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USEFULNESS OF SELECTED INTENSIVE VARIETIES OF SHORT-DURATION GRASSES FOR MEADOW RENOVATION ON ALLUVIAL SOILS WITH THE DIRECT UNDERSOWING METHOD

Summary

Undersowing is a method of supplementing and enriching species composition of grasslands without interfering in soil habitat. The method brings about an increase of grassland biodiversity and allows for maintaining many local ecotypes of fodder grasses in meadow sward. The aim of the study was to assess the effect of enrichment of meadow sward through direct undersowing short-term intensive grass varieties of high fodder value on the quality of produced fodder. The experiment was set up on a meadow of simplified floristic composition on alluvial soil in drying riparian habitat in Żuławy Elbląskie. Two weeks before undersowing the meadow was sprayed with herbicide Fernando 225 EC at a dose of 3 l·ha^{-1}. Undersowing was made in the end of September 2012. Assessment of fodder quality from sward undersown with special mixtures was performed in the years 2013-2015 according to RFV index. Obtained results showed that tetraploid varieties Lolium perenne, Lolium×boucheanum and Festulolium braunii, which constituted 5 – 25% of the sward, and the frequency of mowing were the main factors affecting fodder quality. The use of Lolium×boucheanum and Festulolium braunii significantly improved the quality of produced fodder and thus increased the potential milk production from 1 ha of undersown meadow.
***Key words**: grasslands, undersowing, fodder quality from grasslands*

PRZYDATNOŚĆ WYBRANYCH, INTENSYWNYCH ODMIAN KRÓTKOTRWAŁYCH GATUNKÓW TRAW DO RENOWACJI ŁĄKI METODĄ SIEWU BEZPOŚREDNIEGO W WARUNKACH GLEB ALUWIALNYCH

Streszczenie

Podsiew to metoda polegająca na uzupełnieniu i wzbogaceniu składu gatunkowego zbiorowisk trawiastych bez głębszej ingerencji w środowisko glebowe. Powoduje więc wzrost bioróżnorodności zbiorowisk trawiastych, pozwalając na utrzymanie w runi wielu wartościowych, lokalnych ekotypów traw pastewnych. Celem pracy była ocena wpływu wzbogacenia runi łąkowej metodą podsiewu bezpośredniego krótkotrwałymi, intensywnymi odmianami traw o wysokiej wartości pastewnej na jakość produkowanej paszy. Doświadczenie statyczne założono na łące o uproszczonym składzie florystycznym w warunkach Żuław Elbląskich, położonej na glebie aluwialnej w posusznym siedlisku łęgu zgrądowiałego. Dwa tygodnie przed wykonaniem podsiewu zastosowano oprysk odchwaszczający preparatem Fernando 225 EC - 3 l·ha^{-1}. Podsiew wykonano w trzeciej dekadzie września 2012 roku. Ocena wartości pokarmowej paszy z runi podsianej specjalistycznymi mieszankami, prowadzona w latach 2013-2015 według wskaźnika RFV wykazała, że decydującym czynnikiem o jakości paszy były: stosowane do podsiewu tetraploidalne odmiany Lolium perenne, Lolium×boucheanum i Festulolium braunii, stanowiące łącznie 5-25% udziału w runi oraz częstotliwość koszenia podsianej łąki. Wykorzystanie Lolium×boucheanum i Festulolium braunii wpłynęło na poprawę jakości produkowanej paszy w istotny sposób podnosząc potencjalną produkcję mleka w przeliczeniu na 1 ha podsianej łąki.
***Słowa kluczowe**: użytki zielone, podsiew, jakość paszy z użytków zielonych*

