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THE EFFICIENCY OF FEEDING BEEF CATTLE USING SILAGE OF VARIOUS CONTENT OF LEGUMINOUS PLANTS

Summary

Studies were carried out in the years 2013-2015 in a private farm in Kąty (Podlaskie Province) specialising in beef cattle breeding. The aim of undertaken studies was to analyse the efficiency of feeding beef cattle using grass silage from meadow sward of different leguminous plants content. In two subsequent years (2014 and 2015) feeding experiment was performed on bull calves of Limousine race having initial body mass 359-363 kg in 2014 and 270-290 kg in 2015 divided into two groups, 9 heads in each. The factor differentiating animal feeding referred to the share of leguminous plants in experimental silages given to animals. The efficiency of feeding was compared with that used in 2013 according to long breeder's habit. Daily body weight gains of bulls, daily cost of feeding and the cost of obtaining 1 kg of body gain were evaluated. Increased share of legumes in silage resulting from grassland renovation through undersowing improved the efficiency of feeding and decreased its costs. Dosing of fodder in 2014 allowed for increasing daily body gains to 1.15 kg/head in the control group and to 1.26 kg/head in the group of cattle fed with silage containing leguminous plants. This enabled to decrease daily cost of feeding to 2.34 PLN per head and the cost of obtaining 1 kg body gains to 1.88 PLN per kg.
Key words: *beef cattle, legumes, costs of feeding, weight gain*

EFEKTYWNOŚĆ ŻYWIENIA OPASÓW Z WYKORZYSTANIEM SIANOKISZONEK Z RÓŻNYM UDZIAŁEM ROŚLIN BOBOWATYCH

Streszczenie

Badania prowadzono w latach 2013-2015 w indywidualnym gospodarstwie rolnym w miejscowości Kąty (woj. podlaskie) specjalizującym się w hodowli bydła mięsnego. Celem podjętych badań była analiza efektywności żywienia bydła opasowego z wykorzystaniem sianokiszonek z runi łąkowej z różnym udziałem roślin bobowatych. Kolejno w dwóch latach badań tj. w 2014 i 2015, przeprowadzono doświadczenia żywieniowe na buhajkach rasy Limousine o początkowej masie ciała 359-363 kg w 2014 roku i 270-290 kg w 2015 roku, podzielonych na dwie grupy po 9 sztuk. Czynnikiem różnicującym żywienie zwierząt był różny udział roślin bobowatych w sianokiszonkach doświadczalnych wchodzących w skład dawek pokarmowych opasanych zwierząt. Tłem oceny efektywności żywienia było żywienie stosowane w 2013 roku, zgodne z wieloletnimi nawykami hodowcy. Oceniano dobowe przyrosty masy ciała buhajków, dzienny koszt żywienia i koszt uzyskania 1 kg przyrostu. Zwiększenie udziału roślin bobowatych w sianokiszonce, w wyniku renowacji trwałych użytków zielonych metodą podsiewu, przyczyniło się do poprawy efektywności opasu i zmniejszenia kosztów żywienia. Wprowadzenie dawkowania pasz w 2014 roku pozwoliło na zwiększenie dobowych przyrostów masy ciał do poziomu 1,15 kg szt.$^{-1}$ w grupie kontrolnej i 1,26 kg szt.$^{-1}$ w grupie bydła żywionego sianokiszonką z udziałem roślin bobowatych. Pozwoliło to na zmniejszenie dziennego kosztu żywienia do 2,34 zł na sztukę oraz kosztu uzyskania 1 kilograma przyrostu do 1,88 zł/kg.
Słowa kluczowe*: bydło mięsne, rośliny bobowate, koszty żywienia, przyrosty masy ciała*

1. Introduction

Low profitability is one of the factors limiting beef production in Poland [1]. To improve economic efficiency, at low prices, breeders are forced to search for real possibilities of decreasing costs of production [2]. Calculations of profitability of beef production and the analysis of percent structure of unit costs indicate the importance of feeding as the most significant profitability factor [3]. Possibilities of improving the efficiency should be seen in decreasing feeding costs and increasing daily body gains due to improved quality of bulk fodder.

