Barbara WRÓBEL, Krystyna J. ZIELIŃSKA*, Agata U. FABISZEWSKA**
Institute of Technology and Life Sciences
* Prof. Wacław Dąbrowski Institute of Agricultural and Food Biotechnology
** Warsaw University of Life Sciences
e-mail: b.wrobel@itp.edu.pl

THE EFFECT OF FERTILISATION AND UNDERSOWING PERMANENT MEADOW WITH A MIXTURE OF GRASSES AND LEGUMES ON THE AMOUNT AND QUALITY OF SWARD YIELD IN VIEW OF ITS USEFULNESS FOR ENSILAGE

Summary

The aim of this study was to assess the effect of sward enrichment in valuable grass and legume species through undersowing on the amount and quality of yield and its usefulness for ensilage. Two-factorial field experiment in a cross system was set up on experimental meadow. Three 0.8 ha plots were delineated, one was undersown with a mixture of grasses and Trifolium pratense L. (MI), the second – with a mixture of grasses and Lotus corniculatus L. (MII), and the third (control) was not undersown. The second analysed factor included the form of fertilisers: mineral NPK versus manure fertilisation. Botanical composition of sward, yielding and the content of nutritive components were estimated every year. Mown sward of the first cut was ensiled in large cylindrical bales. The content of nutritive components and the concentration of fermentation products was analysed in silage. Applied undersowing resulted in the increased share of legumes at the cost of grasses and weeds. Undersowing was also the factor significantly differentiating biomass yield. The highest yields in 2014 were obtained from plots undersown with a mixture containing Trifolium pratense L. In the second study year the biggest yield was noted for sward undersown with a mixture containing Lotus corniculatus L. Sward from undersown plots had higher content of total protein, lower content of sugars and significantly lower sugar to protein ratio. The enrichment of botanical composition of sward through undersowing exerted a significant impact on nutritive value of silages. The greatest nutritive value (expressed as relative feed value RFV) was found in silages made of sward undersown with a mixture of grasses and Lotus corniculatus L.
***Key words**: Lotus corniculatus, meadow sward, silage, Trifolium pratense*

WPŁYW NAWOŻENIA I PODSIEWU ŁĄKI TRWAŁEJ MIESZANKĄ TRAW I ROŚLIN BOBOWATYCH NA WIELKOŚĆ I JAKOŚĆ PLONÓW RUNI W ASPEKCIE JEJ PRZYDATNOŚCI DO ZAKISZANIA

Streszczenie

Celem badań było określenie wpływu wzbogacenia runi łąkowej w wartościowe gatunki traw i roślin bobowatych metodą podsiewu na wielkość i jakość plonów oraz ich przydatność do zakiszania. Na łące doświadczalnej założono dwuczynnikowe doświadczenie łanowe w układzie krzyżowym. W tym celu wytyczono trzy łany o powierzchni 0,8 ha każdy, spośród których jeden został podsiany mieszanką traw i Trifolium pratense L. (MI), drugi - mieszanką traw i Lotus corniculatus L. (MII), trzeci nie został podsiany (kontrola). Drugim badanym czynnikiem była forma nawożenia: nawożenie nawozami mineralnymi NPK i obornikiem. Corocznie oceniano skład botaniczny runi, plonowanie oraz zawartość składników pokarmowych. Skoszoną ruń łąkową z I pokosu zakiszono w dużych belach cylindrycznych. W kiszonce oznaczano zawartość składników pokarmowych oraz koncentrację produktów fermentacji. W wyniku zastosowanego podsiewu stwierdzono wzrost udziału roślin bobowatych kosztem udziału traw i chwastów. Zastosowany podsiew był również czynnikiem istotnie różnicującym wielkość plonów biomasy. W 2014 roku średnio istotnie najwyższe plony uzyskano z obiektów, na których zastosowano podsiew mieszanką z udziałem Trifolium pratense L. W drugim roku badań istotnie najwyżej plonowała ruń podsiana mieszanką z udziałem Lotus corniculatus L. Ruń z obiektów podsianych charakteryzowała się średnio wyższą zawartością białka ogólnego, niższą cukrów prostych oraz istotnie niższym stosunkiem cukrów do białka. Wzbogacenie składu botanicznego runi łąkowej metodą podsiewu miało również istotny wpływ na wartość pokarmową kiszonek. Największą wartością pokarmową, wyrażoną wskaźnikiem względnej wartości pokarmowej RFV charakteryzowały się kiszonki sporządzone z runi obiektów, na których zastosowano podsiew mieszanką traw i Lotus corniculatus L.
***Słowa kluczowe:** Lotus corniculatus, ruń łąkowa, sianokiszonka, Trifolium pratense*

