Journal of Ecological Engineering
Volume 14, No. 3, July 2013, pp. 63–68
DOI: 10.5604/2081139X.1056046 *Research Article*

EVALUATION OF THE FEED QUALITY OF *FESTULOLIUM BRAUNII* MIXTURES WITH MICROBIOLOGICALLY SUPPLIED RED CLOVER AND ALFALFA

Jacek Sosnowski[1], Kazimierz Jankowski[1]

[1] Departament of Grassland and Green Areas Creation, University of Natural Sciences and Humanities in Siedlce, B. Prusa 14, 08-110 Siedlce, Poland, e-mail: laki@uph.edu.pl

Received: 2013.05.07
Accepted: 2013.06.10
Published: 2013.07.10

ABSTRACT

The experience with cultivation of *Festulolium braunii* (Felopa variety) in mixtures with red clover (Tenia variety), and alfalfa (Tula variety), was founded in April 2007 on an experimental object of Grassland Department and Green Areas Creation UP-H in Siedlce. The first experimental factor were 3-grass-legumes mixtures having the following composition: M1 – *Festulolium braunii* 50%, *Trifolium pretense* L. 50%, M2 – *Festulolium braunii* 50%, *Medicago sativa* ssp. *media* 50%, M3 – *Festulolium braunii* 50%, *Trifolium pratense* L. 25%, *Medicago sativa* ssp. *media* 25%. Combinations with soil's medium amendment was marked as UG, and without soil's medium amendment – BUG. In addition, nitrogen fertilization in the annual dose of 60 kg $N \cdot ha^{-1}$, potassium 120 kg $K_2O \cdot ha^{-1}$ and phosphorus in the amount of 80 kg $P_2O_5 \cdot ha^{-1}$ were applied on all plots. Detailed study included the chemical composition of plant, which was determined at the Institute of Technology and Life Sciences in Falenty. The obtained results were used to calculate the following measures of the energy of and protein value feed: NEL – net energy of lactation, $JPM \cdot kg^{-1}$D.M. – feed unit for milk production, $JPŻ \cdot kg^{-1}$ D.M. – feed unit for livestock production, nBO – useful protein, BNŻ – rumen nitrogen balance. Furthermore, using the multivariate comparative of taxonomic analysis method the synthetic comparative measure of forage quality Q was evaluated. The use of soil's medium amendment, regardless of the types of mixture, cuts and years of research, resulted in higher values of all measures. However, the analysis of synthetic measure of feed quality showed that in terms feed quality the best was the three component *Festulolium braunii* mixture with *Trifolium pratense* L. and *Medicago sativa* ssp. *media*.

Keywords: mixture, energy value, protein value, quality of feed.

INTRODUCTION

One of the priority tasks of sustainable agriculture is to care about good quality of food and feed. In case of grass-legume mixtures, the basic problem is to achieve a balance between the level of production and its quality, connected directly with feed value [6]. In many studies [3, 5, 13, 15] due to a favorable chemical composition of dry matter and high productivity, advantages of *Festulolium braunii* with legume plants as a very good source of fodder intended for ruminants are highlighted. Kryszak [11] reported that legume crops with *Festulolium* characterized by a high protein content and the optimum fiber. At the same time they constitute a significant source of phosphorus, calcium, magnesium, sodium and potassium. This author underlines that the content of these components in dry matter complieswith the INRA system. However, according to Borowiecki [6], the nutritional value of feed material should be primarily the result of digestibility, energy and protein value of crops. Moreover, in their studies [2, 4, 7], they pay attention to the time for the first cut and the appropriate programmed fertilization, which is an important factor affecting the quality of the harvest. Recently, the studies presented in the literature concerning the supply

of the soil from agricultural crops by preparations based on micro-organisms [10, 15, 16] which, as mentioned by Sulewska et al. [16], a effected positively soil fertility, plant health and yield. In addition, studies by Sosnowski and Jankowski [15] have shown that they have caused productivity growth of *Festulolium braunii* mixtures with alfalfa and red clover. Therefore, the aim of this study was to determine the effect of species composition and quantitative of *Festulolium braunii* mixtures with red clover and alfalfa supplied with soil's medium amendment (SMA), on their energy and protein value. Moreover, attempts to develop a synthetic measure of feed quality on the basis of parameters describing the energetic and protein value.

MATERIAL AND METHODS

The experience with *Festulolium* cultivation with red clover and alfalfa was founded in April 2007, in randomized blocks in 3 replications at the experimental object of Grassland Department and Green Areas Creation UP-H in Siedlce (geographical coordinates: 52.169 °N, 22.280 °E). A detailed description of soil and meteorological conditions of the conducted experiment was presented in the work by Sosnowski and Jankowski [15]. Surface plot was 6m^2. In the year of sowing out only infestation cuts was carried. The full period of three cuts using of experimental objects was in 2008–2010.