1. Introduction

Floristic composition of grasslands is one of the main indices determining the nutritive value of meadow sward. In nearly optimum meteorological conditions it is possible to maintain for a long time the species composition desired in view of produced fodder. However, due to unfavourable natural conditions or errors made by the user, floristic composition becomes simplified or even degraded as a result of disappearance of some valuable plant species. They are replaced by species of lower utility value like dicotyledon herbs and weeds, which sometimes may become dominants [2]. Habitat degradation is a secondary phenomenon resulting from unfavourable changes of factors affecting the growth and development of vegetation. In such circumstances meadow sward needs to be improved. After application of selective herbicides, meadow sward does not often need radical methods of renovation and direct undersowing may appear sufficient. Undersowing consists in supplementing and enriching species composition of grasslands without deep interference in soil habitat. This measure increases biodiversity of grassland communities and helps maintaining many valuable local ecotypes of fodder grasses in meadow sward. This way impoverished sward may be enriched with special grass varieties adapted to habitat conditions and the type of meadow management [6].

Competition enforces farmers to produce fodder of high nutritive value at the lowest cost [9]. Recent technological progress made undersowing an easily available method of increasing the richness of meadows and pastures in newest

intensive grass varieties. Therefore, it should not be classified as the method of grassland renovation [6]. It should rather be dealt with as a nurturing measure repeated regularly every 3 to 4 years.

Soil moisture is an important factor affecting the success of undersowing in Żuławy Wiślane [5, 11]. The period of seed germination and rapid initial growth of young seedlings depends on good (optimum) and possibly long soil moisture. The sum and distribution of precipitation and hence soil moisture are quite variable among years, which is the factor out of our control.

The aim of this study was to assess the effect of enrichment of meadow sward in short-term, intensive grass varieties of high fodder value with the direct undersowing method on the quality of produced fodder.

2. Material and methods

Studies were initiated in 2012 in Helenowo situated in Żuławy Elbląskie on alluvial soil in drying riparian habitat. The experiment was set up on meadow of simplified floristic composition with the random block method in four repetitions according to scheme presented in table 1. The sward before undersowing was dominated by *Dactylis glomerata* L. and *Phleum pratensis* L. with a small share of *Festuca pratensis* (Huds), *Elymus repens* L. and *Poa pratensis* L. Grasses constituted 65 - 70% of plant cover, dicotyledons – about 30 - 35%, and legumes were present in trace amounts. Two weeks before undersowing the sward was sprayed with selective herbicide Fernando 225 EC at a dose of 3 $l \cdot ha^{-1}$. Undersowing was made in the end of September 2012.

Mineral fertilisation applied in the years 2013-2015 included: phosphorus in a single dose of 40 kg $P \cdot ha^{-1}$ applied in spring, potassium in amount of 100 kg $K \cdot ha^{-1}$ applied in two equal doses in spring and in the middle of the growing season. Fertilisation with nitrogen was differentiated into: N1 – 30 $kg \cdot ha^{-1}$ applied under the regrowth and N2 – 40 $kg \cdot ha^{-1} \cdot cut^{-1}$ (according to amount of cuts in the year). Doses of particular nutrients are presented in table 1.

Short-term tetraploid varieties of: the perennial rye-grass (*Lolium perenne* L.), Italian rye-grass (*Lolium multiflorum* Lam.), intermediate rye-grass *Lolium* x *boucheanum* Kunth), and inter-genus hybrid *Festulolium braunii* (K. Richt., A. Camus) were selected for this study. Grass mixtures of two components from those listed above (perennial rye-grass and intermediate rye-grass or perennial rye-grass and the hybrid *Festulolium braunii*) were used in ½ of the norm to undersow the meadow mown 4 times. For undersowing meadows mown 3 times, grass mixtures were composed of three grasses (tab. 1) in 1/3 of the norm for each. Fifty percent of the seeding norm i.e. 20 $kg \cdot ha^{-1}$ were used when undersowing with every mixture. Two meadows with old sward of simplified composition dominated by the cock's foot (*Dactylis glomerata* L.) and timothy grass (*Phleum pratense* L.) mown 3 and 4 times served as a control (tab. 1).

Meadow is situated 0.40 m b.s.l. on very heavy alluvial soil underlined with loose sand (8F bc·pl). Soil characteristics are presented in table 2.

