.g. 15 t . ha-1 per year at three or four cut system with 3 - 4 harvests a year, about 15 t of dry matter from a hectare). This species is heading in each cutting and can persist over 3 – 7 years under suitable soil/environmental conditions. It is necessary to leave some what higher stubble when cut, and during grazing to keep low or medium stock density). It is tolerant against drought, and it is effective in improving water infiltration, therefore it is suitable for works well in the areas susceptible to erosion. The crop herbage matures more slowly compared to many other grasses and even in the early maturity athesis it shows high digestibility of organic matter and excellent nutritive value (Pozdíšek et al., 2002).

Effects of silage additives on silage fermentation, composition, and animal performance depend on the additive used, its rate of application, the activity of biological preparations, the type of forage, DM content, and chemical composition. Responses to additives, therefore, are extremely variable because of a wide range of factors (Harrison et al., 1994).

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The main aim of this study was the determination on nutritive value of mountain brome (Bromus marginatus Nees ex Steud.) during the development of grass crop before the first cut, to find the optimal period for suitable ensilaging, and consider the possibilities of fermentation regulation at its ensilaging.

MATERIAL AND METHODS

The field experiment was established in 2004 at the Grass Breeding Station Levočské Lúky (elevation 580 m above sea level) on the plots of east exposition. Average annual temperature was 5.9 0C, and average annual rainfall 600 mm. The soil in the experimental area was heavier, aluminous with mean content of mould to 2 %. In the spring 50 kg N ha –1 (+ 30 kg P, and 20 kg) was applied. The experiment included five plots 1 x 10 m large. The green grass samples were taken four times over May and June to determine dry matter yield and chemical composition of herbage. The samples were taken in the following stage of crop development: stems elongation, beginning of heading, full heading, and end of heading.

In this experiment the ensilage capacity and the control of ensilage process of brome forage at the full heading phase was studied. After 24 hours of wilting the grass matter was chopped, homogenized and put into laboratory silos (1.7 litres volume). Four different groups were included in this experiment:

- T0 – a non-treated control
- T1 – treated with a biological additive consisting of Lactobacillus plantarum DSM 3676-7 Propionic bacterium DSM 9576. 7. 2 ml of solution were applied per 1 kg of forage.
- T2 – treated with a biological additive consisting of Lactobacillus plantarum DSM 12771. 2.0 ml solution of additive per 1 kg of feed.
- T3 – treated with a biological-enzymatic additive consisting of two Lactobacillus plantarum strains, two Pediococcus acidilactic strains, and enzymatic component with amylase, cellulase, hemicellulase and pentose. 2 ml of solution were applied per 1 kg of feed.

Each treatment consists of six replicates. The laboratory silos were placed in a dark room at 21 ± 1 0C . Silage losses of dry matter were determined at regular 21-days intervals. After 180 days of fermentation the silages was experiment finished.

The concentrations of dry matter, crude protein, crude fibre, ADF, NDF, hemicelluloses, water-soluble carbohydrates (WSC), crude fat and ash was determined in samples of grass matter, and silages. Also, the concentration of nitrogen free extract was calculated.

In the grass silages the relative dry matter losses (%) as well as the following fermentation parameters were determined: silage extract pH, lactic acid, acetic acid, propionic acid, butyric acid, valeric acid, capronic acid, alcohol and NH3 of total N.

All nutrition, and fermentation parameters were determined according to actual norm (Výnos MP SR, 2004). Content of WSC was determined by using the Luff-Schoorl titration method, pH electrometrically. Lactic acid, acetic acid, propionic acid, butyric acid, valeric acid and capronic acid levels were determined by gas chromatography, alcohol and NH3 by the microdiffusion method according to Conway. Total volatile fatty acids, total acids were calculated out of the determined concentrations. Energy concentrations in the silages were calculated by Sommer et al. (1994). The results were statistically evaluated by one-factorial analysis of variance, and compared by Student-t test (Statgraphics).

RESULTS AND DISCUSSION

The concentrations of principal organic substances of cv. Tacit during Growth period are given in Table1. It was confirmed that the concentrations of individual substances were significantly changed. The concentration of dry matter increased from 199.88 to 275.82 $g.kg^{-1}$ dry matter in the stage of stem elongation and end of heading, respectively. The concentration of crude fibre was of similar tendency as their level increased from 278.72 to 343.64 $g.kg^{-1}$ dry matter in the same stage of crop development. The WSC concentration slowly increased during the experimental period of the crop growth. On the other hand crude protein concentration was gradually decreased during crop development from 160.98 to 89.64 $g.kg^{-1}$ dry matter. With mature increased content of WSC, decreased also levels of reducing sugar, fat, and ash too.