The first experimental factor were 3-grass legumes mixtures with the following composition: M1 – *Festulolium braunii* (Felopa variety) 50%, *Trifolium pratense* L. (Tenia variety) 50%, M2 – *Festulolium braunii* (Felopa variety) 50%, *Medicago sativa* ssp. *media* (Tula variety) 50%, M3 – *Festulolium braunii* (Felopa variety) 50%, *Trifolium pratense* L. (Tenia variety) 25%, *Medicago sativa* ssp. *media* (Tula variety) 25%.

The adopted amount of sowing seeds of individual mixtures contained: *Festulolium braunii* 40 kg·ha^{-1}, *Trifolium pratense* L. 21 kg·ha^{-1}, *Medicago sativa* ssp. *media* 26 kg·ha^{-1}. The second factor was soil's medium amendment, whose composition is given by Sosnowski and Jankowski [15].

Soil's medium amendment, was used for plants watering in the phase of grasses shooting in the first regrowth, as a solution at a dose of 0,9 l·ha^{-1} diluted in 350 l of water. Combinations of soil's medium amendment, were marked as UG, and without soil's medium amendment.

In addition, nitrogen fertilization (34% ammonium nitrate) was applied on all the plots in three divided doses, sown in succession at each regrowth in the amount of 20 kg N·ha^{-1} (60 kg N·ha^{-1}annualy). Potassium (60% potassium salt) 120 kg K_2O·ha^{-1} per year, as well as nitrogen fertilization under the regrowth was applied. Phosphorus (46% superphosphate) in the dose of 80 kg P_2O_5·ha^{-1} was sown once in early spring.

The analysis of the chemical composition of dry matter yield was carried out for all the cuts, gathered in the last two years of the experiment in the Institute of Technology and Life Sciences in Falenty. Based on the formulas given in the work edited by Dymnicka and Sokół [9], the following measures of energy and protein feed was calculated from the obtained data. It was NEL – net energy of lactation (MJ·kg^{-1}D.M.) JPM·kg^{-1}D.M. – feed unit for milk production, JPŻ·kg^{-1} DM – feed unit for livestock production, nBO – usable protein i.e. the amount of total protein available in the small intestine and the protein of rumen microbial which developed from that part of feed protein, which was distributed in the rumen (g·kg^{-1} D.M.) BNŻ – rumen nitrogen balance (g N·kg^{-1}D.M.). All the results were evaluated statistically by using variance analysis. The means differentiation was verified by Tukey's test at significance level $p \leq 0.05$.

Furthermore, using the taxonomic multivariate analysis of comparative method [1], based on the value of individual energy and protein measures of feed developed a synthetic comparative measure of quality fodder (Q).

Q measure was determined in the following steps:

- Step 1: Construction of the matrix (Table 1) – to determine its dimensions.
- Step 2: Alignment of preferences direction: Studying all the result it wa chncluded that the characteristic adopted the nature of a stimulant, so the transformation of values was based on the following formula:

$$X_{ij} = Y_{ij}$$

where: Y_{ij} – value of j-th feature for i-th mixture.

- Step 3: Normalization features – normalization was based on the following formula:

$$n_{ij} = \frac{Y_{ij}}{Y_{j\max}}$$

Table 1. Matrix

Mixture	Diagnostic feature				
	j_1	...	...	…	j_n
i_1					
…					
i_m					X_{mn}

Where: n = 5, m = 3, i – kind of mixture (i = 1, ..., m), j – feature (j = 1, ..., n); X_{mn} – value of n-feature for the m-th mixture.

where: n_{ij} – normalized value of *j*-th feature for the i-th mixture so that: $n_{ij} \in [0, 1]$ and becomes the undenominational value,
Y_{jmax} – maximum value of the j-th feature.

- Step 4: Construction of a synthetic meter Q – the meters are the averages weighted of the standardized diagnostic features:

$$Q = \sum_{j=1}^{s} w_j \times n_{ij}$$

where: Q – measure of the feed quality,
n_{ij} – normalized values of j-th characteristic for i-th mixture,
w_j – weight of j-th feature.

The validity of features ("weight") was determined on the basis of correlation coefficients [14] the relationship between various diagnostic features and dry matter yield of individual mixtures, given in the work of Sosnowski and Jankowski [15]. Sample size (n = 36) were defined as follows: 3 (lications) ×3 (number of cuts) ×2 (objects UG and BUG) ×2 (chemical analysis of the two years of the experiment). The value of correlation coefficients (at $p \leq 0.05$) is shown in Table 2.