Available forms of phosphorus and potassium in soil were determined with the Egner-Riehm method. Magnesium was analysed with atomic adsorption spectrophotometry according to the method by Schachtschabel. Floristic composition was estimated with botanical-gravimetric method and utility value of meadow sward (Lwu) was calculated according to Filipek [4]. Utility value given in a 10-grade scale was determined based on botanical composition, percentage share of each species and the numbers of utility value attributed to every species.

Table 1. Experimental scheme
Tab. 1. Schemat doświadczenia założonego w 2012 roku na łące trwałej w Helenowie

Treatment	Undersown species and their varieties	Cut number	Fertilization
1	*Lolium perenne* var. Jaran *Festulolium braunii* var. Sulimo	4	N1PK
2	*Lolium perenne* var. Jaran Życica mieszańcowa var. Nadzieja	4	N1PK
3	*Lolium perenne* var. Jaran *Lolium* x *boucheanum* var. Nadzieja, *Festulolium braunii* var. Sulimo	3	N2PK
4	*Lolium perenne* var. Jaran *Festulolium braunii* var. Sulimo, *Lolium multiflorum* var. Turtetra	3	N2PK
5 - control	natural sward (old)	3	N2PK
6 - control	natural sward (old)	4	N1PK

Source: own study / *Źródło:* opracowanie własne

Table 2. Physical and chemical soil characteristics of experimental field in Helenowo
Tabela 2. Charakterystyka fizykochemiczna gleby na doświadczeniu w Helenowie

Depth [cm]	Bulk density [$g \cdot cm^{-1}$]	pH 1 N KCl	Concentration of available components [$mg \cdot kg^{-1}$ s.m. soil]		
			P	K	Mg
0-20	1,295 (blok A i B)	4,88	42	411	50
	1,269 (blok C i D)	5,29	31	327	52
21-40	1,315 (blok A i B)	5,36	45	206	52
	1,307 (blok C i D)	5,32	39	243	48
41-60	1,307 (blok A i B)	6,31	43	111	17
	1,378 (blok C i D)	6,33	23	79	21

Source: own study / *Źródło:* opracowanie własne

Plant material was collected from each plot and cut for the analyses of dry mass, total protein, crude fibre and its fractions (neutral detergent fibre NDF and acid detergent fibre ADF), raw ash, carbohydrates and crude fat with the NIRS method using NIRFlex N-500 apparatus and ready-to-use calibrations of the firm INGOT®. Obtained results were used to qualitatively assess fodder from sward enriched with special grass varieties by undersowing. Assessment was performed with the test of Linn and Martin [7]. Classifying parameter was the relative feed value calculated from the equation:

$$RFV = (DDM \cdot DMI) : 1.29 \quad (1)$$

where: RFV- relative feed value (dimensionless)

DDM - digestibility of dry mass calculated from the equation:

$$DDM = (88.9-0.779) \cdot ADF\ [\%] \quad (2)$$

DMI – dry mass ingestion calculated from the equation:

$$DMI = 120 : NDF\ [\%] \quad (3)$$

Fodder from grasslands, whose relative feed value exceeds 151 is recommended for best cows of the highest milking efficiency while that of RFV between 125 and 151 is recommended for good cows and young heifers selected for reproduction.

Feed value of sward was also estimated with the indirect method based on potential amount of milk obtained from produced fodder per 1 ha. Feed value was calculated from net energy of lactation NEL and based on the assumption that if 1 kg of dry mass of fodder contains 3.17 MJ of NEL, then the amount of energy will be sufficient to produce 1 kg of milk of 4% fat content [3].

Meteorological conditions

Meteorological conditions in 2012 (undersowing performed in September this year) and in the years 2013-2015 are presented in table 3.