Fodder from permanent grasslands is the cheapest source of energy, protein, mineral components and vitamins [4]. Farm-based economic analysis of feeding made by farmers most often focuses on the price factor. Costs of fodder are often underestimated in economic calculation because of complicated economic balance and expenditures incurred on e.g. renovation of meadow and pasture sward. Final effect of applied feeding programme may be observed only based on the assessment of growth rate of animals and on monitoring technical and productive indices of breeding. Sustainable and economically rational fodder management is fundamental for efficient reduction of unit costs of breeding based on the use of fodder from permanent grasslands and (in specialised farms) also from arable lands [5].

Possibility of reducing productive costs is in many farms limited due to a lack of optimization of feeding strategy to existing farm conditions like the share of permanent grasslands and of legumes in grassland sward [6]. Practical rationalization of fodder management in a farm is difficult because of many natural and technological factors [5]. Long used, often intuitively, feeding programmes may thus appear capital-intensive from the productive point of view.

Present use of grassland productive potential is unsatisfactory [7] and possible improvements and cost reductions are associated with the improvement of botanical composition and sward enrichment in legumes [8, 9, 10] most ap-

propriately with the undersowing method [11]. Quality of fodder from permanent grasslands, including valuable proteins and energy, determines both the body gains in animals and the quality of produced meat [12, 13], so the technological and productive parameters directly affecting economic efficiency [5]. The use of low quality fodder prolongs the time of fattening and consequently results in greater use of nutritive components, worsening of meat quality [14] and in increase in feeding costs due to greater use of concentrates [15, 16]. Better utilisation of own fodder [17], despite some initial costs, definitely improve economic situation of a farm [18]. In this study we assumed that the enrichment of meadow sward in special grass varieties and legumes will improve the quality of bulk fodder, which in turn would increase the economic efficiency of feeding. The aim of undertaken studies was to analyse the effectiveness of feeding beef cattle using silages with different content of leguminous plants.

2. Material and methods

2.1. Farm characteristic

Studies were carried out in the years 2013-2015 in a farm of an area of 62 ha (including 48 ha of permanent grasslands) specialising in beef cattle breeding in Kąty (53°22′N 22°59′E), in Podlaskie Province.

Permanent grasslands in the farm were ascribed to dry ground habitats and on small hills – to impoverished dry grounds. Plant communities covering about 15-year-old meadow were classified as cock's-foot-fescue-meadow grass group *(Dactylis glomerata - Festuca rubra - Poa pratensis)* with a high percent of dicotyledons in meadow sward. Meadow grass (*Poa pratensis* L.) was the dominating species in pasture. Grass silage is produced in a form of big bales from meadow sward. Mown-pasture grasslands were used to produce hay or silage. Arable lands were used to grow cereals (market wheat and triticale) including 5 ha sown with a cereal mixture of oats and barley grown mainly as cattle fodder.

In 2012, before starting our nutritional studies, permanent grasslands in the farm were renovated with the direct undersowing method. Mixtures of tetraploid grasses and legumes adapted to habitat conditions and the way of utilisation were used for undersowing.

Farm owner specialises in breeding cattle of the *Limousine* race and keeps two bulls and 40 cows with the young (20 heifers and 20 bull calves). Both heifers and bull calves are kept on pasture during the growing season and feed with green pasture and cow's milk. In the end of the vegetation season bull calves are separated and intended for fattening while heifers are left with cows. Sale of the cattle livestock in the study period amounted 20 heads a year, mainly fattened bulls and faulty cows.

2.2. Feeding experiments

Two feeding experiments were performed in the years 2014-2015 to compare the effects of feeding beef cattle of the *Limousin*e race with doses containing grass silage. The main factor differentiating animal feeding in the study years referred to the share of legumes in silage. The efficiency of feeding was compared with that from the year 2013, when animals were fed according to long breeder's habit. Experimental animals were bull calves of the *Limousine* race of initial body mass 359-363 kg in 2014 and 270-290 kg in 2015. In both years animals were randomly divided into two groups, 9 heads in each. Control group was fed with control silage and experimental group („with clover") was fed with silage containing legumes. Each group was similar with respect to condition, age and body mass. Bull calves were fed with feed doses, whose composition resulted from real nutritive value and complied with animal demands and assumed daily gains of body mass in particular feeding periods.