1. Introduction

In many farms oriented to intensive cattle breeding, more and more attention is being paid to the quality of bulk fodder, which is the main component of feed doses used in cattle feeding [1, 2]. Fodder from permanent grasslands, in order to compete with other bulk fodder, should have a high concentration of digestible energy, optimum protein content, be palatable and first of all, should conform to specific digestion processes in ruminants.

Proper species composition of meadow sward is the precondition for obtaining high quality bulk fodder. An alarming phenomenon observed on more than 50% of grasslands in the country consists in unfavourable changes in botanical composition of meadow and pasture sward, which evidence their degradation [3]. Declining yields and poorer quality of obtained fodder are the consequence of degradation.

Undersowing - the introduction of seed mixtures of valuable grass and legume species adapted to habitat condi-

tions and type of management - is relatively cheap and effective method of sward improvement [4, 5, 6, 7]. Particular role in improving meadow sward is attributed to legumes, whose share in such mixtures may amount to as much as 30%. Most often used plants of this group are: *Trifolium pratense* L. and *Trifolium repens* L. and sporadically *Trifolium hybridum* L and *Lotus corniculatus* L. [8].

Increasing the share of legumes in meadow sward causes the increase in yields and improves feed value of obtained fodder [9, 10, 11, 12]. Legumes enrich fodder in nutritive components, especially in nitrogen compounds, increase biodiversity of grassland communities and, by fixing atmospheric nitrogen, enable limitation of mineral nitrogen fertilisation, which translates into lower costs of fodder production and to environmental protection [13]. Moreover, application of fodder from meadow sward with legumes improves economic efficiency of feeding and favourably affects the quality of animal products.

The aim of this study was to assess the effect of enriching meadow sward with valuable grass and legume species by the method of undersowing on the amount and quality of yields and their usefulness in hay ensilage production.

2. Material and methods

Studies were carried out in the years 2014–2015 on permanent meadow that belonged to Experimental Farm of the Institute of Technology and Life Sciences (ITP) in Falenty (52°8'14"N, 20°55'29"E). Two-factorial field experiment in a cross set up was established on a 2.4 ha experimental meadow [14]. Three 0.8 ha plots were delineated and the first was undersown with a mixture of grasses and *Trifolium pratense* L. (MI), the second – with a mixture of grasses and *Lotus corniculatus* L. (MII) (tab. 1), and the third was not sown and served as a control. Plots were undersown on 29th March 2012 with a prototype turf processing machine elaborated in the Masovian Research Centre of ITP in Kłudzienko. The second study factor included fertilisation with mineral NPK and manure at annual doses corresponding to 60 kg N ha^{-1}. Plots in variants of the first factor were divided in two halves. Half of each plot was fertilised with mineral NPK fertilisers at doses: N 60 kg ha^{-1} (20 kg in spring and 20 kg after each of the 1st and 2nd cut), P – 30 kg·ha^{-1} (once in spring) and K- 60 kg·ha^{-1} (20 kg in spring and 20 kg after each of the 1st and 2nd cut). Other halves of plots were fertilised every year in November with cattle manure in amounts equivalent to those applied in mineral fertilisers (60 kg N·ha^{-1}).

During the first cut botanical composition of sward was analysed with the Klapp's method [15] by estimating the share of particular species in yield with a precision of 1%. Whole plots were mown with rotary mower three times a year. The first cut was made between 19th and 28th May. Samples of meadow sward were collected to determine the yield of green and dry mass and for chemical analyses. Mown sward of the first cut after preliminary drying to about 40% of dry mass was collected with a rolling baler and ensiled in bales of a mass of about 400 kg. Three large bales were made from each plot and transported to a storage place, where the bales were wrapped with four layers of foil. Two samples of fodder were taken for chemical analyses from each bale in November.