Monthly sums of atmospheric precipitation and monthly mean temperatures in vegetation season were analysed and compared with the long-term means. Hydrothermal coefficient of Sielianinow [1] was used for detailed assessment of thermal and rainfall conditions:

$$k = \frac{P \cdot 10}{\sum t} \quad (4)$$

where: P – monthly sum of atmospheric precipitation [mm]

Σ t – sum of daily means of air temperature > 0^0C

Moisture characteristics for the vegetation season was determined acc. to Skonera and Puła [10] and presented in table 4.

Table 3. Meteorological conditions during experimental period
Tab. 3. Warunki meteorologiczne w okresie prowadzenia badań

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average/sum***	
Year													IV-IX	Year
Temperature [^{o}C]														
2012**	-08	-6,1	4,2	8,3	14,1	15,7	19,2	18,5	14,4	8,5	x	x	15,0	x
2013**	-3,5	-0,1	-1,5	7,1	15,6	18,0	18,7	18,9	13,0	10,2	x	x	15,2	x
2014**	x	x	x	9,1	12,0	13,8	20,0	16,8	14,1	9,3	x	x	13,6	x
2015**	x	x	x	6,6	10,8	13,9	16,4	19,8	13,7	6,8	x	x	13,6	x
1971-1995*	-1,9	-1,6	1,8	6,2	11,9	15,0	17,0	16,7	12,6	8,1	3,0	0,0	13,2	7,4
Precipitation [mm]														
2012**	59,8	31,8	22,2	33,0	18,4	82,6	88,2	38,1	27,9	37,6	x	x	288,2	x
2013**	33,5	14,9	7,5	26,8	40,9	37,8	95,2	34,1	14,7	39,2	x	x	249,5	x
2014**	x	x	x	28,2	52,8	92,9	29,2	54,3	29,8	12,8	x	x	300,0	x
2015**	x	x	x	66,1	30,6	37,2	68,6	12,2	96,7	23,0	x	x	334,4	x
1971-1995*	17,3	12,7	16,6	22,6	40,4	67,6	66,7	71,5	70,1	47,9	38,5	25,8	338,9	484,6

Source: own elaboration based on / *Źródło:* opracowanie własne na podstawie

*- data from the Sea Branch of Institute for Meteorology and Water Management in Gdynia / dane z Oddziału Morskiego IMGW w Gdyni; **- data from meteorological station of Żuławy Branch of Institute of Technology and Life Sciences in Helenowo near Elbląg / dane ze stacji agrometeorologicznej ITP ŻOB w Helenowie; ***- "average" values concern temperatures and "sum" – precipitations / średnia opadów

Table 4. Pluviotermic conditions in Helenowo during growing season 2012-2015
Tab. 4. Warunki pluwiotermiczne w okresie wegetacji w 2012-2015 roku w Helenowie

Month	IV	V	VI	VIII	VIII	IX	X
2012							
Sielianinov coeficient	1,32	0,42	1,75	1,48	0,66	0,64	1,42
Moisture characteristics	optimum	very dry	enough wet	optimum	very dry	very dry	optimum
2013							
Sielianinov coeficient	1,26	0,85	0,70	1,64	0,58	0,38	1,25
Moisture characteristics	rather dry	dry	very dry	enough wet	very dry	extremely dry	rather dry
2014							
Sielianinov coeficient	1,04	1,41	2,24	0,35	1,05	0,70	0,45
Moisture characteristics	rather dry	optimum	wet	extremely dry	rather dry	very dry	very dry
2015							
Sielianinov coeficient	3,32	0,91	0,89	1,35	0,20	2,35	1,09
Moisture characteristics	extremely wet	dry	dry	optimum	extremely dry	wet	rather dry

Source: own study / *Źródło:* opracowanie własne

Rainfall conditions (tab. 4) were not favourable for sprouting and initial growth of grass seeds introduced to meadow sward. Drought before undersowing in September 2012 lasted nearly 2 months. Nevertheless, sprouting of undersown grasses was observed in the end of October because rainfall conditions were optimal in this time (tab. 4). Rainfalls in spring 2013 were also optimal and exerted positive effect on the development and yielding of undersown grasses. Dry or extremely dry weather in August and September of this year limited biomass increments of the last cut. In 2014 optimum thermal and water conditions occurred only in the spring months. Summer drought limited plant growth and made 3rd out of 4 cuts impossible. Vegetation season of the year 2015 started after dry and snowless winter. Low water resources in soil from winter retention brought about restricted increase of yields and summer drought further decreased yielding of undersown meadow sward.

