NUTRITIONAL VALUE OF VIRGINIA FANPETALS (*SIDA HERMAPHRODITA RUSBY*) PROTEIN IN EVALUATION OF NITROGEN FERTILIZATION EFFECT ON ENVIRONMENT

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Summary

Objective. The research objective was to use the Virginia fanpetals (*Sida hermaphrodita Rusby*) nutritional value in the evaluation of nitrogen fertilization impact on the environment.

Material and methods. The studies involved Virginia fanpetal's forage fertilized with 100, 200 and 300 kg N/ha doses, dried and used in the biological assays performed on fistulated cows. The obtained feed material was examined to determine protein content and its biological value. In the bioassays conducted on animals protein degradation in the rumen was determined as well as its true intestinal digestibility.

Results. The optimum of 200 kg N/ha dose had a direct influence on the increasing protein content and its biological value. In consequence of this protein nutritional value formation, high rate (81%) of protein degradation and true digestibility were reported.

Conclusions. Growth of protein content in forage crops under nitrogen fertilization should be assessed by its nutritional value, availability and true digestibility in animal nutrition. This effect of nitrogen fertilization may implicate reduced nitrogen release to the human work environment and the atmosphere.

Key words: protein nutritional value, Virginia fanpetals, nitrogen fertilization

INTRODUCTION

The recent decades have been marked with increasing interest in the rational management of fodder crop nutrients. It results form the need of obtaining the feed material of irrefutable superior nutritional value and the environmental protection. Among the microelement fertilizers, nitrogen modifies the content and nutritional value of feed material proteins to the highest degree. In forage plants, excessive nitrogen load increases non-protein nitrogen compounds contents. The compounds can be toxic to animals and further in the food chain – to human and natural environment (5, 11, 12).

Animal farms are known to be the major emitter of ammonia to the environment resulting in the environment acidification and eutrophication of surface and coastal waters. Therefore, the aim in the intensive animal production proves to be not only reduction of manure output but also its properties affecting the environment. In order to promote feed efficiency in animals, the tendency is to make optimal use of feed proteins in animal nutrition through the formation of its nutritional value (13).

Virginia fanpetals (*Sida hermaphrodita Rusby)* is a new perennial adapted for cultivation in Poland. Its multidirectional cultivation appears to be the plant advantage as well as a great capacity of adaptation to changing climate and soil conditions including chemically degraded areas (3). Virginia fanpetals is a fodder, medicinal and energy crop. Besides, the plant may be used as herbal material as its leaves and roots contain mucus in the amounts comparable to those of marshmallow (4).

Virginia fanpetals responds most strongly to nitrogen fertilization increasing the protein content to over 20% (13). Protein concentration rise is associated with concurrent changes in its nutritional value affecting digestibility and use of this component in animal nutrition. Interdependence of these changes may have a direct impact on nitrogen emission from animal manure to the internal environment of animal maintenance, as well as human and external environment.

The objective of the present study was to evaluate the use of nutritional value of Virginia fanpetals protein and its availability in animal nutrition as a measure of nitrogen fertilization effect on the environment.

MATERIAL AND METHODS

Research plant material was constituted by Virginia fanpetals forage obtained from the two-year field study.

The plants were fertilized with the 100, 200 and 300 kg N/ha doses.

A protein level in the Virginia fanpetals forage was determined according to the Kjeldahl method with the use of Kjeltec kit (1). Amino acids content was established with the Beckman's automated instrument.

Protein nutritional value was calculated using the essential amino acid index EAAI.

Dried forage from the field studies was used in the tests on milk cows fitted with a rumen and duodenal fistula.

Feeding trials studying protein availability involved Virginia fanpetals dried forage after 200 and 300 kg N/ha fertilizer doses application.

Crude protein degradation in the rumen was measured by the nylon bag technique (7).

Intestinal digestibility of protein was estimated using the mobile nylon bag technique (9).

The studied nutrients were determined separately for leaves and the whole Virginia fanpetals plant. Obtained results were analyzed statistically by STATISTICA program.

