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THE FEEDING VALUE ASSESSMENT OF FORAGE FROM SOME C-4 GRASS SPECIES IN DIFFERENT PHASES OF VEGETATION. PART III. *PANICUM VIRGATUM* L.

ABSTRACT

Chemical composition of forage from two varieties of switch grass (*Panicum virgatum* L.) was determined at different stages of vegetation. Changes in contents of some chemical compounds were noted during plants growth and development. Crude protein content decreased while structural carbohydrates (crude fiber, neutral detergent fibre – NDF, acid detergent fiber) increased during vegetation progress. 'Forestburg' variety has significantly higher NDF content as compared to 'Dacotah' variety. Water soluble carbohydrates content decreased together with plant growth and development. Forage from switch grass varieties ensiled quite easy. Silage quality ranged from good (silage with supplements P II and P IV) to satisfactory (supplements P I and P III). All silages, except silage with supplement P IV, were stable during oxidative test.

Key words: aerobic stability, chemical composition, quality, *Panicum virgatum*, silage stage of vegetation

INTRODUCTION

Switch grass (*Panicum virgatum* L.) is warm-season species, of C-4 photosynthesis pathway. It is winter-hardy and drought-resistant grass that prefers lower, moist sites, but grows under a wide range of climatic conditions and soils in Central, North and South America, temperate Asia and China, north-central Pacific. It is caespitose, erect and 1.0 to 3.0 m tall, leafy and vigorous species (Quatrocci, 2006). It is one of the dominant species in North American prairie. Commercial varieties of switch grass are an valuable source of forage for ruminants, especially during summer drought period, were more pasture grass species fall into dormancy. Many varieties were also bred to extensive use for soil conservation. It is moderately salt tolerant and works well on erodible sites (Quatrocci, 2006). Dry matter yields of switch grass in United

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States varied from 3.4 to 9.3 t/ha (Haferkamp and Copeland 1984; Brejda *et al.* 1994; Boe and Ross 1998).

In European conditions C-4 grasses were introduced in Poland and Germany and tested for energetic (Majtkowski and Majtkowska 1998, Lewandowski *et al.* 2000) and forage purposes (Lewandowski *et al.* 2000). The efficiency of water, nitrogen and other components is higher for C-4 grasses then for C-3 grass species (Nalborczyk *et al.* 1996). Switch grass could be an alternative source of forage for animals mostly in region of extreme water deficits during summer in Poland.

The aim of above work was to determine the chemical composition and ensilage ability of switch grass (*Panicum virgatum*) varieties grown in Poland, during different phases of development as well as quality and oxygenic stability of silage.

MATERIALS AND METHODS

Materials for above experiment were two varieties of switch grass (*Panicum virgatum* L.): Dacotah and Forestburg. Seed samples of above varieties were kindly provided by Gene Bank from Bismarck, USA. Grass was planted at spring of 1998 on the field, in Botanical Garden of Plant Breeding & Acclimatization Institute, Bydgoszcz, Poland. Single plants (100 of Dacotah and 120 of Forestburg) were planted on the lessives soil, with distance 25 cm x 25 cm.

Each year from 1998 to 2002 plants were allowed to produce seeds and seed heads were collected. No additional treatments (fertilization, watering) were used. During three consecutive years (2003, 2004, 2005) forage was collected at following phases of development:

- vegetative phase (VS) – at 72 (±4) day of vegetation for Dacotah variety, and at 74 day (±5) for Forestburg (days starting from 1st April),
- beginning of earing (BE) – at 95 day (±8) for Dacotah and 108 day (±7) for Forestburg,
- beginning of flowering (BF) – at 108 (± 7) day for Dacotah and 123 (±5) for Forestburg.

Details of weather conditions during experiment were described by Piłat *et al.* (2007). Green forage was collected randomly from 3 points on plantation, each point of 1m^2. Forage was cut by hand collector ca. 3 cm above ground. Further analysis were performed in Department of Animal Nutrition and Feed Management Economy, Agricultural University in Bydgoszcz.