Once a month during experiment, fodder samples were taken for analyses. In samples of grass silage and in silage from maize, nutritive components were determined with the NIRS [19] method using NIRFlex N-500 apparatus with ready-for-use calibrations provided by INGOT®. The content of nutritive components in concentrated fodder was taken from the tables of INRA. Nutritive value of fodders was determined according to INRA 1988 based on chemical composition and calculated with INWAR for Windows 1.6 software [20]. Feeding doses were balanced according to the INRA system [21] with the use of INRATrion software. Mean daily feed intake in nutritive doses from particular feeding periods and years are given in table 1.

Basic bulk fodder used in feeding bull calves consisted of grass silage from meadow sward differing, depending on experimental variant, in the content of legumes. Chemical composition and nutritive value of silages are presented in table 2. In basic dose (in 2013) the share of legumes (mainly the red clover) in silage amounted to about 10%. In the study years (2014 and 2015) the share of legumes in silages given to control group of animals was 2-3% while in that given to experimental group ("with clover") the total share of legumes (the red clover with a small percent of the bird's-foot trefoil) was 25-30%.

Table 1. Mean daily feeds intake (kg DM)
Tab. 1. Średnie dzienne pobranie pasz (kg sm)

Component	Feeding group				
	2013 basic	2014		2015	
		control	with clover	control	with clover
Grass silage	4.00	4.34	5.90	6.50	4.95
Maize silage	4.55	2.36	1.66	2.27	2.25
Concentrate	3.44	1.74	-	0.37	-
Urine	-	0.015	-	0.02	-
Fodder chalk	-	0.04	-	0.07	-
Monocalcium phosphate	-	-	-	0.03	0.07
Post-extraction middlings	-	1.05	-	0.03	-
Total intake of dry matter	11.99	9.54	7.56	9.29	7.27

Source: own work / Źródło: opracowanie własne

Table 2. Average nutrient concentration and nutritive value of silages used in animals feeding
Tab. 2. Skład chemiczny i wartość pokarmowa sianokiszonek stosowanych w żywieniu opasów

Components	Feeding group				
	2013 basic	2014		2015	
		control	with clover	control	with clover
Chemical composition (g kg^{-1} s.m.)					
Dry matter	469.5	611.8	423.1	607.4	378.6
Total protein	125.0	138.2	144.4	121.4	136.4
Crude ash	71.9	76.5	82.7	66.7	76.7
Crude fat	35.1	34.2	36.6	29.5	34.15
Crude fibre	296.6	300.9	275.7	282.9	276.7
NDF	523.6	582.8	518.8	581.2	500.2
ADF	343.7	348.0	322.6	329.8	323.5
Content in 1 kg of feed					
UFV	0.67	0.67	0.67	0.68	0.67
PDIN (g)	72.80	78.35	84.12	74.02	79.44
PDIE (g)	74.52	76.21	76.99	71.13	76.47

Source: own work / Źródło: opracowanie własne

In relation to demands, feeding doses contained silage from maize and concentrated fodder. Animals had permanent access to water and saltlicks. The amount of given fodder and of leftovers were determined when feeding. The latter amounted to 5% in the control group and only 1-2% of given fodder in experimental group of animals. The time of fattening was 177 days in 2014 and 247 days in 2015. In our study we predicted differentiated period of fattening, which was an outcome of natural disequilibration of animal groups and of non-feeding factors. Each feeding period was preceded by a two-week long transitory period aimed at adapting animals' intestine flora to a given type of fodder. In each feeding experiment animals were tested four or five times (every 30-48 days) for daily body gains.

2.3. Economic analysis

Economic analysis included calculation of the costs of feeding beef cattle based on given doses and on detailed information concerning animal fattening. Necessary calculations were based on monthly publication of the Institute of Agricultural and Food Economy (Agricultural Market, Analyses, Trends, Assessments), on Integrated System of Agricultural Market Information (Ministry of Agriculture and Rural Development) and on calculations of Agricultural Advisory Centres. Evaluation of used fodders was performed for their mean costs in 12 months of the year 2014 (table 3).

Table 3. Average prices adopted in determining the cost of feeding
Tab. 3. Średnie ceny przyjęte w określeniu kosztów żywienia

Forage	Price per 1 kg
Maize silage	0.08
Urine	1.64
Monocalcium phosphate	3.76
Fodder chalk	0.26
Post-extraction middlings	1.35
Grass silage	0.13
Concentrate	0.63

Source: own elaboration on Integrated Agricultural Market Information System, Agricultural Market Analysis. Tendencies of Rating IERiGŻ PIB and ODR [22]
Źródło: opracowanie własne wg Zintegrowany System Rolniczej Informacji Rynkowej, Rynek Rolny Analiz. Tendencje Oceny IERiGŻ PIB i ODR [22]

Presented studies cover the years 2013-2015 but 2014 was selected to minimise the effect effect of varying market prices in subsequent years. Based on obtained results, the daily mean cost of feeding and the cost of body masse increase by 1 kg in the whole fattening period were calculated.

