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THE USEFULNESS OF INTER-SPECIES HYBRIDS WITHIN THE COMPLEX *Lolium-Festuca* FOR UNDERSOWING MEADOWS IN ŻUŁAWY ELBLĄSKIE

Summary

The aim of this study was to preliminarily assess the effect of enrichment of meadow sward through direct undersowing with hybrids of grasses from the Lolium-Festuca complex on their share in sward a year after treatment and on the quality of produced fodder. Studies started in 2016 in Helenowo (Żuławy Elbląskie) on permanent meadow situated on alluvial soil. The meadow was dominated by Dactylis glomerata (L). and Poa pratensis (L.) with a small share of Festuca pratensis (Huds.), Elymus repens (L.) and Phleum pratensis (L.). The meadow was undersown with selected varieties of two hybrids: Festulolium braunii (var. Paulita+Felopa and Perun) and Festulolium pabulare (var. Brečva and Hykor). After initially good sprouting, seedlings of studied Festulolium varieties started to die out. The highest resistance to unfavourable pluvio-thermal conditions was found in Perun variety, smaller – in varieties Brečva and Hykor and the lowest in Paulita+Felopa varieties sown in a mixture (25% of complete sowing each). The yield of undersown meadow sward in the year of treatment depended mostly on floristic composition of sward and only slightly – on selected Festulolium variety. Natural composition of sward and the frequency of mowing were the main factors affecting nutritive value of sward. Potential milk production from fodder of studied sward was 12.4 thous. kg · ha^{-1} when meadow was mown 4 times and 11.3 thous. kg · ha^{-1} at 3-time mowing.
***Key words**: inter-genus grass hybrids, complex Lolium-Festuca, direct undersowing*

PRZYDATNOŚĆ WYBRANYCH MIESZAŃCÓW MIĘDZYGATUNKOWYCH W OBRĘBIE KOMPLEKSU *Lolium-Festuca* DO PODSIEWU ŁĄK W WARUNKACH ŻUŁAW ELBLĄSKICH

Streszczenie

Celem pracy była wstępna ocena wpływu wzbogacenia runi łąkowej przez podsiew bezpośredni odmianami mieszańców międzyrodzajowych traw w obrębie kompleksu Lolium-Festuca na ich udział w runi w okresie roku po dokonaniu zabiegu oraz jakość produkowanej paszy. Badania rozpoczęto w 2016 roku na Żuławach Elbląskich w miejscowości Helenowo, na łące trwałej położonej na glebie aluwialnej, w której dominowały: Dactylis glomerata L. i Poa pratensis L. z niewielkim udziałem Festuca pratensis (Huds.), Elymus repens L. Phleum pratensis L. Do podsiewu łąki wykorzystano wybrane odmiany dwóch mieszańców: Festulolium braunii (odm. Paulita+Felopa oraz Perun) i Festulolium pabulare (odm. Brečva i Hykor). Po dobrych wschodach, w wyniku pogarszania się warunków pluwiotermicznych, zaobserwowano zamieranie – z różną intensywnością - siewek badanych odmian Festulolium. Największą odporność na niekorzystne warunki pluwiotermiczne, wykazała odmiana Perun, mniejszą natomiast - odmiany Brečva i Hykor, najmniejszą zaś wysiane w mieszance (po 25% pełnego wysiewu) odmiany Paulita+Felopa. Stwierdzono, że plonowanie łąki w roku jej podsiewu, było zależne głównie od składu botanicznego runi, zaś w niewielkim – od doboru podsianej odmiany Festulolium. Głównym zaś czynnikiem decydującym o wartości pokarmowej pasz z runi badanej łąki w roku wykonanego podsiewu była częstotliwości jej koszenia oraz naturalny skład florystyczny runi. Potencjalna produkcja mleka z paszy badanej runi w użytkowaniu 4-kośnym wynosiła ok. 12,4 tys. kg · ha-1, zaś w 3-kośnym – ok. 11,3 tys. kg · ha-1.
***Słowa kluczowe**: mieszańce międzygatunkowe traw, kompleks Lolium-Festuca, podsiew bezpośredni*

1. Introduction

Degradation of sward in permanent grasslands is observed in all habitats, most often in insufficiently wet, post bog and dry ground lowland sites fed mainly by rainfall. Deficits of precipitation in the vegetation period make soils of such habitats extremely dry. Soil degradation is also enhanced by abandoned fertilisation and limited mowing, especially when the second and third cut are not executed [8]. Habitat degradation is a secondary phenomenon being a consequence of unfavourable factors affecting growth and development of vegetation [3].