3. Results and discussion

Spraying with selective herbicide Fernando 250 EC made in the beginning of September 2012 eliminated dicotyledons, which constituted 30 – 35% of meadow sward. Undersowing with simplified grass seed mixtures filled the gaps in sward that remained after elimination of weeds. As a result of unfavourable meteorological conditions in August and September 2012 and in the vegetation seasons 2013 – 2015 (tab. 4), undersown special grass varieties amounted from 5 to 25% of sward (tab. 5). Nevertheless, sward from all variants showed very high utility value Lwu [4]. Undersowing with special grass varieties in unfavourable thermal and water conditions in the year of sowing and later only slightly improved the utility value of meadow sward. Spraying with selective herbicide was the factor that might directly affect the improvement of the Lwu index. Spraying eliminated much of weeds, which in large amounts decrease the utility value of meadow sward. Moreover, the index elaborated and published in 1973 may now raise some doubts as to the assessment of sward because it does not consider recent achievements in growing fodder grasses.

An assessment of feed value of enriched sward calculated acc. to the RFV index (figs. 1-3) showed that the frequency of mowing, apart from applied special grass varieties, was a decisive factor. According to Linn and Martin's test [7], sward mown 4 times gave fodder of the value, which fulfils demands requested in feeding cows of high milking efficiency (RFV > 151). Lower values of RFV were noted only in the 3rd cut in the years 2013 and 2015. From sward mown three times, fodder of lower nutritive value (RFV 125-151) was obtained in the 1st and 2nd cut but only in 2013. In the next two years RFV exceeded 151 because of increased share of undersown grasses. Fodder of the highest value of RFV was obtained from meadows mown both three and four times during the last autumn cut in all study variants.

Distinct differentiation was demonstrated in the RFV value among subsequent cuts of undersown and control meadows mown both three and four times in the three study years.

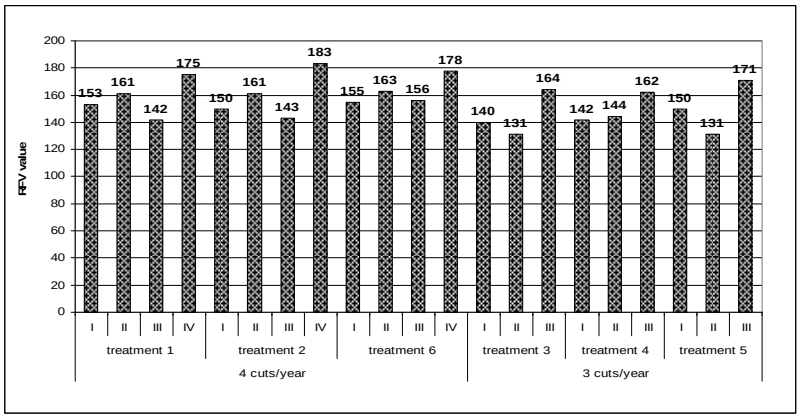
Practical and economic index that may indirectly assess feeding value of bulk fodder for ruminants is the potential amount of milk produced from that fodder calculated per 1 ha. Studies showed that nutritive value of fodder depended on seed mixture used for undersowing and to a less extent on the frequency of mowing (fig. 4).

Unfavourable thermal and water conditions in the study period could be one of the main factors decreasing the differences in potential milk production between swards cut 3 and 4 times. Higher feed value of fodder obtained from sward cut 4 times was the reason why, despite lower dry mass yields per ha, potential milk production summed over the three-years-long study period was similar to that estimated for sward mown three times.

