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STABILITY AND PRODUCTIVITY ASSESSMENT OF LEGUME-GRASS MIXTURES USED FOR RENOVATION OF ORGANIC GRASSLANDS ON ORGANIC SOILS

Summary

Botanical composition and dry mass yielding of meadow (M) and pasture (P) mixtures (designed – M1 and P1, market – M2 and P2, control, simplified – M3 and P3) and species or varieties (Dactylis glomerata – M4 and Lolium perenne (4n)– P4) intended for organic grasslands on mud-peat-muck organic soils were studied in the years 2006–2010. Pasture mixtures were mown 5 times a year and meadow mixtures – 3 times a year. The smallest changes were observed in mixtures P1 and M1. Most stable in pasture management were: Poa pratensis, Phleum pratense, Festuca rubra while Festuca pratensis, Agrostis gigantea and Trifolium repens retreated from sward. Lolium perenne and L multiflorum maintained a high share for 4 years of experiment. Most stable on meadows were: Poa pratensis and Festuca rubra and Lolium perenne. Legumes Trifolium hybridum and T. pratense retreated while T. repens maintained 10% share for 2 years. Percentage share of Dactylis glomerata was very large for 2 years and large for the next two years similarly to the share of Festuca pratensis and Phleum pratense. Dry mass yields depended more on thermal and moisture conditions than on the type of mixture but the largest dry mass yield for 4 study years was obtained from meadow designed M1 mixture - Festuca pratensis (19%), Festuca arundinacea (20%), Phleum pratense (20%), Dactylis glomerata (5%), Poa pratenis (13%), Festuca rubra (10%), Trifolium hybridum (8%), Trifolium pratense (5%). Observed disappearance of differences resulting from the composition of sown mixtures. However, proper selection of species and varieties and multi-species composition of mixtures may slow down this process in subsequent years due to diverse developmental dynamics of particular components.
***Key words**: grass-legume mixtures, productivity, organic meadows, botanical composition, renovation*

OCENA TRWAŁOŚCI I PRODUKCYJNOŚCI MIESZANEK TRAW I MOTYLKOWATYCH DROBNONASIENNYCH DO RENOWACJI EKOLOGICZNYCH UŻYTKÓW ZIELONYCH NA GLEBACH ORGANICZNYCH

Streszczenie

W latach 2006-2010 badano skład botaniczny i plonowanie (s.m.) mieszanek łąkowych (Ł) i pastwiskowych (P): zaprojektowanych Ł1 i P1, handlowych Ł2 i P2, kontrolnych (uproszczonych) Ł3 i P3 oraz gatunków i odmian wskaźnikowych Ł1 (Dactylis glomerata) i P4 (Lolium perenne (4n), przeznaczonych na użytki ekologiczne na glebie organicznej. Mieszanki pastwiskowe koszono 5-krotnie, a łąkowe 3-krotnie. Najmniejsze zmiany zaszły w mieszankach zaprojektowanych - P1 i Ł1. W użytkowaniu pastwiskowym najtrwalsze były Poa pratensis, Phleum pratense, Festuca rubra, a wypadły Festuca pratensis, Agrostis giganthea oraz Trifolium repens. Lolium perenne oraz L. multiflorum utrzymywały się z dużym udziałem przez 4 lata użytkowania. W użytkowaniu łąkowym najtrwalsze były Poa pratensis, Festuca rubra i Lolium perenne. Wypadły Trifolium hybridum, T. pratense, natomiast T. repens utrzymywała się z ok. 10% udziałem przez 2 lata. Udział Dactylis glomerata był bardzo duży przez 2 lata i duży - przez następne 2 lata, podobnie Festuca Pratensis i Phleum pratense. Plony s.m. bardziej zależały od warunków termicznych i wilgotnościowych niż od rodzaju mieszanki, jednak największe plony s.m. za 4 lata badań, dała mieszanka zaprojektowana Ł1 - Festuca pratensis (19%), Festuca arundinacea (20%), Phleum pratense (20%), Dactylis glomerata (5%), Poa pratenis (13%), Festuca rubra (10%), Trifolium hybridum (8%), Trifolium pratense (5%). Zaobserwowano zanik różnic wynikających ze składu wysianych mieszanek. Jednakże właściwy dobór gatunków i ich odmian do mieszanek oraz wielogatunkowość mieszanek ze względu na zróżnicowaną dynamikę rozwoju różnych komponentów w kolejnych latach użytkowania spowalnia ten proces.
***Słowa kluczowe**: mieszanki trawiasto-motylkowate, produktywność, łąki ekologiczne, skład botaniczny, odnawianie*

1. Introduction

The worsening of botanical composition of grassland sward, particularly that inappropriately fertilised and managed is the problem often encountered in agricultural practise . Valuable grass and legume species retreat and are replaced by species of worse utility value. Degradation is particularly enhanced on peat-muck soils due to proceeding mucking and mineralization of organic matter and worsening air and water conditions [7]. Renovation of species composition of such communities is necessary in such circumstances. An important element decisive for positive effects of renovation is The selection of species (and varieties) adapted for the system and type of grassland utilisation is an important element decisive for positive effects of renovation. Plant breeding aims at improving grassland stability and ability to exploit the natural yield-forming potential of organic soils [13]. This is especially desired in organic farming in which „mineral nitrogen fertilisers are not used” (art. 12, par. 1e, EU Decree no 834/2007 of 28 June 2007) and legumes are the main source of nitrogen. The amount of nitrogen fixed symbiotically by various small-seeded legume plants is estimated at 31 - 86 kg $N \cdot t^{-1}$ of dry mass of sward [6].

The aim of this study was to assess the stability and productivity of selected grass and legume species and varieties used in mixtures sown in organic farms oriented to the quality and stability of grasslands.