3. Results

Feeding cattle observed in 2013 represented less effective and traditional way of feeding. Nutritive doses given in this year based on silage, ensiled maize and on concentrated fodder (table 1). Daily body weight gains measured in control weighing were only 0.91 kg (table 4).

Introduction of fodder dosing according to animal demands (irrespective of the type of silage) in 2014 allowed for increasing daily body weight gains to 1.15 kg in the control group and to 1.26 kg in the group fed with grass silage with legumes (table 4). This evidenced a remarkable increase in animal growth rate. The year 2015 was definitely worse with respect to grassland productivity in Poland. Unfavourable production conditions were reflected in fodder quality in the farm (table 2), which may explain a decrease in daily body weight gains to about 1 kg (table 4). However, despite less favourable conditions in this year, mixtures with a high percent of legumes gave the daily rate of fattening higher by 0.08 kg compared with the control group.

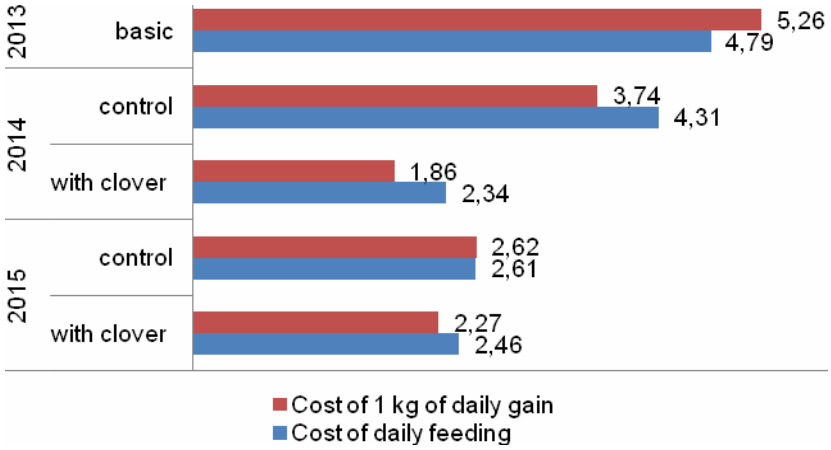
Introduction of grass silage with legumes in the years 2014 and 2015 allowed also to simplify applied balanced doses acc. to the INRA system (table 1). It was possible to eliminate concentrated fodder since grass silage and silage from maize fully covered animal demands for nutritive components.

The efficiency of beef cattle breeding is determined in 65-70% by feeding [16]. The enrichment of meadow sward in legumes increased the quality of bulk fodder but also improved productive effects of animals fed with such a fodder. Juszczyk and Rękojerski [5] are of the opinion that the use of good quality own fodder decreases the costs of animal production. Increasing the share of legumes in silage obtained from undersown permanent grassland decreased the costs of feeding and markedly improved the efficiency of fodder area in the farm. Hence, we succeeded in limiting the costs of obtaining 1 kg of body gains to 1.86 PLN and daily cost of feeding to 2.34 PLN/head in 2014 (fig. 1).

Table 4. Results of feeding experiments
Tab. 4. Wyniki testów żywieniowych

	Feeding group									
	2013 basic		2014				2015			
			control		with clover		control		with clover	
	mean	*SD*	mean	*SD*	mean	*SD*	mean	*SD*	mean	*SD*
Initial body weight, kg	317	*60*	363	*73*	359	*78*	290	*40*	270	*26*
Final body weight, kg	523	*115*	565	*123*	581	*101*	534	*58*	542	*48*
Weight body gain, kg	206	*99*	202	*57*	222	*30*	244	*28*	272	*34*
Period of feeding, days	226	-	177	-	177	-	247	-	247	-
Daily body weight gains, g per head^{-1}	910	*0.19*	1150	*0.32*	1260	*0.17*	990	*0.11*	1100	*0.14*