After drying, amounts of following components and coefficients were determined according the same procedures as given by Piłat *et al* (2007): dry matter (DM), organic matter (OM), crude protein (CP), crude fat (CT), crude fiber (CF), nitrogen-free extracts (NFE), structural carbohydrates: neutral detergent fiber (NDF) and acid detergent fiber (ADF), hemicelluloses (HEM), water soluble carbohydrates (WSC), buffer capacity of forage (BC) and forage fermentation coefficient (VK).

Due to limited amount of forage from each of tested variety, mixture from Dacotah and Forestburg were further used as switch grass forage for ensiling. Forage with supplements (Table 1) was ensiled and further analyzed in the same way as in Piłat *et al.* (2007).

Table 1

Ensilage supplements used in above experiment

Supplement	Main components of supplement
Without supplement (P I)	—
Chemical supplement (P II)	Formic acid 55% Formate ammonium 24% Propionic acid 5% Other organic acids 2% Water 14%, coloring substance E150d
Microbiological supplement (P III)	Lactic acid bacteria - min. 10×10^9 CFU per g of substance
Microbiological - enzymatic supplement (P IV)	Microbiological part: lactic acid bacteria - min. 6.7×10^9 CFU/g Enzymatic part: cellulase - min. 43000HEC/g

Data were analyzed with SAS® statistical package (SAS Institute, 2004 a, b). Tukey's Honestly Significant Differences (HSD) test was used for testing the significance of unplanned pairwise comparisons between means.

RESULTS AND DISCUSSION

Chemical composition of forage during vegetation phases.

Vegetative phase. No significant differences between both tested varieties were found for chemical composition of forage collected during vegetative phase (Table 2). Dry matter in forage of switch grass varieties ranged from 23.17% (Dacotah) to 24.59% (Forestburg). Crude protein (CP) content in dry matter was also similar: from 13.66% (Forestburg) to 14.14% (Dacotah). Above values were slightly higher than for *Dactylis glomerata* (10.90% of CP in forage dry matter), as it was mentioned by Yahaya *et al.* 2001. It has been proved, that average CP content in *Phleum pratense* forage dry matter ranged from 9.45% (at first cut) to 16.12% at second cut (Łyszczarz *et al.* 1998). Similar values were also noted for other C-3 forage grasses, where CP content ranged from 12 to 15% dry matter of meadow fescue (*Festuca pratensis* Huds.) and from 10.62 to 18.31% for timothy (*Phleum pratense* L.) and meadow fescue mixture (Filipek and Kasperczyk 1992, Rinne *et al.* 1997).

Crude fiber (CF) content in switch grass forage ranged from 31.52 to 32.76% of dry matter of Forstburg and Dacotah, respectively. Neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicelluloses (HEM) contents were similar in both tested varieties. For Dacotah it was 65.23% for (NDF) and 33.72% for (ADF), for Forestburg 65.92% and 33.62%, respectively. Yahaya *et al.* (2001) reported 55.8% (NDF) and 32.10% (ADF) for *Dactylis glomerata* forage. For *Festuca pratensis* it was 62.32% (NDF) and 34.82% (ADF) and for *Phleum pratense* and *Festuca pratensis* mixture – from 46.4% to 64.5% (NDF) and from 20.2% to 31.1% (ADF) (Filipek and Kasperczyk 1992, Rinne *et al.* 1997).

Table 2

Chemical composition of switch grass (*Panicum virgatum* L.) forage during different phases of vegetation

Variety	DM * [%]	Content in dry matter [%]									BC
		OM	CP	CT	CF	NFE	NDF	ADF	HEM	WSC	
					vegetative phase						
Dacotah	23.17	92.70	14.14	2.86	32.76	42.94	65.23	33.72	31.51	5.69	4.09 a
Forestburg	24.59	92.89	13.66	2.61	31.52	45.10	65.92	33.26	32.66	6.00	3.42 b
					begining of earing						
Dacotah	28.04	94.04	8.22	1.74	37.18	46.90	71.59 b	38.69	32.90	4.84	2.90
Forestburg	28.00	94.19	7.68	1.52	38.89	46.10	74.25 a	41.32	32.93	4.66	2.78
					begining of flowering						
Dacotah	31.33	94.48	7.17 A	1.32	37.94	48.05	73.69	42.19	31.50	5.28	2.84 A
Forestburg	30.69	94.83	5.53 B	1.49	39.58	48.23	74.80	42.74	32.06	4.59	2.46 B