Results obtained in this experiment correspond well with the results of Pozdíšek et al. (2002) but it is necessary to stress that the site has significant role on the concentration of individual organic substances. Result from the study of these authors shown that digestibility organic matter, and crude protein rapidly decreased from the phase elongation (OM digestibility 68.8 %, CP digestibility 64.8 %) to the end of heading stage (OM digestibility 59.2 %, CP digestibility 22.3 %).

The energy value of brome forage was influenced by changes of dry matter content. There was a tendency with increasing dry matter content decreased ME, and NEL value in feed. The same tendency was confirmed for PDIN and PDIE value, respectively. At the end of head formation the brome forage contents NEL 5.57 $MJ.kg^{-1}$ DM, and PDI 85.2 $g.kg^{-1}$ DM, respectively and these parameters decreased to 4.78 MJ $NEL.kg^{-1}$ DM, and 66.9 g $PDI.kg^{-1}$ DM at the end of heading. Level of yield from first cut this grass increased during of vegetation from 2.4 t DM (12 t FM) to 5.63 t DM (20.4 t FM) per hectare.

The second part of our study was focused on the possibilities effecting the fermentation processes during ensilaging of brome forage. The sward was cut at the full heading phase and crude fibre content reached the level of 317.65 g.kg^{-1} DM. The content of another substances are given in Table 2. Due to the relatively low N rate of fertilizing, the crude protein content was only 106.18 g.kg^{-1} dry matter. Content of water-soluble carbohydrates (WSC) 104.44 g kg^{-1} DM was sufficient, and it is a prediction of good fermentation process.

The application of additive is an important factor, when grass for silage is cut in a correct time and contains sufficient N (Opitz von Boberfeld, 2002). The effect of such additives is significant when early cutting and moderate pre-wilting are applied. After a delayed cutting, however, only the increase of the digestibility of organic matter can be expected.

Míka and Kohoutek (2002) reported that mountain brome cv. Tacit is grass convenient particularly to silage production. Good dry matter content, higher concentration of water-soluble carbohydrates and low buffering capacity are precondition for very good ensilagebility. The optimal time of cut to silage producing is the end of heading and beginning of flowering because this grass compared with other grasses is ageing slower (Míka and Řehořek, 2004). However, ours results show that optimal cut time for silage is the elongation phase, at latest at the heading.

The content of fermentation products was very low in the non–treated silage T0 (Table 3). That was

Table 1: Nutrition value, energy, and yield of mountain brome in different maturity

Parameter	Phenological phase			
	End of elongation	Beginning of heading	Full heading	End of heading
Dry matter (g. kg^{-1} FM)	199.88	219.92	209.67	275.82
Organic matter (g.kg^{-1} DM)	917.11	921.90	926.88	935.80
Crude protein (g.kg^{-1} DM)	160.89	131.67	121.44	89.83
Crude fibre (g.kg^{-1} DM)	278.72	311.78	342.83	343.64
ADF (g.kg^{-1} DM)	294.80	330.12	354.58	366.33
NDF (g.kg^{-1} DM)	503.84	576.10	591.68	615.96
Hemicelluloses (g.kg^{-1} DM)	209.04	245.98	237.10	249.63
Nitrogen free extract (g.kg^{-1} DM)	449.30	450.36	438.65	477.43
WSC (g.kg^{-1} DM)	120.96	121.73	104.02	140.92
Sugar reducing (g.kg^{-1} DM)	66.75	68.23	58.19	62.02
Fat (g.kg^{-1} DM)	28.20	28.09	23.95	24.89
Ash (g.kg^{-1} DM)	82.89	78.10	73.12	64.20
ME (MJ.kg^{-1} DM)	9.51	8.97	8.59	8.37
NEL (MJ.kg^{-1} DM)	5.57	5.20	4.93	4.78
NEV (MJ.kg^{-1} DM)	5.36	4.91	4.58	4.39
PDIN (g.kg^{-1} DM)	100.30	82.40	75.90	55.60
PDIE (g.kg^{-1} DM)	85.20	79.20	76.40	66.90
Yield (t DM. ha^{-1})	2.40	3.03	3.77	5.63