Fast and even sprouting does not always guarantee proper development of seedlings. EDWARDS et al. [5] underline that the period from grass sprouting to the beginning of branching is most critical in their development, more important than the sprouting itself. Sometimes, after initially good sprouting the seedlings rapidly start to die out [2, 6, 15]. Their survival is mainly determined by abiotic factors like water, temperature, light and nutrients. Die-out of seedlings after undersowing is mostly observed in summer months due to prevailing droughts and intensive competition from vegetation of the primary sward [7].

Market competition enforces farmers to produce valuable fodder at the lowest costs [10]. Technological progress of the recent years has made direct undersowing an easily available method of enrichment of grassland sward in the newest intensive varieties of grasses and legumes. Therefore, undersowing should not be classified as a method of grassland restoration but rather as a nursing treatment repeated regularly every 3-4 years [9].

Effective fodder production for herbivorous animals at drought stress in summer and thermal stress in winter is possible thanks to *Festulolium* hybrids [13]. One of the most important inter-genus grass hybrids within *Lolium-Festuca* complex is *Festulolium braunii* obtained from cross-breeding of autotetraploid forms of meadow fescue with the Italian ryegrass in a combination of *Festuca pratensis* (2n = 4x = 28) x *Lolium multiflorum* (2n = 4x = 28) [14]. Varieties of *Festulolium braunii* (K. Richt.) are valuable components in mixtures on alternate grasslands and may even be used for renovation of permanent meadows [13, 17, 18]. High nutritive value and a great yield-forming potential of these hybrids give a chance of decreasing production costs of milk and beef [15].

The aim of the study was to preliminarily assess the effect of enrichment of meadow sward through direct undersowing with inter-genus grass hybrids from the *Lolium-Festuca* complex on their share in sward a year after treatment and on the quality of produced fodder.

2. Material and methods

Studies started in 2016 in Helenowo (Żuławy Elbląskie) on alluvial soil. Two-factor experiment was set up on a meadow of simplified botanical composition with the random block method in three repetitions. Before undersowing the sward was dominated by *Dactylis glomerata* (L.) and *Poa pratensis* (L.) with a small share of *Festuca pratensis* (Huds), *Elymus repens* (L.) and *Phleum pratensis* (L.). Grasses constituted about 60 – 90% of plant cover in total, dicotyledons – 10-40% and legumes were present in trace amounts. Analysis of the first cut was performed with botanical-gravimetric method. Subsequent cuts were analysed with the Klapp's method and the autumn cut in 2016 was analysed with the simplified botanical-gravimetric method by separating undersown *Festulolium* varieties from the remaining biomass of the sample. Undersowing was made on 7-8th April 2016 with the row system. Undersowing system consisted in manual cutting of rows of a cross-section of regular 3 cm triangle spanned by 20 cm in experimental plot. After placing seeds of studied grass species, the rows were filled with local soil.

Applied mineral fertilisation included: phosphorus in a single dose of 40 kg·ha^{-1} applied in spring and potassium (100 kg·ha^{-1}) applied in two equal doses in spring and in the middle of the vegetation season. Undersown sward was mown three or four times. Therefore, nitrogen fertilisation was differentiated into N1 (30 kg·ha^{-1} under each regrowth) used in meadow mown four times and N2 (40 kg·ha^{-1}) used in meadow mown three times. An experimental scheme of combinations of *Festulolium* hybrids and varieties used in undersowing is presented in table 1.

The meadow is situated on polder „Fiszewka F" 0.40 m below sea level on shallow very heavy alluvial soil underlined by loose sand (8F bc·pl). Soil characteristics are presented in table 2. Available forms of soil phosphorus and potassium were determined with the Egner-Riehm's method, those of magnesium – with the Schachtschabel's method following AAS measurements. Floristic composition was assessed with botanical-gravimetric method and with the Klapp's method and utility value of sward (E_{GQ}) was estimated after Novák [11].