* - for explanation of symbols – see ‚Materials and methods'
Values in the same columns marked with different letters differ significantly a,b,....$p<0.05$, A, B … $p<0.01$

There was no significant difference between water soluble carbohydrates content for switch grass varieties – mean WSC value was 6% of forage dry matter. Higher values of WSC content were reported by Rinne *et al.* (1997) for *Phleum pratense* and *Festuca pratensis* mixture and ranges from 11.7% to 23.8% of dry matter.

Estimated buffer capacity of Dacotah variety (4.09 g of lactic acid per 100 g of dry matter) was significantly higher than for Forestburg (3.42 g of lactic acid per 100 g of dry matter).

Beginning of earing. At this phase DM increase up to 28% (similar in both varieties) was noted. CP contents ranged from 7.68% (Forestburg) to 8.22% (Dacotah). CF content was similar for both varieties and ranged from 37.18% (Dacotah) to 38.89% (Forestburg). No statistical differences between tested varieties were found for: ADF, HEM and WSC contents. Buffer capacity (BC) was also similar for varieties and ranged from 2.78 (Forestburg) to 2.90 (Dacotah) gram of lactic acid per 100 g of dry matter (Table 2). Dacotah exposed significantly lower ($p<0.05$) content of NDF as compared to Forestburg.

Begining of flowering. Dry matter content ranged from 30.69% (Forestburg) to 31.33% (Dacotah) (Table 2). Forestburg had significantly lower ($p<0.01$) CP content (5.53%) as compared to Dacotah (7.17%). NDF, ADF, HEM and WSC contents were similar in both varieties. BC of Forestburg (2.46 g of lactic acid per 100 g of dry matter) was significantly lower ($p<0.01$) than value obtained for Dacotah (2.84 g).

Decrease of CP content from 14 – 16% in spring to 4% in July was also noted by Brejda *et al.* (1994), Burns *et al.* (1997) and Newell (1968). Therefore high quality of switch grass hay can be obtained if harvested during vegetative phase (Burns *et al.* 1997).

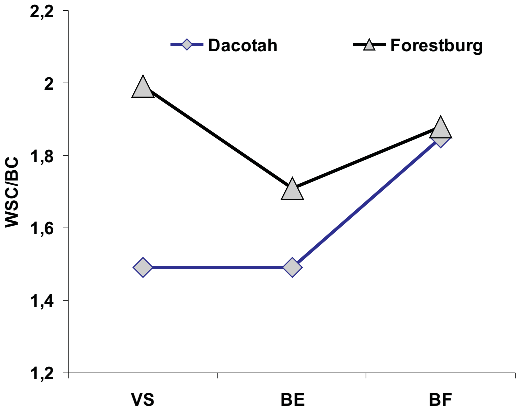

Fig. 1. Changes in water soluble carbohydrates to buffer capacity quotient (WSC/BC) in different phases of vegetation of tested switch grass (*Panicum virgatum* L.) varieties

WSC/BC quotient was different in phases of vegetation (Fig.1). For Dacotah variety WSC/BC increased from 1.49 at vegetative phase and beginning of earing to 1.85 during flowering. Different relations were found for Forestburg variety, where WSC/BC decreased from 1.99 during vegetative phase, through 1.71 during beginning of earing to 1.88 during flowering. For both varieties differences between vegetative phases were not significant. WSC/BC quotients for switch grass varieties were higher than estimated by Janicki and Piłat (1998) for C-3 forage grasses, where values ranged from 1.00 to 1.37. Lower values of WSC/BC were also given by Podkówka (2001) for *Festulolium* forage collected at first (1.84) and third cut (0.93). For other forage grass species WSC/BC ranged from 1.93 to 1.23 (*Lolium perenne*, from first and third cut, respectively) and from 1.11 to 1.38 (*Phleum pratense*, also from first and third cut, respectively) (Podkówka 2001).