Table 2: Content of nutrition in mountain brome after 24 hours wilting

Dry matter g.kg^{-1} FM	Crude protein	Crude fibre	ADF	NDF	Nitrogen free extract	WSC	Fat	Ash	NEL MJ.kg^{-1} DM	PDI g.kg^{-1} DM
	g.kg^{-1} DM									
396.23	106.18	317.65	348.11	585.73	476.28	104.44	24.49	75.39	4.92	64.30

affected by higher level of dry mater in ensilaged grass. Application of biological, and biological - enzymatic additives significantly positive influenced the fermentation process. The acidity (pH value) decreased from 4.64 at the T0 silage to value of 3.74 – 3.85 in inoculated silages. The lowest pH value was detected in the treatment T1.

The losses of dry matter over the fermentation process correspond well with the previous results. The highest losses were confirmed in the non-treated silages T0 - 7.85 %, and were significantly reduced in the treatments with inoculation. The lowest losses of dry matter are typical for treatment T3 (3.48 %).

There are also changes in the concentration of organic acids in the silages. The lowest concentration of lactic acid (15.84 $g.kg^{-1}$ DM) was detected in the non-treated (T0) silage, and the highest one in treated silage T2 (45.48 $g.kg^{-1}$ DM). The application of biological additives reduced the concentration of acetic acid from 9.15 $g.kg^{-1}$ DM in untreated silage T0 to the value of 1.84 – 3.11 $g.kg^{-1}$ DM in inoculated silages T1 - T3.

Table 3: The fermentation parameters in mountain brome silages

Parameters (n = 6)	Untreated silage T0		Variants of treated silages T1		T2		T3		Statistical significance of differences	
	x̄	s	x̄	s	x̄	s	x̄	s	P < 0.05	P < 0.01
pH	4.64	0.04	3.74	0.00	3.85	0.04	3.82	0.01		0:1,2,3 1:2,3
Dry matter losses (%)	7.85	0.56	5.03	0.60	4.05	0.75	3.48	0.35		0:1,2,3 1:3
Acids in g.kg-1 DM										
- lactic	15.84	1.76	44.53	5.51	45.48	2.82	45.33	1.64		0:1,2,3
- acetic	9.15	1.37	3.11	0.73	2.82	0.90	1.84	0.06	2:3	0:1,2,3 1:3
- propionic	0.32	0.00	0.11	0.15	0.21	0.12	0.04	0.03	0:1 2:3	0:3
- butyric + i.b.	1.30	0.34	0.69	0.23	0.98	0.35	0.23	0.06	1:3	0:1,2,3 2:3
- valeric + i.v.	0.07	0.06	0.06	0.06	0.31	0.07	0.23	0.06		0,1:2,3
- capronic + i.c.	0.03	0.00	0.05	0.04	0.16	0.15	0.03	0.00		
Total VFA (g.kg-1 DM)	10.88	1.28	4.02	1.22	4.49	1.40	2.37	0.12	1:3	0:1,2,3 2:3
Total acids (g.kg-1 DM)	26.72	2.85	48.54	5.64	49.96	3.92	47.70	1.69		0:1,2,3
Alcohol (g.kg-1 DM)	2.56	0.46	1.43	0.17	1.54	0.17	1.23	0.13	2:3	0:1,2,3
NH3-N of total N in %	4.92	0.60	2.75	0.64	3.00	0.69	3.31	0.15		0:1,2,3