Ground water table in experimental area was controlled with the use of four piesometres. In spring 2016 ground water table varied from 80 to 105 cm below ground and systematically decreased during the vegetation season. In September ground water table was at 142-168 cm below ground. Thus, ground water table depths and the structure of soil profile indicate that the demands of meadow sward for water were satisfied by atmospheric precipitation.

Table 1. Scheme of experiment on permanent meadow in Helenovo
Tab. 1. Schemat doświadczenia na łące trwałej w Helenowie

Object	Variety of *Festulolium*	Cross combination	Cultivar
1	*F. brauni*	*Festuca pratensis x Lolium multiflorum*	Paulita+Felopa
2	*F. pabulare*	*Lolium multiflorum (2x) x Festuca arundinacea var. genina (6x)*	Brečva
3	*F. pabulare*		Hykor
4	*F. brauni*	*Lolium multiflorum x Festuca pratensis*	Perun
5 - control	Natural (old) sward mown 3times in the growing season		-
6 - control	Natural (old) sward mown 4times in the growing season		-

Source: own study / Źródło: opracowanie własne

Table 2. Phisical and chemical characteristic of soil on experimental field in Helenovo
Tab. 2. Charakterystyka fizykochemiczna gleby w warunkach doświadczenia w Helenowie

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

Source: own study / Źródło: opracowanie własne

Meteorological conditions in the year of undersowing and in the preceding year are presented in table 3.

Monthly sums of atmospheric precipitation and monthly mean temperatures in the vegetation season were analysed and compared with long-term means. Mean air temperature in the vegetation season of 2016 was higher than the long-term mean by about 1^{o}C. Sum of precipitation for the same period was lower by about 42% than the long-term mean. Selianinow's hydro-thermal coefficient [1] was used for detailed assessment of pluviometric conditions:

$$k = \frac{P \cdot 10}{\sum t},$$

where: P - monthly sum of atmospheric precipitation [mm], Σ t - sum of daily mean air temperatures > 0^{o}C

Moisture characteristics for the vegetation season were determined after Skonera and Puła [16] and are presented in table 4.

Table 3. Meteorological conditions (means: 24 hours temperature and sums of precipitations) during experiment
Tab. 3. Warunki meteorologiczne (średnie dobowe wartości temperatury i sumy opadów) w okresie prowadzenia badań

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Average / Sum	
Year													IV-IX	Year
Temperature [°C]														
2015**	x	x	x	6,6	10,8	13,9	16,4	19,8	13,7	6,8	x	x	13,53	
2016**	x	x	x	6,2	15,0	17,7	18,6	17,6	15,5	7,8	x	x	15,10	
1971-2010*	-	-	-	7,8	12,7	15,6	17,7	17,5	13,2	8,4	-	-	14,08	-
Precipitation [mm]														
2015**	x	x	x	66,1	30,6	37,2	68,6	12,2	96,7	23,0	x	x	311,4	
2016**	x	x	x	43,4	45,8	55,2	15,5	50,5	19,3	57,0	x	x	229,7	
971-2010*	-	-	-	35,3	54,9	75,3	83,3	77,8	68,2	56,0	-	-	394,8	-

Source: own work based on:
*- data from the Sea Branch of Institute for Meteorology and Water Management in Gdynia
**- data from meteorological station of Żuławy Branch of Institute of Technology and Life Sciences at Helenowo near Elbląg

Table 4. Pluviotermic conditions in Helenovo during growing seasons 2015 and 2016
Tab.4. Warunki pluwiotermiczne w okresie wegetacji w 2015 i 2016 roku w Helenowie

Month	IV	V	VI	VII	VIII	IX	X
2015							
Sielianinov's coeficient	3,34	0,91	0,89	1,35	0,66	0,20	2,35
Moisture characteristic	extremely wet	dry	dry	optimum	very dry	extremely dry	wet
2016							
Sielianinov's coeficient	2,33	0,98	1,04	0,28	0,93	0,42	2,36
Moisture characteristic	wet	dry	dry	extremely dry	dry	very dry	wet