The value of correlation coefficient for individual features in the range of mixtures was averaged (arithmetic mean) and accounted the share of average in the sum of averages, what states the validity of feature (Table 3).

The formula for measuring the quality of feed for analyzed mixtures, therefore, adopted the following form:

$$Q = 0{,}217 \times n_{NEL} + 0{,}140 \times n_{JPM} + 0{,}154 \times n_{JPŻ} + 0{,}273 \times n_{nBO} + 0{,}216 \times n_{BNŻ}$$

RESULTS AND DISCUSSION

Grass-legumes mixtures delivered a valuable feed for ruminants, with a quality which, according to Ciepiela et. al [8], provides energy value. The studies have shown that this value expressed as the net energy of lactation was differenced, both under the influence of fertilizer agent and the composition of the mixtures (Table 4). The highest energy value characterized the cultivation of *Festulolium* mixtures with red clover (5.12 MJ·kg^{-1} D.M.), but the lowest *Festulolium* with alfalfa (4.76 MJ·kg^{-1} D.M.). The introduction of microorganisms into the soil under the cultivation, caused an increase in the NEL value, regardless of the mixture type.

The studies show that regardless of the mixture type using the soil's medium amendment, caused a significant increase of JPM from 0.78 to 0.83. The research also shows that increasing the share of alfalfa as a component of the mixture caused an increase of JPM. However from

Table 2. The value of the correlation coefficient (*r*) between dry matter yield of *Festulolium braunii mixture* with red clover and alfalfa and the various measures of energy and protein value of feed

Measures	Mixtures		
	M1 n = 36	M2 n = 36	M3 n = 36
NEL	0.62642	0.59097	0.57915
JPM	0.38803	0.38230	0.39300
JPŻ	0.42073	0.40734	0.45015
nBO	0.80921	0.70755	0.74847
BNŻ	0.62732	0.54657	0.59832

Table 3. Average value of correlation coefficient (r) of some feature and its weight

Measures	Correlation coefficient	Validity of feature
NEL	0.5988	0.2170
JPM	0.3877	0.1405
JPŻ	0.4260	0.1545
nBO	0.7550	0.2737
BNŻ	0.5907	0.2143
Σ	2.75851	1.000

Table 4. The energy value of 1 kg D.M. *Festulolium braunii* mixtures with red clover and alfalfa supplied with soil's medium amendment (average from cuts and years)

Mixtures	Soil's medium amendment		Mean
	UG	BUG	
NEL (MJ)			
M1	5.32 Aa	4.91Ab	5.12 A
M2	5.03 Aa	4.49 Bb	4.76 B
M3	5.14 Aa	4.80 ABa	4.97 AB
Mean	5.16 a	4.73 b	
JPM			
M1	0.78 Ba	0.73 Bb	0.76 B
M2	0.87 Aa	0.83 Aa	0.85 A
M3	0.86 Aa	0.79 ABb	0.82 A
Mean	0.83 a	0.78 b	
JPŻ			
M1	0.82 Aa	0.75 Bb	0.79 A
M2	0.75 Ba	0,71 Ba	0.73 B
M3	0.83 Aa	0.80 Aa	0.81 A
Mean	0.80 a	0.75 b	

• Average in lines marked by the same small letters not differed significantly
• Average in columns marked with the same capital letters not differed significantly

NEL – net energy of lactation, JPM – feed unit for milk production, JPŻ – feed unit of livestock production, M1, M2, M3 – the mixtures, UG – a combination with soil's medium amendment, BUG – combinations without soil's medium amendment.

the work of Kryszak [11] for two mixtures with alfalfa or red clover resulted that the higher value of JPM characterized the feed containing red clover. The results obtained by this author, however, as indicates Borowiecki [6], researches are typical and are responsible for feed units of milk production of tall fescue mixtures with red clover, harvested at the stage of flower buds formation of clover.

The unit feed of livestock production for some crops ranged from 0.73 for mixture of *Festulolium* with clover (M1) to 0.81 for three component *Festulolium* mixture with clover and alfalfa (M3). Additional supply of the crops with microbial preparation, as in case of JPM, also resulted in a significant increase of presented characteristics. It should be noted, however, that those values were on average 17% higher than JPŻ for meadows with hay and silage obtained and evaluated by Nazaruk et al. [12] in organic farms.