Source: own work / Źródło: opracowanie własne



Source: own work / Źródło: opracowanie własne

Fig. 1. Costs of daily feeding and obtaining 1 kg of body gain in following periods of feeding
Rys. 1. Dzienny koszt żywienia i uzyskania 1 kg przyrostu w kolejnych okresach żywienia

The presence of red clover and bird's-foot trefoil in silage provided notable economic and productive effects. Studies repeated in 2015 confirmed observed tendencies in terms of compared costs. The use of mixtures with a high content of red clover enabled to reduce unit costs of body gains and feeding to 2.27 and 2.46 PLN, respectively. Definitely higher differences were observed in favourable conditions of the vegetation season 2014. As shown in fig. 1, optimisation of nutritional doses through effective undersowing of grass mixtures with high legume content and dosing fodder according to animals' demands allows for important reduction in the costs of body gains from 3.74 to 1.86 PLN (i.e. by as much as 1.88 PLN per kg).

4. Summary

The farm in Kąty specialised in breeding beef cattle of the *Limousin* race has sufficient area of grounds to provide feeding based mainly on own feed base. Permanent grasslands occupy 48 ha of farm area and may entirely cover the needs of cattle herd. Sward from permanent meadows was mainly used to produce silage in big bales and hay or silage were obtained from mown and grazed areas. Cereals and maize intended for cattle fodder were grown on arable lands.
Nutritional studies initiated in 2013 illustrated less effective and traditional way of cattle feeding used in many farms. Changes in the feeding system were possible due to grassland renovation performed before, to the improvement of bulk fodder quality and to introduction of fodder dosing in order to their more rational utilisation. Renovation of permanent grasslands through the enrichment of sward in legumes improved the quality of obtained fodder and increased their potential utilisation by animals. The presence of legumes in sward allows for obtaining higher protein yields from unit area [10] and for decreasing fertilisation with mineral nitrogen fertilisers [23]. Decreasing costs of fertilisation and the improved utilisation of fodder with legumes thanks to its better palatability and nutritive value improved economic effects of the farm, which was also found by Goliński [6]. Similar benefits from increased share of legumes in sward were noted by Radkowski and Radkowska [9].

Better utilisation of permanent grasslands, especially in the unfavourable economic climate, enabled partial diversification of plant production and sale of cereals thus improving economic efficiency. Appropriate and adapted to productive possibilities balancing of doses with red clover in silage allowed for replacing fairly expensive fodder components, which definitely affected unit costs of production.

5. Conclusions

Dosing fodder in accordance with norms regarding their nutritive value and animals' demands, irrespective of the share of legumes in silage, allows for significant increasing in daily body gains in fed animals through better feed utilisation. All this may also shorten the productive cycle

Application of silage with legumes in feeding beef cattle allowed for eliminating concentrates and increasing in daily body gains from 0.91 kg to 1.26 kg per head.

The use of silage with legumes reduced both the cost of obtaining 1 kg daily body gain and daily cost of feeding by about 50%.

Enrichment of grassland sward in legumes and its application in feeding beef cattle as well as better utilisation of fodder area and own fodder sources may really reduce the costs of beef production.

6. References

[1] Litwińczuk Z., Grodzki H.: Stan hodowli i chowu bydła w Polsce oraz czynniki warunkujące rozwój tego sektora. Przegląd Hodowlany, 2014, 6, 1-5.

[2] Balcerak M.: Ekonomiczne aspekty hodowli bydła mięsnego. Bydło Mięsne, 2014, 1, 28-32.

[3] Jabłonka K., Kałuża H., Marcysiak A., Nawrocki T., Szarek S.: Ekonomika w rolnictwie. REA, 2006, Warszawa.

[4] Juszczyk S.: Poszukiwanie możliwości obniżania kosztów w gospodarstwach mlecznych. Zeszyty Naukowe Przeglądu Hodowlanego, 2002, 65, 75-80.

[5] Juszczyk S., Rękojarski M.: Koszty bezpośrednie pasz łąkowo-pastwiskowych w gospodarstwach mlecznych województwa Łódzkiego. Roczniki Nauk Rolniczych, 2007, Seria G, T 94, Z 1, 35-45.

[6] Goliński P.: Ekonomiczne aspekty wykorzystania motylkowatych na użytkach zielonych. Biul. Nauk. ART Olsztyn, 1998, 1, 59-74.