Source: own study / Źródło: opracowanie własne

Thermal and moisture conditions in the beginning of growth were favourable for undersown seeds of *Festulolium* varieties. Large water capacity of heavy alluvial soil provided optimum moisture of the upper soil layer and suitable conditions for sprouting of undersown grasses. Unfortunately, the period from sprouting till the beginning of branching was most critical for undersown grasses (tab. 4). After initially good sprouting, seedlings of *Festulolium* varieties were observed to die out. The greatest resistance to unfavourable pluvio-thermal conditions was found in *Perun* variety and slightly lower – in *Brečva* and *Hykor*. The least resistance to pluvio-thermal conditions showed a mixture of *Paulita+Felopa* varieties (tables 4 and 5).

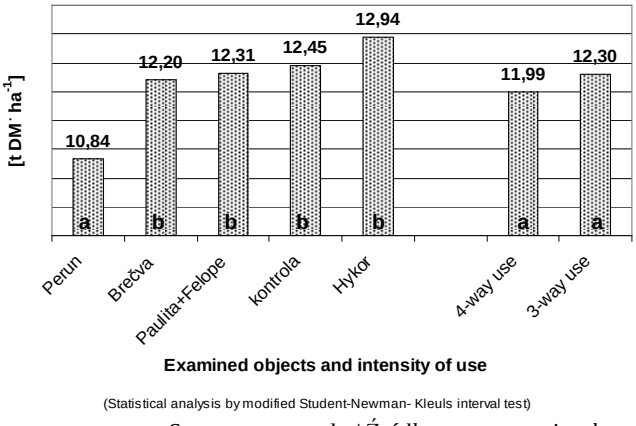
Botanical-gravimetric analysis of last cuts of sward in 2016 showed clear differentiation of the contribution of undersown *Festulolium* varieties (table 5). The best effect of undersowing was noted for *Perun* variety, especially when sown into a sward mown three times (29% share). Other varieties had smaller, several percent share in yielded biomass. The meadow where the experiment was situated abuts on arable land where the soil and water conditions are similar. Hence, considerable share of dicotyledonous species - typical for arable fields – in the meadow sward. It was noticed trace share of legumes and absence of sedges.

According to grassland score assessment [11], utility value (UV) of sward in all plots mown four times (table 5) ranged from valuable to very valuable (E_{GQ} 70-90). The value of sward mown three times was in the same range. The only exception was the control plot, whose score (E_{GQ} 50-70) was assessed as valuable to less valuable.

Noteworthy, some plant species present in sward in more than 3% share may decrease nutritive value of fodder or be harmful for fed animals as shown by Novák [11]. Higher share of these plant species was noted in some studied plots mown three times (table 5).

3. Sward yielding

Yield assessment was performed in two ways: in relation to applied *Festulolium* variety and to the frequency of mowing in the vegetation season (fig. 1). No significant difference was found in yields of sward mown three and four times. Significantly lower dry mass yields per hectare were, however, noted in plots undersown with *Perun* variety compared with those undersown with other *Festulolium* varieties despite positive effects of undersowing with the former one. The reason of lower yielding should not, however, be sought in the variety but rather in natural floristic composition of studied plot. A high (25%) share in sward undersown with *Perun* variety had the chickweed (*Stellaria media* L.), which probably exerted significant, though random, effect on yielding. No significant differences were found in yielding between other plots and the control.



Source: own study / Źródło: opracowanie własne

Fig. 1. Yielding of meadow sward undersown with selected varieties of Festulolium. Helenowo 2016
Rys. 1. Plonowanie runi łąkowej w roku wykonania zabiegu podsiewu bezpośredniego odmianami mieszańców Festulolium brauni i Festulolium pabulare

Table 5. Floristic composition of sward undersown with seeds of *Festulolium* varities. Helenowo 2016
Tab. 5. Skład florystyczny podsianej runi wybranymi odmianami Festulolium. Helenowo 2016