Late mowing and three cut sward use, caused an increase of indigestible matter content and decrease in total protein share in the analyzed feed. In 1kg dry matter of the tested plant material were an average 109.81 g of useful protein (Table 5). This value was on average 10% lower than the content of nBO in the hay from the red clover and about 7% higher than the meadow hay [9].

The highest value of protein (111.41 $g \cdot kg^{-1}$ D.M.) regardless of fertilization, characterized *Festulolium* mixture with red clover (M1). In ad-

Table 5. The protein value of 1kg D.M. *Festulolium braunii* mixtures with red clover and alfalfa supplied with soil's medium amendment (average from cuts and years)

Mixtures	Soil's medium amendment		Mean
	UG	BUG	
nBO (g)			
M1	113.21 Aa	109.62 Ab	111.41 A
M2	109.53 Ca	107,26 Bb	108.40 B
M3	111.29 Ba	107.96 Bb	109.65 AB
Mean	111.34 a	108.28 b	
BNŻ (g N)			
M1	1.02 ABa	0.97 ABb	0.99 AB
M2	0.98 Ba	0.95 Ba	0.96 B
M3	1.06 Aa	1.01 Ab	1.03 A
Mean	1.02 a	0.97 b	

• Average in lines marked by the same small letters not differed significantly
• Average in columns marked with the same capital letters not differed significantly

nBO – the amount of usable protein, BNŻ – rumen nitrogen balance, M1, M2, M3 – the mixtures, UG – a combination of soil's medium amendment (SMA), BUG – combinations with soil's medium amendment

dition, it was demonstrated that the addition of alfalfa caused a reduction of this value which for the feed of *Festulolium* in mixture only with alfalfa (M2) amounted approximately to 108 g. The cultivation of mixtures on the objects supplied with microorganisms, resulted in an increase of their protein value, regardless of their species composition. In DLG, system for assessing the value of the feed, it is recommended also to define the rumen nitrogen balance (BNŻ), which is the difference between the total protein contained in feed and the protein available in the thin intestine, expressed in grams of nitrogen. Rumen nitrogen balance of the analyzed material received a positive value (Table 5) and independently of the fertilizer, the factor ranged from + 0.96 g $N \cdot kg^{-1}$ D.M.- for *Festulolium* mixture with alfalfa to +1.03 g $N \cdot kg^{-1}$ D.M. for *Festulolium* mixture with red clover and alfalfa.

A positive value of balance indicates that protein value of this feed expressed in the protein useful (nBO), has been reduced an average by about 0.99 g $N \cdot kg^{-1}$ D.M., in relation to the values expressed in the total protein. Moreover, this suggests that the feed has an unbalanced energy to protein ratio and can be used in feed rations with the feed with a negative balance, eg barley cake, wheat bran or with silage from corn. Due to differences in the values of individual indicators of energy and protein in the analyzed mixtures to assess clearly the quality of the tested feed, taxonomic comparative method was used. This analysis showed that in the synthetic approach the best feed material was *Festulolium braunii* mixture with red clover and alfalfa. The values of the measure feed quality *Q* for this crop amounted 0.98 (Figure 1). Lower quality in terms of synthetic estimation had the both two-component mixtures.

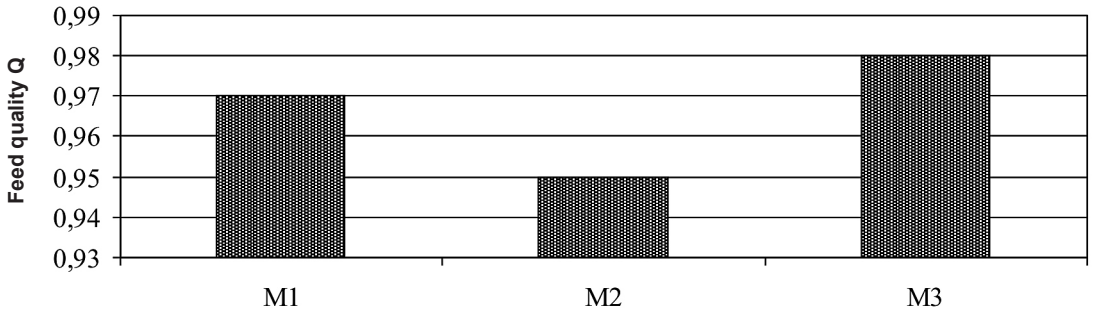

Fig. 1. The measure value of the feed quality (Q) of each mixtures of *Festulolium braunii* with red clover and alfalfa

CONCLUSION

1. The supply to the soil by soil's medium amendment, regardless of the mixture type and study years, resulted in higher values of all analyzed indicators, the energy and protein of assessed feed.
2. Addition of red clover as a mixture component, caused an increase in the value of net energy lactation (NEL) and the feed unit of livestock production (JPŻ), but caused a slight but significant decrease in feed units of milk production (JPM).
3. The highest protein value expressed by useful protein (NBO) and by rumen nitrogen balance (BNŻ), characterized only the *Festulolium* mixtures with red clover undepend on the botanical composition.
4. Multivariate comparative analysis showed that the best feed material had a mixture *Festulolium braunii* with red clover and alfalfa. Plant material containing only alfalfa as a plant legumes obtained the lowest value of feed quality measure Q.