Forage fermentation coefficient (VK) for switch grass varieties increased with plant growth and development (Fig. 2). It ranged from 35.12 (vegetative phase) to 41.81 (beginning of flowering) for Dacotah variety and from 40.54 to 49.60 for Forestburg, respectively. As it has been proved by Weissbach (1998) VK of value higher than 35 ensure correct fermentation.

Silages made from mixture of switch grass varieties had from 24.04% (silage without supplement - control) to 25.44% (supplement PII) dry matter. CP contents ranges from 11.43% (supplement II) to 12.64% (supplement PIII) of dry

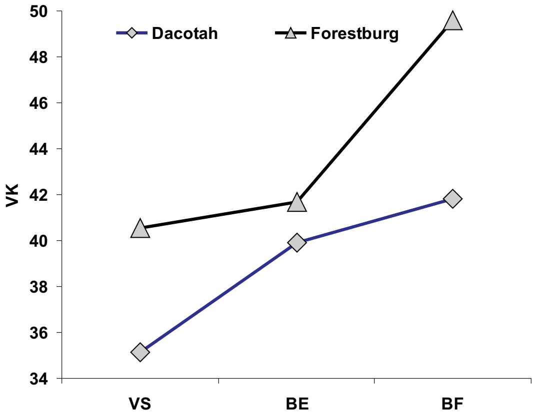

Fig. 2. Changes in fermentation coeffcient (VK) in different phases of vegetation of tested switch grass (*Panicum virgatum* L.) varieties

Table 3

Chemical composition of silages from switch grass

Supplement	DM [%]	Content in dry matter [%]							
		OM	CP	CT	CF	NDF	ADF	HEM	NFE
				Green forage					
—	27.49	92.84	10.46	1.48	32.60	72.33	39.23	33.10	48.30
				Silages					
P I	24.04	91.61	11.84	2.99^{b}	33.91	74.57^{a}	43.22^{a}	31.35	42.87
P II	25.44	92.14	11.43	2.80^{b}	33.62^{a}	71.25^{ab}	40.99^{ab}	30.26	44.29
P III	24.25	91.58	12.64	2.96^{b}	35.76^{b}	71.72^{ab}	41.01^{ab}	30.71	40.22
P IV	23.88	91.49	11.53	2.49^{a}	33.73	70.30^{b}	39.24^{b}	31.06	43.74

Values in the same columns marked with different letters differ significantly a, ab, b … $p<0.01$

matter (differences were not significant). Silage with supplement PIV had significantly lower ($p<0.05$) share of crude fat in dry matter than other supplements used (Table 3). Addition of chemical supplement (PII) resulted in significantly lower ($p<0.05$) crude fiber content in dry matter as compared to silage with microbiological supplement. Silage without supplement (control - PI) had significantly higher NDF and ADF contents as compared to silage with PIV supplement. It is similar to results reported by Loures (2004). When pre-dried forage of *Panicum maximum* (guinea grass) was ensiled with cellulolytic enzymes or enzymes with *Lactobacillus plantarum*, significant decrease of NDF, ADF, cellulose and HEM was noted. Silages from guinea grass had also similar dry matter content as noted for switch grass in our experiment and it ranges from 24.0% to 27.2% (Paziani *et al.* 2005). On the other hand, silages from switch grass had higher crude protein (CP) content (from 11.53% to

12.64% of dry matter) than silages from guinea grass. Paziani *et al.* (2005) reported CP content from 8.5% to 10.2% for silages from guinea grass. NDF contents in silages from guinea grass ranged from 67.8% to 69.4% and was lower than for silages from switch grass (from 70.30% to 74.57% NDF in dry matter) (Paziani *et al.* 2005). Switch grass silages had also lower content of ADF (from 39.24% to 43.22%) than guinea grass silages (from 45% to 46.4%).