Object	4 cuts					3 cuts				
	1	2	3	4	6	1	2	3	4	5
Festulolim variety	4	6	10	16	0	2	4	4	29	0
Festuca rubra (L.)	5	0*	3	-	-	0	-	0	-	-
Festuca pratensis Huds.	-	-	5	-	-	0	-	3	3	-
Dactylis glomerata (L.)	51	15	41	20	39	61	18	38	8	25
Agrostis gigantea Roth	-	-	1	-	-	-	-	-	-	-
Elymus repens (L.) Gould	4	10	9	5	3	3	11	6	20	3
Arrhenatherum elatius (L.)	-	-	0	-	-	18	-	9	-	-
Bromus hordeaceus (L.)	-	-	0	-	-	-	-	3	2	-
Phleum pratense (L.)	-	9	2	8	16	2	14	7	3	5
Poa pratensis (L.)	33	45	23	22	14	8	19	6	20	32
Poa annua (L.)	-	-	-	-	-	-	0	-	-	-
Alopecurus pratensis (L.)	0	-	-	-	22	0	-	-	-	0
Lolium perenne (L.)	-	1	0	4	-	-	20	2	1	-
Share of grasses	97	86	94	75	94	94	86	78	86	65
Trifolium repens (L.)	0	-	0	-	-	0	0	-	-	-
Plantago lanceolata (L.)	-	0	-	-	-	-	-	-	-	-
Heracleum sphondylium (L.)	0	-	-	-	0	-	-	-	-	-
Heracleum sibiricum (L.)	3	2	0	-	-	0	0	-	-	-
Glechoma hederacea (L.) [**!]****	-	0	0	-	-	-	-	-	0	-
Melandrium album Garcke	0	-	0	-	0	-	-	0	0	26
Stachys annua (L.)	-	-	-	-	-	-	-	-	0	-
Viola arvensis Murr.	0	1	1	-	-	0	0	1	0	1
Stellaria media (L.)Vill.	0	2	3	25	1	-	-	12	14	0
Geranium pusillum (L.)		0	-	-	-	-	-	0	-	-
Ranunculus repens (L.)	-	-	-	-	-	-	-	-	0	1
Lamium purpureum (L.) [!]	0	0	**2**	0	**1**	-	0	0	0	0
Chenopodium polyspermum (L.)	-	-	0	-	-	-	-	-	-	-
Achillea millefolium (L.)	0	0	-	-	0	-	-	-	-	0
Papaver rhoeas (L.)	-	-	0	-	-	-	-	-	-	-
Tripleurospermum maritimum (L.)	0	0	0	-	4	0	13	0	0	0
Sonchus arvensis (L.)	0	0	0	0	0	0	-	0	-	-
Taraxacum officinale F.H. Wigg.	0	0	0	0	0	0	-	0	0	0
Myosotis arvensis (L.)	0	0	0	0	0	-	0	2	0	1
Veronica arvensis (L.)	0	-	-	-	0	0	1	-	-	4
Erigeron canadensis (L.)	-	0	-	0	0	-	-	-	0	-
Polygonum aviculare (L.)	0	0	0	0	0	-	0	0	0	-
Cerastium holosteoides Fr. em. Hyl.	0	0	-	0	0	-	0	0	-	0
Matricaria chamomilla (L.)	0	0	0	-	0	-	-	-	-	-
Rorippa sylvestris (L.)	-	-	-	-	-	-	0	0	-	-
Rumex crispus (L.). [!]	0	0	0	0	0	-	-	-	-	-
Capsella bursa-pastoris (L.) Medik. [!]	0	0	0	0	0	**4**	0	**7**	0	**2**
Anthriscus sylvestris (L.)	0	9	-	-	0	2	-	0	-	-
Share of *Dicotyledoneae*	3	14	6	25	6	6	14	22	14	35
UV by Novák	87,5	84,3	84,0	73,1	86,3	84,1	80,00	70,1	75,5	64,5

Notes: * 0 – vestigial share; ** [!] - in case of share > 3% fodder can be harmful or its feeding value can be lower

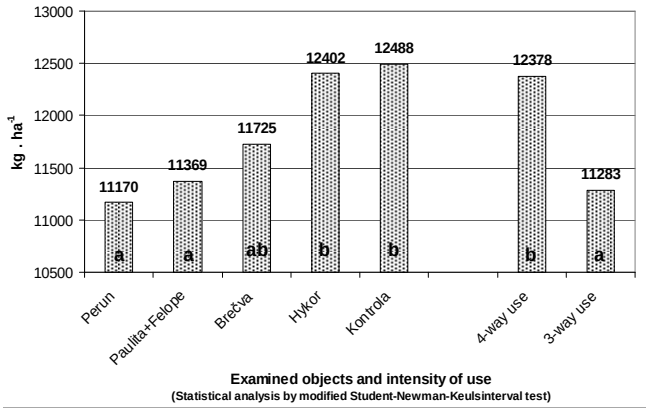
Source: own study / Źródło: opracowanie własne