RESULTS

In general, varying protein contents determined in Virginia fanpetals forage was dependent on a dose of nitrogen fertilization (tab. 1).

Increasing nitrogen fertilization rate caused growth of a protein level in the Virginia fanpetals forage. In the leaves, besides primarily high protein concentration (29,9%), the effect of nitrogen fertilization on this component variation proved to be insignificant.

Nitrogen fertilization had a variable impact on the exogenous amino acid level (tab. 2). In the whole Virginia fanpetals plant, except for histidine and tyrosine, an increased content of the determined amino acids was found along with increase of nitrogen fertilization up to 200 kg N/ha dose. In the plant's foliage, under nitrogen fertilization, the exogenous amino acid level showed similar, rising tendency, apart from tyrosine.

The highest dose of 300 kg N/ha resulted in a decrease of exogenous amino acid content in the Virginia fanpetals forage to the content lower than at 100 kg N/ha fertilization. A marked decrease between 15 and 32% of the amino acid level was observed for lysine, leucine, isoleucine, phenylalanine and tyrosine.

Changes in the amino acid protein composition induced by nitrogen fertilization clearly influenced its nutritional value (tab. 3). The nutritional value of the Virginia fanpetals leaf protein was characterized by high and virtually the same value (66%) up to fertilization level of 200 kg N/ha dose. A higher nitrogen input caused a large decline of protein nutritional value of 13%. Similar tendencies of changes occurring at a small increase of fertilization rate up to 200kg N/ha were reported for the whole Virginia fanpetals plant. The differences in protein nutritional value at the applied nitrogen fertilization levels proved to be statistically significant.

The feeding tests performed on the cows showed a high degradation rate of dried forage of Virginia fanpetals fertilized with 200 kg N/ha dose (tab. 4). Rapid and high protein degradation rate exceeding 91% was observed as early as in 8th hour of incubation in the rumen. The high degradation rate of protein maintained throughout the whole incubation time in the rumen.

For comparison, this high protein degradation rate (90%) of Virginia fanpetals dried forage fertilized with the 300 kg N/ha dose was only obtained until 48 hour incubation in the rumen.

High true digestibility of over 83% (tab. 5) is a measurable effect of rumen protein degradation rate of Virginia fanpetals dried forage fertilized with 200 kg N/ha dose.

Table 1. Influence of nitrogen fertilization on crude protein in *Sida* forage.

Material Fertilization	Leaves	Whole plant
N 100	27,2	16,2
N 200	29,6	17,6
N 300	29,9	19,1
Mean	29,9	17,0

a, b, c – differences statistically significant $p < 0,0$

Table 2. Influence of N fertilization on essential amino acid content in *Sida* forage (%).

Forage	N kg/ha	Exogenous amino acids									
		Lys	Met	Tre	Try	His	Leu	Ile	Wal	Phe	Tyr
Whole plant	N 100	3,97	0,69	2,02	1,21	1,70	3,26	2,33	2,90	3,18	1,39
	N 200	4,13	0,88	2,17	1,15	1,65	4,12	2,57	3,12	3,64	1,33
	N 300	3,53	0,86	1,74	1,09	1,54	3,04	1,92	2,75	2,59	0,90
Mean		3,88	0,81	1,96	1,21	1,67	3,47	2,27	2,92	3,14	1,21
Leaves	N 100	6,32	2,43	2,76	2,78	2,28	5,32	3,25	4,38	4,19	3,24
	N 200	7,22	2,37	3,07	2,66	2,32	4,73	3,52	4,68	4,73	2,37
	N 300	5,98	2,33	2,64	2,98	1,98	4,68	3,38	3,85	3,74	1,74
Mean		6,51	2,38	2,82	2,53	2,19	5,37	3,38	4,30	4,22	2,15

Table 3. Influence of N fertilization on net protein value in *Sida* forage (%)

Material Fertilization	Leaves	Whole plant
N 100 N 200 N 300	66,,8[a] 66,1[ab] 53,0[ac]	50,8 52,4 43,7[ac]
Mean	60,6	49,0

a, b, c – differences statistically significant $p < 0,05$

Table 4. Rumen degradation of sida meal (%) in cows and its true digestibility

Material Incubation time	Sida meal		Differences in protein degradation (percentage unit)
	N 200	N 300	
4 h	80,7	66,7	14,0
8 h	91,2	81,5	9,7
16 h	94,2	88,1	6,1
24 h	94,8	89,3	5,5
48 h	95,1	90,3	4,8
Mean	91,2	83,2	–

Table 5. Evaluation of availability and digestibility of sida meal protein.