After drying and grinding sward samples, the content of nutritive components was analysed with the NIRS method [16] using NIRFlex N-500 apparatus and ready-to-use calibrations for hay made by INGOT® firm. Samples of fresh silage were analysed for dry mass, pH, the content of lactic acid, volatile fatty acids, ammonia and basic nutritive components with the method as above.

Obtained data on yielding, chemical composition of sward and hay silage were statistically processed. The significance of differences was tested with the Tukey HSD test at $p<0.05$. Coefficients of correlation were calculated for the relationship between nutritive components of sward and percentage share of particular plant groups in meadow sward. Calculations were made with two-way ANOVA module of the Statistica 6 software (Statsoft, Polska).

3. Results

3.1. Botanical composition of meadow sward

Undersowing with a mixture of grasses and legumes had favourable effect on botanical composition of meadow sward. On all undersown plots, irrespective of fertilisation the share of legumes increased at the cost of grasses, herbs and weeds. The share of particular species depended mainly on the composition of mixture used for undersowing (tab. 2).

Particularly favourable changes consisted in the increased share of legumes. On plots undersown with MI mixture, the share of *Trifolium pratense* L. in sward increased to 17% on plot fertilised with manure and to 33% on NPK fertilised plot in the year 2014. This evidenced the ability of *Trifolium pratense* L. to fast development after undersowing, its competitiveness with respect to other plant species and usefulness for undersowing meadows [17, 7, 18].

Table 1. Seed mixtures composition used for undersowing
Tab. 1. Skład mieszanek zastosowanych do podsiewu

Seed mixture I			Seed mixture II		
Species	Variety	Share in mixture (%)	Species	Variety	Share in mixture (%)
Festuca pratensis Huds.	Pasja	25	*Festuca pratensis* Huds.	Pasja	25
Phleum pratense L.	Karta	12	*Phleum pratense* L.	Karta	12
Festulolium	Felopa	15	*Festulolium*	Felopa	15
Poa pratensis L.	Skiz	5	*Poa pratensis* L.	Skiz	5
Lolium perenne L.	Naki	5	*Lolium perenne* L.	Naki	5
Dactylis glomerata	Amera	8	*Dactylis glomerata*	Amera	8
Trifolium pratense L.	Chlumecky	30	*Lotus corniculatus* L.	Leo	30

Source: own work / Źródło: opracowanie własne

Table 2. Botanical composition of meadow sward (%) before the 1st cut
Tab. 2. Skład botaniczny runi łąkowej (%) przed I pokosem

	Without undersowing (control)				Undersowing with mixture MI				Undersowing with mixture MII			
	NPK		Manure		NPK		Manure		NPK		Manure	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
High grasses of good value												
Alopecurus pratensis L.	-	-	1	1	-	-	1	1	-	-	-	-
Dactylis glomerata L.	32	34	24	21	19	39	26	28	28	42	33	31
Festuca pratense L.	-	-	-	-	4	7	-	-	4	8	5	6
Festuca arundinacea Schreb.	-	-	-	-	-	-	-	-	1	-	-	-
Total	**32**	**34**	**25**	**22**	**23**	**46**	**27**	**29**	**33**	**50**	**38**	**37**
Short grasses of good value												
Festuca rubra L.	10	10	7	7	7	8	7	7	10	10	10	12
Lolium perenne L.	1	1	8	11	-	-	8	7	-	-	-	-
Poa pratensis L.	27	28	27	29	19	25	24	23	16	18	22	15
Total	**38**	**39**	**42**	**47**	**26**	**33**	**39**	**37**	**26**	**28**	**32**	**27**
Other grasses												
Agrostis stolonifera L.	-	-	4	2	-	-	-	-	-	-	-	-
Elymus repens (L.) Gould	1	1	8	9	-	-	2	2	1	-	-	-
Holcus lanatus L.	-	-		0	-	-	-	-	-	-	1	1
Total	**1**	**1**	**12**	**11**	**0**	**0**	**2**	**2**	**1**	**0**	**1**	**1**
Legumes												
Lotus corniculatus L.	-	-	-	-	-	-	-	-	11	16	7	15
Trifolium pratense L.	4	4	7	4	33	15	17	16	5	1	2	3
Trifolium repens L.	-	1	1	3	-	+	-	2	-	1	-	1
Total	**4**	**5**	**8**	**7**	**33**	**15**	**17**	**18**	**16**	**18**	**9**	**19**
Herbs and weeds												
Achillea millefolium L.	6	5	2	3	5	2	3	4	6	2	6	3
Capsella bursa-pastoris L.	-	-	-	-	-	-	-	-	1	-	-	-
Cerastium holosteoides Fr. em. Hyl.	+	-	+	-	1	-	-	-	-	-	1	1
Cirsium arvense (L.) Scop.	-	-	+	-	-	-	-	-	-	-	-	-
Cirsium rivulare (Jacq.) All.	-	-	1	-	+	-	-	-	-	-	-	-
Heracleum sphondylium L.	+	-	-	-	-	-	-	-	-	-	-	-
Plantago lanceolata L.	-	-	+	-	1	1	-	-	-	-	1	1
Plantago media L.	-	-	-	-	-	-	-	-	+	-	-	-
Ranunculus repens L.	-	-	-	-	-	-	1	-	-	-	-	-
Rumex acetosa L.	2	2	-	-	1	-	1	-	-	1	2	1
Rumex crispus L.	1	1	-	-	1	-	-	-	-	-	-	-
Rumex obtusifolius L.	-	-	3	3	-	-	2	2	-	-	+	-
Sonchus arvensis L.	1	+	-	-	1	-	1	1	2	+	-	-
Stellaria media (L.) Vill.	-	-	-	-	-	-	-	-	1	-	-	-
Taraxacum officinale F.H. Wigg.	15	13	6	6	8	3	7	7	14	1	10	10
Carex sp.	-	-	1	1	-	-	-	-	-	-	-	-
Total	**25**	**21**	**13**	**13**	**18**	**6**	**15**	**14**	**23**	**4**	**20**	**16**