Table 5. Helenowo 2013 - sward composition in 2013-2015 [*in %*]
Tab. 5. Wskaźnik wilgotności gleby (SMI) w okresie wegetacji w latach 2013-2015 w Helenowie

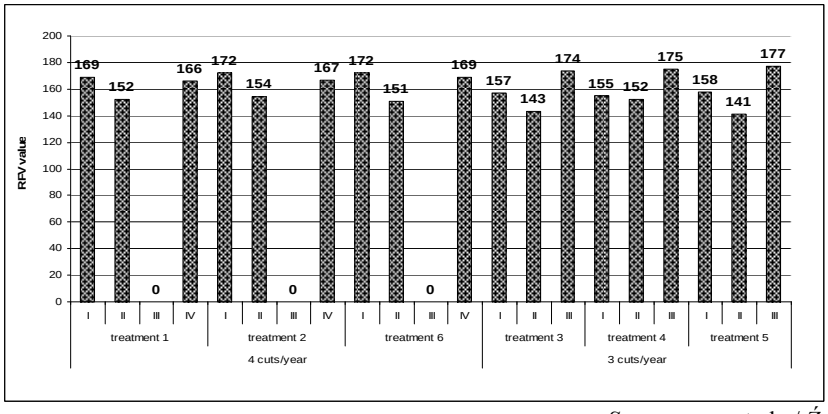
Number of cuts	3 cuts/year			4 cuts/year		
Treatment	5	4	3	6	2	1
2013						
Species in old meadow sward	97	87	90	92	78	82
Undersown grass species	-	10	5	-	7	8
Papilionaceae together	-	-	-	-	-	-
Dicotyledonous together	3	3	5	8	15	10
Utility value of meadow sward Lwu	8,81	8,89	8,84	8,72	8,52	8,79
2014						
Species in old meadow sward	95	71	73	80	67	86
Undersown grass species	-	24	25	-	18	9
Papilionaceae together	-	-	-	-	-	-
Dicotyledonous together	5	5	2	20	15	5
Utility value of meadow sward Lwu	9,25	9,59	9,35	8,20	8,34	8,77
2015						
Species in old meadow sward	87	72	84	82	80	82
Undersown grass species	-	14	5	-	7	8
Papilionaceae together	-	-	-	+	+	-
Dicotyledonous together	13	14	11	18	13	10
Utility value of meadow sward Lwu	8,45	8,32	8,64	8,27	8,78	8,66

Source: own study / *Źródło:* opracowanie własne



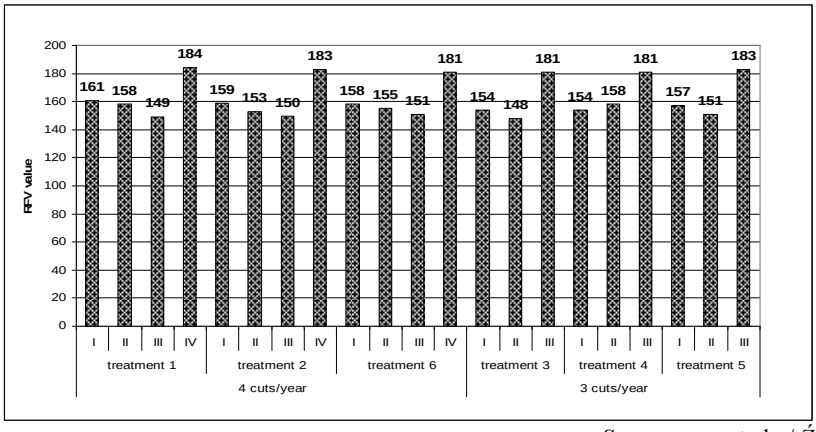
Source: own study / *Źródło:* opracowanie własne

Fig. 1. Relative feed value index (RFV) of undersown sward in particular harvests Helenowo 2013
Rys. 1. Wskaźnik względnej wartości pokarmowej RFV runi badanych łąk z poszczególnych pokosów w 2013 roku