4. Assessment of fodder value of sward

Fodder value of sward was estimated based on potential milk production per ha from fodder obtained from undersown sward. Calculation was based on NEL and according to the assumption that if 1 kg of dry mass of fodder contains 3.17 MJ-NEL then energy concentration is sufficient to produce 1 kg of milk of 4% fat content [4].

Assessment of nutritive value of fodder showed significant differentiation of potential milk production in relation to the frequency of mowing and to *Festulolium* variety used for undersowing (fig. 2). In 2016 the effect of undersown *Festulolium* variety on nutritive value of meadow sward (decisive for potential milk production) was small.

The share of *Festulolium* varieties in sward at the end of the vegetation season varied from several to fifteen or so percent (table 5). Hence, natural floristic composition and the frequency of mowing was the main factor affecting the nutritive value of sward from analysed meadow. Potential milk production from meadow mown four times was 12.4 thous. kg ha^{-1} while from that mown three times it was about 11.3 thous. kg · ha^{-1}.



Source: own study / Źródło: opracowanie własne

Fig. 2. Potential milk production from fodder produced from meadow sward undersown with selected varities of Festulolium. Helenowo 2016

Rys. 2. Potencjalna produkcja mleka z runi łąkowej w roku wykonania zabiegu podsiewu bezpośredniego odmianami mieszańców Festulolium brauni i Festulolium pabulare

5. Summary

Studies started in 2016 in Helenowo (Żuławy Elbląskie) on permanent meadow situated on alluvial soil. Vegetation was dominated by *Dactylis glomerata* L. and *Poa pratensis* L. with a small contribution of *Festuca pratensis* (Huds.), *Elymus repens* L. and *Phleum pratensis* L. Selected varieties of two hybrids: *Festulolium braunii* (var. *Paulita+Felopa* and *Perun*) and *Festulolium pabulare* (var. *Brečva* and *Hykor*) were used in the study. After initially good sprouting, seedlings of *Festulolium* varieties started to die out.

Preliminary assessment of the effect of sward enrichment through direct undersowing with inter-genus grass hybrids within the *Lolium-Festuca* complex showed the highest resistance of *Perun* variety to unfavourable pluviothermal conditions present in 2016 during sprouting and initial growth phases. *Brečva* and *Hykor* varieties were less resistant. *Paulita+Felopa* varieties undersown in mixtures of 25% of complete doses, were most sensitive to unfavourable conditions.

According to score evaluation of grassland quality, utility value of the sward in studied plots mown three and four times (with the exception of control plot mown three times) ranged from valuable to very valuable (E_{GQ} 70-90). The main factor affecting utility value of meadow sward should not be sought in the variety of undersown *Festulolium* variety but in floristic composition of sward intended for undersowing.

Yield assessment was performed in relation to applied *Festulolium* variety and to the frequency of mowing in the vegetation season. No significant difference was found in yields of sward mown three and four times. Differentiation of yielding observed in the year of treatment depended on floristic composition of undersown sward and to a slight degree – on the variety of undersown grass.

The effect of undersown *Festulolium* varieties on nutritive value of fodder from studied meadows in the year of undersowing was low due to small contribution of applied varieties in meadow sward. The main factor decisive for nutritive value of sward from analysed meadows was related to the frequency of mowing and natural floristic composition. Potential milk production from meadow mown four times was 12.4 thous. kg ha^{-1} and from that mown three times it was 11.3 thous. kg · ha^{-1}.

Preliminary assessment of the usefulness of selected varieties of inter-genus hybrids from the *Lolium-Festuca* complex indicates that *Perun*, *Brečva* and *Hykor* varieties were most suitable for undersowing meadows on heavy alluvial soils in Żuławy Elbląskie at drought stress.

6. References

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