Explanations: + species occurred in less than 1%; - species has not occurred

Source: own work / Źródło: opracowanie własne

However, the species is less stable, especially in drying habitats. In the next study year of intensive droughts the share of the meadow clover decreased drastically in plot fertilised with NPK to reach the level of 15 - 16% share. This result confirms a great sensitivity of *Trifolium pratense* L. to water deficits and considerable effect of climatic conditions on its persistence in meadow sward [7, 5]. Rapid withdrawal of *Trifolium pratense* L. from grassland sward was also demonstrated by Barszczewski et al. [9], Dembek and Łyszczarz [19] and Kozłowski et al. [20], which shows the need of frequent, sometimes every 2 – 3 years, introduction of this species by undersowing. On plots undersown with the MII mixture containing seeds of *Lotus corniculatus* L. the share of this species in variant fertilised with NPK was 11% and in variant fertilised with manure - 7%. In the second year the share of the common bird's-foot trefoil increased to 15 – 16%. *Lotus corniculatus* L. as compared with *Trifolium pratense* L. is more resistant to unfavourable climatic conditions and persists longer in undersown sward, especially at low level of nitrogen fertilisation [21].

Grasses were the dominating group of plants on all experimental plots. In the first study year their share in sward varied from 50% to 71% on undersown plots and from 70% to 79% on control plots. In the second year the share of grasses increased on all plots. Remarkable increase (to 80%) was observed on plot undersown with the MI mixture and fertilised with mineral NPK. Undersowing had no significant effect on species composition of this group of plants. *Dactylis glomerata* L. was the dominating species on all plots. Especially intensive development of this species was noted in the second year of study, particularly on plots fertilised with mineral fertilisers (tab. 2). Apart from *Poa pratensis* L. and *Festuca rubra* L., this species had the

greatest share in yields (tab. 2), especially on plots fertilised with mineral fertilisers. Intensive growth of *Dactylis glomerata* L. proves its strong competitive abilities and tolerance to water deficits in the vegetation season [22, 7]. The share of other grass species was low and did not exceed several percent. A small, few percent's share of *Festuca pratensis* Huds. in sward of undersown meadows, despite its 25% content in both seed mixtures (tab. 1), confirms poor usefulness of this species for undersowing meadows in conditions similar to those prevailing in the experiment [7].
Dicotyledon herbs and weeds were numerously present apart from grasses and legumes. The herbs are rich in biologically active substances, have often higher contents of protein, mineral components and fibre, which makes their better digestibility, but their yields are small [23, 24]. It is commonly thought that these plants should amount to no more than 10% of species composition of a good meadow or pasture. On most experimental plots their share was several or about fifteen percent and on three plots it exceeded 20%. Species composition of this plant group was similar on all plots. Most frequent species were: *Taraxacum officinale* sp., *Achillea millefolium* L. (meadow herbs of utility value Lwu = 6) and *Rumex acetosa* L. (a plant indicator of acidic soils). According to Kryszak [25] these species evidence synanthropisation of meadow community.