REFERENCES

1. Grabinski T., Wydymus S., Zeliaś A. 1989. Metody taksonomii numerycznej w modelowaniu zjawisk społeczno-gospodarczych. PWN, Warszawa.
2. Borowiecki J. 2001. Wpływ terminu koszenia pierwszego pokosu na poziom plonowania i wartość pokarmową *Festulolium*. Zesz. Prob. Post. Nauk. Rol., 474, 235−239.
3. Borowiecki J. 2002. Produkcyjność roślin motylkowatych ich mieszanek z trawami. Pamiętnik Puławski, 130, 57−63.
4. Borowiecki J. 2002. Wpływ nawożenia azotem na plon i wartość pokarmową *Festulolium braunii* odm. Felopa. Pamiętnik Puławski, 131, 39−48.
5. Borowiecki J. 1997. Przydatność *Festulolium* do uprawy w mieszankach lucerną mieszańcową. Pamiętnik Puławski, 109, 35−44.
6. Borowiecki J. 2004. Możliwość prognozowania jakości wieloletnich roślin motylkowatych i ich mieszanek z trawami. Post. Nauk Rol., 4, 62−70.
7. Borowiecki J., Staniak M. 2001. Wpływ terminu koszenia pierwszego pokosu na poziom plonowania i zawartość białka *Festulolium* odmiany Felopa. Zesz. Probl. Post. Nauk Rol., 474, 235–239.
8. Ciepiela G.A., Jankowska J., Kolczarek R., 2008. Plon jednostek paszowych uzyskany z kupkówki pospolitej uprawianej w siewie czystym i w mieszankach z roślinami motylkowatymi. Zesz. Nauk. WSA w Łomży, 37, 5−13.
9. Dymnicka M., Sokół J.L. 2001. Podstawy żywienia zwierząt. Wyd. SGGW, Warszawa.
10. Klama J., Jędryczka M., Wiśniewska H., Gajewski P. 2010. Ocena stopnia rozwoju oraz kondycji fizjologicznej ozimych roślin pszenicy i rzepaku w uprawie z zastosowaniem efektywnych mikroorganizmów. Nauka Przyroda Technika, 4(6), 1−8.
11. Kryszak J., 2001. Plonowanie i jakość mieszanki *Festulolium braunii* (K. Richter) A. Camus z koniczyną łąkową i lucerną siewną na gruntach ornych. Zesz. Probl. Post. Nauk Rol., 479, 173−178.
12. Nazaruk M., Jankowska-Huflejt H., Wróbel B. 2009. Ocena wartości pokarmowej pasz z trwałych użytków zielonych w badanych gospodarstwach ekologicznych. Woda - Środowisko - Obszary Wiejskie, t. 9, 1(25), 61−76.
13. Olszewska M. 2008. Productivity of *Festulolium braunii* (K. Richt.) A. Camus and *Festuca pratensis* L. grown in mixtures with *Lotus corniculatus* L. depending on multiple nitrogen rates. Acta Sci. Pol., Agricultura, 7(2), 101−114.
14. Prończuk S., Prończuk M., Żyłka D. 1997. Metody syntetycznej oceny wartości użytkowej traw gazonowych. Zesz. Prob. Post. Nauk Rol., 451, 125−133.
15. Sosnowski J., Jankowski K,. 2010. Wpływ użyźniacza glebowego na skład florystyczny i plonowanie mieszanek kostrzycy Brauna z koniczyną łąkową i lucerną mieszańcową. Łąkarstwo w Polsce, 13, 157−166.
16. Sulewska H., Szymańska G., Pecio A. 2009. Ocena efektów stosowania użyźniacza glebowego UG-max w uprawie kukurydzy na ziarno i kiszonkę. Journal of Research and Application in Agriculture Engineering, 54(4), 120−125.
17. Wojtala-Łozowska L., Parylak D. 2010. Porażenie pszenicy ozimej przez choroby podsuszkowe w zależności od przedplonu, zastosowania użyźniacza glebowego i materiału siewnego. Postępy w Ochronie Roślin, 50(4), 2057−2064.