Specification	Sida meal	
	N 200	N 300
Protein content, %	16,9	19,7
Protein biological value, %	52,4	43,7
Protein degradation rate (4-48 h), %	86,0	74,0
Protein true digestibility, %	83,5	78,3

DISCUSSION

The necessity to obtain sustained and high yield of fodder crops of proper nutritional value involves high nitrogen fertilizer input. However, nitrogen unused by fodder plants is lost for the agricultural production and released into the atmosphere and hydrosphere. Nitrogen-related hazards occur when the N optimal rates are exceeded. According to The Act on Fertilizers and Fertilization (2007), the allowed annual dose limit is 170 kg N/ha (14).

Under the conditions of intensive animal production system, in order to reduce nitrogen emission levels in animal manure, more efficient use of animal feeds is introduced with an aid of ”environmental sustained feed management systems”. It may be achieved by, among others, providing precisely formulated feed rations of defined protein content and highly nutritional value ensured by the exogenous amino acid level (2, 6). The problem of protein quality under the intensive plant and animal production in association with its availability and, as a consequence, its influence on the natural environment remains poorly investigated.

The present researches have shown the effect of increasing nitrogen fertilization on the crude protein content in Virginia fanpetals forage. However, the modification of amino acid protein composition was possible up to the maximum dose of 200 kg N/ha, otherwise a varying decrease of level of all the amino acids under study was reported. A clear fall of the amino acids level ranging between 32 and 51% was noted for phenylalanine, tyrosine and leucine.

Disadvantageous changes in the exogenous amino acid level in Virginia fanpetals forage resulting from high nitrogen fertilization rate have caused a significant decrease of protein nutritional value in the plant. Declined nutritional value of forage protein produced by intensive nitrogen fertilization is likely to emerge from a rising level of endogenous amino acids at the expense of the exogenous amino acids and thus, changing their ratios. Changes of quantitative proportions between lysine and methionine as well as tyrosine and leucine seem to be especially important (10).

Changes in a level and ratio of exogenous amino acids under the intensive nitrogen fertilization reduce protein nutritional value and therefore, affect its availability and utilization processes in animal organism (5, 8, 10).

Decreased protein nutritional value in Virginia fanpetals dried forage under high N fertilization conditions, affected its use in assimilation process in animal. Negative impact of excessive nitrogen fertilization on protein utilization during the rumen degradation process affecting true intestinal digestibility may, among others, contribute to increased protein nitrogen extraction in animal manure to the environment (5).

The finding was partly confirmed in the present studies where protein from dried Virginia fanpetals N-fertilized at 300 kg N/ha level as compared to the recommended dose, was characterized by the rumen degradation rate lower by 8% at average.

Measurable effect of the appropriate choice of nitrogen fertilization level and thus, a following higher degree of Virginia fanpetals protein rumen degradation in cows proved to be its high true digestibility exceeding the value of 83%.

CONCLUSION

High nitrogen fertilization inducing increased protein content affects negatively its nutritional value. Exceeding the optimal dose of N fertilization (200 kg N/ha) markedly decreases exogenous amino acid level in Virginia fanpetals forage.

Decline of protein nutritional value under excessive nitrogen fertilization decreased protein rumen degradation rate and true digestibility.

Nutritional value of fodder crop protein affected by nitrogen fertilization should become one of the indices

in assessment of protein nitrogen excretion to the environment to meet the minimum requirements for the environmental and human health protection. □

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