3.2. Yielding of meadow sward

Sward on particular plots was characterised by different biomass production. Dry mass yields obtained in 2014 were very high (from 8.67 to 15.31 t DM per ha). Undersowing was the factor significantly differentiating yields in particular cuts and annual yields. On average and irrespective of fertilisation, significantly highest yields were obtained from plots undersown with the mixture containing *Trifolium pratense* L. (mean 14.59 t DM per ha), then with that containing *Lotus corniculatus* L. (12.59 t DM per ha) and the lowest yields were obtained from control plots (9.04 t DM per ha). The form of fertilisation was also the factor significantly differentiating yields (tab. 3). Yield-forming role of manure manifested itself on control plot and on that undersown with *Trifolium pratense* L. The differences in favour of manure fertilisation were 0.74 and 1.45 t ha^{-1}. On plot undersown with *Lotus corniculatus* L. the yield-forming role of manure was, however, similar to that noted on control plot (tab. 3).

In the second study year, due to unfavourable thermal and rainfall conditions, obtained yields were several times lower than those in 2014 (tab. 3). As before, the yields from undersown plots were significantly higher than those from control plots. The highest yields exceeding 5 t per ha were harvested from plot undersown with the MII mixture. This result can be explained by the presence of *Lotus corniculatus* L. in meadow sward. This species has well developed root system and thus is able to acquire water from deeper soil layers, which makes it resistant to unfavourable atmospheric conditions [26, 27]. Positive effect of this species on photosynthesis in grasses was also demonstrated. As shown by Warda and Krzywiec [28], roots of *Lotus corniculatus* L. get in close contact with the roots of grasses, which enables more effective transfer of symbiotically fixed nitrogen. Moreover, *Lotus corniculatus* L. is a plant more biologically active and delivers 30% more nitrogen to soil than *Trifolium pratense* L.

3.3. Chemical composition of meadow sward intended for ensilage

Feed value of fodder obtained from permanent grasslands reflects floristic composition of sward i.e. the share of particular species of grasses, legumes and herbs, which have diverse chemical composition [29, 30]. Introduction of valuable grass and legume species significantly affected the content of nutritional components (tab. 4). Sward from undersown plots contained on average more proteins, less sugars and lower sugar to protein ratio. This was a result of the presence of legumes, which compared with grasses have higher protein content and less crude fibre. The relationship was confirmed by coefficients of linear correlation between the share of plant groups and the content of particular chemical components (tab. 5). It was demonstrated that the increased share of legumes in sward was accompanied by linear increase in total protein and ADL content and by decrease in the percentage share of sugars.
Measures to quantify the usefulness of green fodder for ensilage are: the amount of sugars – substrates in lactic acid fermentation – and buffering capacity, which depends on the concentration of proteins. The content of sugars in evaluated raw material was differentiated between study years and among experimental plots. The higher share of grasses in sward of control plots resulted in significantly (0.49**) higher content of sugars there.

Table 3. Effect of undersowing treatment and form of fertilization on meadow sward yields in successive swaths (t DM ha^{-1})
Tab. 3. Wpływ zabiegu podsiewu i formy nawożenia na wielkość plonów runi łąkowej w kolejnych pokosach (t ~~sm~~. ha^{-1})

Cut	Without undersowing (control)		Undersowing with mixture MI		Undersowing with mixture MII	
	NPK	Manure	NPK	Manure	NPK	Manure
2014						
I	3.48a	4.28ab	5.52bc	5.60bc	6.45c	4.50ab
II	2.76a	2.70a	4.81b	4.84b	4.13ab	3.05a
III	2.43a	2.43a	3.53ab	4.87c	4.30bc	2.77a
Total yield	**8.67a**	**9.41a**	**13.86b**	**15.31b**	**14.88b**	**10.42a**
2015						
I	2.42ab	1.89a	3.54b	3.02ab	3.08ab	3.56b
II	0.57a	0.75	0.80a	0.79a	1.99b	1.02ab
III	0.0	0.0	0.0	0.0	0.0	0.0
Total yield	**2.64a**	**3.00a**	**3.81ab**	**4.34ab**	**4.57ab**	**5.07b**