[7] Jankowska-Huflejt H., Domański J. P.: Aktualne i możliwe kierunki wykorzystania trwałych użytków zielonych w Polsce. Woda Środowisko Obszary Wiejskie, 2008, 8, 2, 31-49.

[8] Terlikowski J.: The effect of permanent grassland sward enrichment with special varieties of grasses and legumes on the quality of produced bulk fodder. J. Res. Appl. Agric. Engng, 2014, 59 (4), 107-110.

[9] Radkowski A., Radkowska I.: Wartość pokarmowa kiszonek sporządzanych z runi łąkowej o zróżnicowanym udziale koniczyny łąkowej oraz wpływ ich skarmiania na przyrosty masy ciała buhajków i jałówek rasy Limousine. Rocz. Nauk. Zoot., 2014, 41, 2, 129-137.

[10] Bojarszczuk J., Staniak M., Harasim J.: Produkcyjność mieszanek pastwiskowych z udziałem roślin motylkowatych w ekologicznym systemie gospodarowania. J. Res. Appl. Agric. Engng, 2011, 56 (3), 27-35.

[11] Barszczewski J., Jankowska-Huflejt H., Mendra M.: Renowacja trwałych użytków zielonych. Materiały Informacyjne, 2015, 42. Wydaw. ITP Falenty, 20.

[12] Lee M.R.F., Evans P.R., Nute G., R., Richardson R.I. Scollan N.D.: A comparison between red clover silage and grass silage feeding on fatty acid composition, meat stability and sensory quality of the *M. Longissimus* muscle of dairy cull cows. Meat Science, 2009, 81 (4) 738-744.

[13] Lee M.R.F., Harris L.J., Dewhurst R.J., Merry R.J., Scollan N.D.: The effect of clover silages on long chain fatty acid rumen transformations and digestion in beef steers. Animal Science, 2003, 76, 491-501.

[14] Kim, E. J., Dawson, J. M., Buttery, P. J., Scollan, N. D.: Performance responses and body composition of beef cattle fed grass silage based diets. An overview. In D. Pullar (Ed.), Beef from grass and forage, 2000, BGS occasional symposium No. 35, 91–95.

[15] Bilik K. Węglarzy K., Choroszy Z.: Wpływ intensywności żywienia buhajków rasy Limousin na wskaźniki produkcyjne i właściwości dietetyczne mięsa. Rocz. Nauk. Zoot., 2009, 36, 1, 63-73.

[16] Litwińczuk Z., Żółkiewski P., Chabuz W., Florek M.: Przyrosty dobowe i wartość rzeźna buhajków opasanych paszami z trwałych użytków zielonych i kiszonką z kukurydzy z uwzględnieniem wartości pokarmowej skarmianych pasz. Roczniki Naukowe Polskiego Towarzystwa Zootechnicznego, 2013, 9, 4, 27-35.

[17] Westreicher-Kristen E., Blank R., Schulz F., Susenbeth A.: Replacing maize silage with red clover silage in total mixed rations for dairy cows: In vitro ruminal fermentation characteristics and associative effects. Animal Feed Science and Technology, 2017, 7, 131-141.

[18] Jarka S.: Analiza czynników wpływających na efektywność gospodarstw mlecznych. Acta Oeconomica, 2007, 6(4), 13-18.

[19] PN-EN ISO 12099: Pasze, ziarno zbóż i produkty przemiału – Wytyczne stosowania spektrometrii bliskiej podczerwieni, 2013, 38.

[20] Kowalski M.Z. Kański J.: WINWAR ver 1.30. Komputerowy program wspomagający wyliczenie wartości pokarmowej pasz według systemu INRA 1988. 1993, AR Kraków.

[21] Praca zbiorowa. Normy żywienia bydła, owiec i kóz. Wartość pokarmowa pasz dla przeżuwaczy. Opracowanie według INRA (1988), 2001, Instytut Zootechniki, Kraków, 218.

[22] Seremak Bulge J.: Rynek rolny. 2013-2014, IERiGŻ - PIB Warszawa.

[23] Barszczewski J., Wasilewski Z., Terlikowski J., Jankowska Huflejt H., Wróbel B.: Standardy gospodarowania na łąkach i pastwiskach niżowych w gospodarstwach nieobjętych programem rolnośrodowiskowo-klimatycznym. Wydawnictwo ITP Falenty, 2014, 72.

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