Source: own study / *Źródło:* opracowanie własne

Fig. 2. RFV of undersown sward in particular harvests Helenowo 2014
Rys. 2. Wskaźnik względnej wartości pokarmowej RFV runi badanych łąk z poszczególnych pokosów w 2014 roku

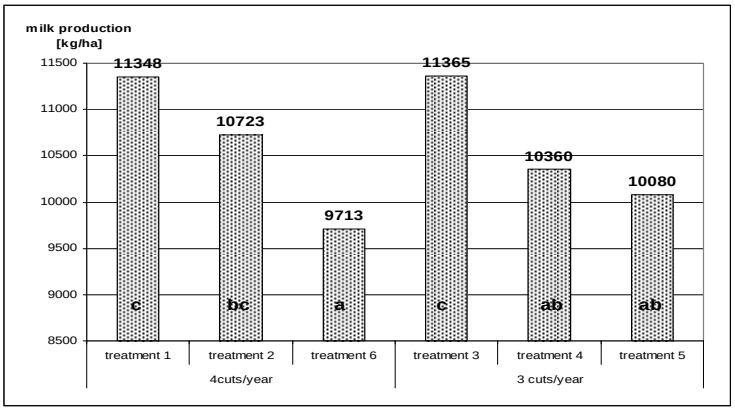


Source: own study / *Źródło:* opracowanie własne

Fig. 3. RFV of undersown sward in particular harvests Helenowo 2015
Rys. 3. Wskaźnik względnej wartości pokarmowej RFV runi badanych łąk z poszczególnych pokosów w 2015 roku

Noteworthy are significant differences in the quality of produced fodder converted into potential milk production among mixtures of grass seeds used in undersowing. Mixtures of perennial rye-grass var. Jaran with *Festulolium braunii* var. Sulimo and perennial rye-grass var. Jaran with intermediate rye-grass var. Nadzieja allowed for obtaining significantly higher potential milk production per ha compared with fodder produced from control sward (fig. 4).

In meadows mown three times, significantly higher potential milk production per ha was obtained from sward undersown with a mixture composed of the perennial rye-grass var. Jaran, intermediate rye-grass var. Nadzieja and *Festulolium braunii* var. Sulimo. Application of a mixture of the perennial rye-grass var. Jaran, *Festulolium braunii* var. Sulimo and Italian rye-grass var. Turtetra did not significantly improve potential milk production with fodder from undersown meadow. Results of the study indicate that positive effect on the quality of fodder produced from sward of meadows situated on alluvial soil in drying riparian habitat had the application of the mixture of intermediate rye-grass var. Nadzieja with *Festulolium braunii* var. Sulimo.



Source: own study / *Źródło:* opracowanie własne

c, **bc**… - repartition into basic and homogeneous groups by Tukey's test

Fig. 4. Potential milk production in period 2013-2015 using feed produced from undersown meadow
Rys. 4. Suma potencjalnej produkcji mleka z okresu 2013-2015 z paszy podsianej łąki w Helenowie

At present, available technical possibilities of enrichment of meadow sward with most valuable grass varieties using direct undersowing allow for repeating this measure every 3 – 4 years. The decreased intensity of management and systematic drying of habitats due to intensive drainage is one of the basic reasons of grassland degradation in Żuławy [11]. Therefore, regular enrichment of sward with the use of undersowing, even at a high risk [5], in newest varieties of fodder grasses and their hybrids and mowing the meadows 4 times may markedly improve the quality of bulk fodder for ruminants.

4. Conclusions

1. A great usefulness was demonstrated of enrichment of meadow sward growing on alluvial soil in drying riparian habitat with a mixture of the intermediate rye-grass var. Nadzieja, *Festulolium braunii* var. Sulimo and perennial rye-grass var. Jaran undersown in simplified mixtures of 2 – 3 components.
2. Systematic (every 3 - 4 years) enrichment of such sward, even at a risk of unfavourable thermal and water conditions, with intensive tetraploid grass varieties may significantly improve the quality of bulk fodder for ruminants.

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