Source: own work / Źródło: opracowanie własne

Table 4. Nutritive components content in the 1st cut meadow sward in successive years of the study
Tab. 4. Zawartość składników pokarmowych w I pokosie runi łąkowej w kolejnych latach badań

Examined parameters	Without undersowing (control)		Undersowing with mixture MI		Undersowing with mixture MII	
	NPK	Manure	NPK	Manure	NPK	Manure
2014						
Total protein [g kg^{-1} DM]	97.7a	108.4ab	124.3b	124.7b	101.9a	104.2ab
Crude fibre [g kg^{-1} DM]	298.6ab	279.8a	286.7a	286.1a	310.2b	296.7ab
Crude ash [g kg^{-1} DM]	88.6	96.4	98.7	100.5	96.3	92.1
NDF [g kg^{-1} DM]	524.4ab	510.5ab	495.3a	496.9a	539.7b	517.7ab
ADF [g kg^{-1} DM]	335.6ab	318.0a	311.5ab	325.9ab	344.6b	337.9ab
ADL [g kg^{-1} DM]	40.5ab	34.6a	42.9b	39.2ab	40.4ab	41.7b
OM digestibility [%]	62.76ab	64.13b	63.07ab	63.51ab	62.06a	62.58ab
Sugars [g kg^{-1} DM]	124.0ab	150.8b	109.1a	118.8ab	107.1a	119.1ab
Sugars/total protein ratio	1.29ab	1.42b	0.88a	0.96ab	1.06ab	1.16ab
2015						
Total protein [g kg^{-1} DM]	85.0a	88.1ab	107.4ab	119.1ab	120.1b	119.2ab
Crude fibre [g kg^{-1} DM]	251.3	255.1	264.2	238.4	268.1	251.1
Crude ash [g kg^{-1} DM]	79.3	80.0	80.3	80.8	86.1	82.5
NDF [g kg^{-1} DM]	492.9	502.6	501.0	452.4	496.2	481.6
ADF [g kg^{-1} DM]	309.3	301.3	316.9	291.5	312.6	303.3
ADL [g kg^{-1} DM]	38.9b	34.7a	41.2b	38.5ab	40.9b	39.7b
OM digestibility [%]	64.81	65.43	64.12	66.19	64.54	65.27
Sugars [g kg^{-1} DM]	174.1ab	190.4b	141.4ab	167.9ab	127.5a	141.2ab
Sugars/total protein ratio	2.08b	2.17b	1.39ab	1.49ab	1.12a	1.20a

Source: own work / Źródło: opracowanie własne

Table 5. Effect of plants group in the sward on the content of nutritive components
Tab. 5. Wpływ udziału grup roślin w runi łąkowej na zawartością poszczególnych składników pokarmowych

Plants group	Total protein	Crude fibre	Crude ash	NDF	ADF	ADL	OM digestibility	Sugars	Sugars/total protein ratio
grasses	-0.36**	-0.28*	-0.34**	0.02	-0.30	-0.31*	0.30*	0.49**	0.47**
legumes	0.60**	-0.17	0.10	-0.32*	-0.13	0.34**	0.13	-0.29*	-0.48**
herbs and weeds	-0.22	0.48**	0.23	0.32*	0.49**	0.09	-0.49**	-0.28*	-0.05

* correlation coefficient significant at level α=0.05
** correlation coefficient significant at level α=0.01

Source: own work / Źródło: opracowanie własne

It is not absolute content of sugars but rather the ratio of sugars to proteins, which is important for evaluation. In analysed plant material the ratio varied from 0.88 to 2.08. Statistical analysis showed significant effect of undersowing on the ratio (tab. 4). Meadow sward from control plots had on average higher ratio of these components than the sward from undersown plots. The comparison may indicate that undersown sward is less useful for ensilage. Bodarski and Krzywiecki [31] demonstrated that increasing percent of clover in a mixture of plants linearly decreases its usefulness for ensilage. Similar effect was also noted in earlier studies on ensiling meadow plants with a high (about 30%) content of *Trifolium pratense* L. in sward [32].