While comparing silages from switch grass with C-3 grasses higher CP and lower structural carbohydrates were noted for the latter. In silages from *Phleum pratense* and *Festuca pratensis* it ranged from 14.8% to 15.5% of CP in dry matter (Nousiainen *et al.* 2003, 2004). For silages made from mixtures of: *Phleum pratense* and *Festuca pratensis* or *Lolium perenne* + *Phleum pratense* + *Festuca pratensis* following CP contents were reported: from 15.6% to 23.4% and from 16.87% to 19.4%, respectively (Khalili *et al.* 2005, Abel *et al.* 2002). The share of NDF in C-3 grasses is almost 50%, while ADF – almost 30% of dry matter (Rinne *et al.* 1997, Abel *et al.* 2002, Nousiainen *et al.* 2003, 2004, Khalili *et al.* 2005).

Silage with chemical supplement (P II) had significantly lower ($p<0.01$) acidity than other supplements used (Table 4). There was also no effect of supplements used on fermentation profile. Statistically similar values of lactic acid were noted for all supplements used, and it ranged from 1.19% (control – no supplement added) to 1.26% (supplements P III and P IV). Acetic acid content ranged from 0.65% (supplement P II) to 0.73% (supplement PIV). Traces of butyric acid were identified only in control silage and in silage with supplement P III. High lactic acid content of silages is not a determinant of its oxidative stability (Weinberg and Muck 1996). Oxidative microorganisms (fungi, moulds and bacteria from genus *Bacillus*) are able to decompose the lactic acid to carbon dioxide, ethanol and acetic acid soon after the silage silos is open. It is therefore an exothermic reaction (Kung 2001).

Table 4

Quality of silages from switch grass

Additive	pH	N-NH$_3$	Acid content [%]			Flieg-Zimmer evaluation	
			Lactic	Acetic	Butyric	Scores	Quality
P I	4.57 A	0.0406	1.19	0.71	0.08	45	Satisfactory
P II	4.31 B	0.0236	1.25	0.65	0.00	77	Good
P III	4.52 A	0.0343	1.26	0.67	0.06	47	Satisfactory
P IV	4.60 A	0.0563	1.26	0.73	0.00	74	Good

Values in the same columns marked with different letters differ significantly A,B … $p<0.01$

Quality of silages made from switch grass was evaluated as a satisfactory (control silage and silage with supplement P III) and as a good (with supplements P II and P IV) (Table 4). It has been stated by Coan *et al.* (2001) that there was no effect of addition of microbiological – enzymatic supplement to guinea grass silage on fermentation direction, its quality and feeding value.

Silage oxidative stability was good during test (Fig. 3). Average silage temperature at 7 day of incubation ranged from 20.46°C (supplement P II) do 21.62°C (control – P I). Temperature of silage with supplement P IV rised to 23°C at the end of oxidative test.

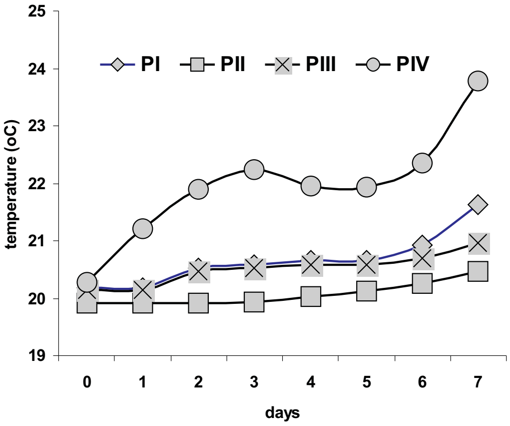

Fig. 3. Average age temperatures of silages during incubations period (ambient temperature 20°C ± 1°C)

It has been suggested by Pahlow and Weissbach (1999) that chemical supplements stabilized silages to 3 days, microbiological – for more than 7 days as compared to silage without supplements – stabilized to 1,5 day. Silages stored for a longer period in anaerobic conditions were much more stable, even if prepared without supplements (Pflaum 2003). Bacterial supplement did not increased silage stability, as it was in the case of chemical supplement.

CONCLUSIONS

High share of structural carbohydrates (NDF, ADF) in forage dry matter indicate necessity of ensiling at early stages of vegetation.

Suitability of switch grass forage to ensiling is similar to common C-3 forage grasses, therefore biomass from tested grass species is suitable for forage purposes.

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