Table 4: Content of nutrition in mountain brome silages

Parameters (n = 6)	Untreated silage T0		Variants of treated silages T1		T2		T3		Statistical significance of differences	
	x̄	s	x̄	s	x̄	s	x̄	s	P < 0.05	P < 0.01
Dry matter (g.kg-1 FM)	369.80	2.16	377.45	2.20	381.37	2.72	383.25	1.64	1:2	0:1,2,3 1:3
OM (g.kg-1 DM)	918.16	2.04	918.35	1.67	917.89	0.97	917.33	4.46		
Crude protein (g.kg-1 DM)	110.82	1.80	109.78	1.93	110.08	1.51	108.87	2.53		
Crude fibre (g.kg-1 DM)	345.45	3.95	328.34	2.39	331.22	7.00	333.21	5.10		0:1,2,3
ADF (g.kg-1 DM)	371.97	17.94	384.95	7.46	384.40	15.44	355.35	3.32		3:1,2
NDF (g.kg-1 DM)	597.45	20.57	578.84	9.43	585.54	6.06	584.63	8.36		
Hemicelluloses (g.kg-1 DM)	225.48	30.42	193.89	13.37	201.14	17.99	229.28	6.86	2:3	1:3
BNLV (g.kg-1 DM)	429.22	7.73	446.13	3.05	441.64	5.63	442.16	5.67	0:2,3	0:1
Residual WSC (g.kg-1 DM)	79.45	7.39	56.43	4.17	65.11	1.69	77.74	3.83		0:1,2 1:2,3 2:3
Fat (g.kg-1 DM)	32.67	0.84	34.11	1.25	34.95	1.65	33.09	1.72	0:2	
Ash (g.kg-1 DM)	81.84	2.04	81.65	1.67	82.11	0.97	82.67	4.46		
NEL (MJ.kg-1 DM)	4.89	0.01	4.89	0.01	4.89	0.01	4.89	0.02		
PDI (g.kg-1 DM)	67.11	1.09	66.48	1.17	66.66	0.92	65.93	1.53		

The concentration of non-valuable butyric acid was the highest in the untreated silage T0 - 1.30 g kg $^{-1}$ DM and lowest in treated silage T2 - 0.23 g.kg^{-1} DM. Also, application of additives positively influenced the production of NH3 - N of total N, which was reduced from 4.92 % in control silage T0 to 2.75 – 3.31 % in treated silages, respectively. The lowest NH3 - N concentration was detected in treatment T1.

Comparison of results obtained in this study with another ones confirmed higher quality of ensilage process in condition of biological additives application. Saarisalo et al. (2003) found the increase of lactic acid from 78.2 to 86.5 – 91 g.kg^{-1}DM in inoculated silages (30 % DM), and the decrease of acetic acid from 16.8 to 9.9 – 11.4 g.kg^{-1} DM . Due to higher silage DM content the concentration of organic acids were higher in presented study.

On the other hand Zastawny and Wróbel (2003) making the silage of 40 % dry matter found in non treated treatment the lactic acid concentration of 14.4 g.kg^{-1} DM, in line with our work. His level was increased to 21.7 and 26.1 g.kg^{-1} DM in inoculated treated silages. In our study the concentration of lactic acid was increased two times.

Saarisalo et al. (2002) found the decrease of butyric acid in non treated grass silage from 10.6 g.kg^{-1} DM to 0.4 – 2.8 g.kg^{-1} DM in inoculated silages. The level of NH3 - N in the same silages was reduced from 6.9 % to 2.0 – 3.3 %, respectively. These results corresponded well with data get in our study too.

The nutrient composition in mountain brome silages shows Table 4. It is obvious that in inoculated silages T1 - T3 were degraded contents of crude fibre, NDF, ADF, and hemicelluloses slightly lower in comparison to untreated silage T0. The positive effect on degradation of crude fibre was higher in silage treated with the biological-enzymatic additive (T3) than in silages treated with biological additives (T1, T2).

The concentration of residual sugars was relative high, especially in untreated and treated T1 silages, respectively. Also, the crude fat, and nitrogen free extract concentrations were higher in treated silages.

Our results corresponded with many authors (Saarisalo et al., 2002; Weissbach, 2003; Osmane et al., 2006; Wróbel and Zastawny, 2004, and others) and proved to be an efficient biological and biological-enzymatic silage additives in producing lactic acid, decreasing pH, to have a low proteolytic activity, and increasing quality of grass silages.

CONCLUSION

Mountain brome (Bromus marginatus Nees ex Steid. cv. Tacit) has high content of crude fibre, and its complex. With maturation increased content of water-soluble carbohydrates, decreased levels of crude protein, sugar, fat, and ash. The results of our study showed that optimum cut time for silage is end of elongation phase, at the latest the phase at beginning of heading.

The application of biological, and biological-enzymatic additives had a positive effect on the quality of the fermentation process and the nutrient levels. Improvement of fermentation parameters in inoculated silages are manifested in decrease of pH value, DM losses, butyric acid, acetic acid, and other volatile fatty acids, alcohol and % NH3-N of total N content. In inoculated silages was also increased level of lactic acid compared with untreated silage. The positive effect on degradation of crude fibre was higher in silage treated with the biological-enzymatic additive as in silages treated with biological additives.

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