3.4. Quality and relative feed value of silages

Most effective way of utilisation of meadow sward with a high content of legumes, apart from grazing by animals, is its conservation by ensilage. Silages from undersown plots had similar qualitative parameters as those obtained from control plots (tab. 6). This finding resulted from substantial share of grasses and small share of legumes (maximum 33% on one plot undersown with the MI mixture) and from preliminary drying of ensiled mass to 35-40% dry mass. As shown in studies on ensilage of meadow sward with varying proportion of *Trifolium pratense* L. [11], it is possible to obtain very good silage even at 50% share of this species. These silages, compared with those from sward devoid of clover, had higher pH, lower concentrations of lactic, acetic and propionic acids but at the same time they had higher feed value.

Based on the content of structural carbohydrates ADF and NDF one may calculate the index of relative feed value RFV, which combines digestibility and fodder uptake into one parameter [33]. The highest feed values expressed as RFV showed silages made of sward from plots undersown with the mixture of grasses and *Lotus corniculatus* L. The lowest (below 120) RFV was found for sward from plots undersown with the mixture of grasses and *Trifolium pratense* L. Low RFV was a result of the high content of NDF fraction, which decided upon theoretically lower fodder uptake (tab. 7).

Table 6. Effect of undersowing treatment and form of fertilization on silage quality (mean from 2014-2015)
Tab. 6. Wpływ podsiewu i formy nawożenia na względna wartość pokarmową kiszonki (średnio z lat 2014-2015)

Examined parameters	Without undersowing (control)		Undersowing with mixture MI		Undersowing with mixture MII	
	NPK	Manure	NPK	Manure	NPK	Manure
Dry matter, g·kg^{-1}	429.1	418.0	404.9	417.2	385.1	427.6
pH	5.15	5.20	4.96	5.14	5.01	4.96
N-NH_3 in total N, g·kg^{-1}	9.36	10.79	9.89	10.22	9.71	10.50
Lactic acid, g·kg^{-1} DM	38.99	28.35	26.53	28.12	24.92	23.89
Volatile fatty acids, g·kg^{-1} DM	66.52	54.23	52.93	51.79	44.88	54.05
Sum of fermentation products, g·kg^{-1} DM	105.50b	82.58ab	79.46ab	79.90ab	69.80a	77.94ab
Share of lactic acid in sum of fermentation products, %	35.98	33.34	33.45	34.06	34.96	31.71

Source: own work / Źródło: opracowanie własne

Table 7. Effect of undersowing treatment and form of fertilization on relative value of silage (mean from 2014-2015)
Tab. 7. Wpływ podsiewu i nawożenia na jakość kiszonki (średnio z lat 2014-2015

Examined parameters	Without undersowing (control)		Undersowing with mixture MI		Undersowing with mixture MII	
	NPK	Manure	NPK	Manure	NPK	Manure
NDF, % DM	48.16ab	47.92ab	50.29b	50.61b	45.60a	48.75ab
ADF, % DM	30.99ab	31.21ab	32.13b	31.93b	30.48a	31.34ab
Dry matter intake (% of body mass)	2.50ab	2.52ab	2.39a	2.38a	2.65b	2.48a
Digestible dry matter (%)	64.76ab	64.59ab	63.87a	64.03a	65.15b	64.48ab
Relative feed value RFV	126ab	126ab	119a	118a	134b	124ab

Dry matter intake, DMI=120/NDF; Digestible dry matter, DDM=88.9-(0.779 x ADF); Relative feed value, RFV=(DDM x DMI)/1.29

Source: own work / Źródło: opracowanie własne

4. Conclusions

1. Applied undersowing of meadows appeared a highly effective measure increasing yields and feed value of obtained biomass. Sward from undersown meadow had higher content of total protein, lower content of sugars and significantly lower sugar to protein ratio.
2. From among applied mixtures of grasses and legumes most persistent and resistant to unfavourable thermal and rainfall conditions was that with *Lotus corniculatus* L.
3. The enrichment of botanical composition of meadow sward with grasses and *Lotus corniculatus* L. exerted significant effect on the quality of silages, which had higher feed value expressed in the relative feed value index.

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