2. Methods

Studies were performed on more than 100 cm thick mud-peat-muck MtIIcc(b) organic soil in Experimental Farm of the Institute of Technology and Life Sciences in province Podlaskie in the years 2006 – 2010. The experiment was set up on permanent meadow with the complete cultivation method in autumn 2005 in a random block system on 15 m^2 (1.5 m wide) plots with four replications. In the year of sowing no mineral fertilisation was applied and in the next years, according to the rules of organic farming, the experiment was fertilised with P_2O_5 (50 kg ha^{-1} in spring in a form of phosphorite) and K_2O (30 kg ha^{-1} in spring and summer each, ¾ of the dose in a form of potassium sulphate and ¼ in a form of karnalite). Grasslands were rolled in spring. The study object was mixtures designed specifically for meadow (*Festuca pratensis, Festuca arundinacea, Phleum pratense, Dactylis glomerata, Poa pratenis, Festuca rubra, Trifolium hybridum, Trifolium pratense*) and pasture (*Festuca pratensis, Phleum pratense, Dactylis glomerata, Agrostis gigantea, Poa pratensis, Festuca rubra, Lolium perenne, Trifolium repens*) (M1 and P1, respectively) assessed together with market mixtures M2 (*Lolium perenne, Phleum pratense, Festuca pratensis, Festuca arundinacea, Poa pratenis, Trifolium hybridum, Agrostis gigantean)* and P2 (*Lolium perenne* and *L. Multiflorum, Festuca pratensis, Festuca rubra, Poa pratensis, Trifolium repens*), control simplified mixtures (M3 - *Phleum pratense, Trifolium repens* and P3 - *Poa pratensis, Lolium perenne, Trifolium repens*) and indicator species (M4 - *Dactylis glomerata* and P4 - *Lolium perenne*) – (Tables 2 and 3) acc. to methods of the Research Centre for Cultivar Testing (COBORU) [5]. The sowing rate for particular species was taken from Polish Norms (Tables 2 and 3). Meadow sward was mown 3 times a year and pasture sward – 5 times a year (simulated grazing).

The study involved: changes of botanical composition of the I cut (estimation method) and dry mass yield. Ground water depths were measured every ten days. The year 2006 was dealt with as a nursing one and in 2010, due to excessive soil moisture, pasture sward was mown only 4 times.

Ground water depth in the years 2007 and 2009 in the experimental area was optimum for grasses and ranged from 32-40 to 80 cm i.e. to the maximum allowable drainage depth for these soils [7]. In 2007 severe ground frosts occurred almost every day till 20 April and in 2009 – till the end of April. In 2008 ground water depth varied between 24 cm (beginning of the vegetation season) and 84 cm (September) while in 2010 meadows were long inundated and only in July the ground water table dropped to the depth of 42-53 cm (tab. 1).

3. Results and discussion

3.1. Floristic composition of sward

Pasture mixtures. In comparison with the composition of sown mixtures, botanical structure changed already in the first (the so-called nursing) year of study (2006).The share of *Festuca rubra*. decreased and the share of *Lolium perenne* increased in P1, P2 and P3 mixtures. The share of *Trifolium repens* decreased from 15 and 25% in sown mixtures to 4-5% in the sward. Severe ground frost in 2007 resulted in decreased share of sown grasses, mainly *Festuca pratensis*, *Festuca rubra* and the *Phleum pratense* L.. Only *Poa pratensis* increased its share up to 66% in P3 mixture. Sown legumes *Trifolium repens* in mixture P1 and in mixture P3 were reduced to trace amounts. Alien (not sown in mixtures) grass species appeared in the sward and weeding increased to nearly 16% in market P2 mixture. In the year 2009 changes in denser sward were smaller, weeding slowed down and amounted to 10-20%. Still large (31-47%) was the share of *Lolium perenne* but in the model object with *Lolium perenne* (P4) it decreased almost by half. In this year an important component of all mixtures was *Poa pratensis* which constituted 25% of P1 mixture, 20.7% of P2 mixture, 55% of P3 mixture and was abundant in model object (P4) where it appeared spontaneously.

Fast proceeding sward degradation manifested itself in 2010. *Poa pratensis* contributed in 40% to the sward of all plots irrespective of whether it was sown in a mixture or not. *Dactylis glomerata*, *Agrostis gigantea* and *Festuca pratensis* disappeared almost totally whereas *Phleum pratense* and *Festuca rubra* remained, especially in P2 (12%). Plots were gradually invaded by spontaneous species like *Poa pratensis* and *Poa annua* with the admixture of *Holcus lanatus*. Due to long inundation, the share of weeds (mainly of *Ranunculus repens* L. resistant to excessive moisture) increased. On the day of fourth harvest (the last in such conditions) weeds constituted 50% of sward.

Table 1. Ground water depths in experimental area (cm)
Tab. 1. Poziom wody gruntowej (cm) na doświadczalnej powierzchni

Year	Ten-day period	Vegetation season					
		April	May	June	July	August	September
2007	I	50	66	71	40	59	60
	II	46	50	80	51	40	47
	III	60	70	72	64	55	54
2008	I	26	58	76	58	72	64
	II	24	62	77	66	53	68
	III	47	66	74	77	63	84
2009	I	42	68	79	60	59	71
	II	32	71	51	64	70	71
	III	66	73	59	70	76	79
2010	I	9	30	13	49	23	9
	II	30	16	15	42	26	14
	III	40	5	21	53	15	17

Source: own study

Table 2. Floristic composition of pasture mixtures (1^{st} cut)

Tab. 2. Skład florystyczny mieszanek pastwiskowych (I pokos)

Mixture/model species (seed rate kg ha^{-1})		Share in sowing %	Share in yield of the 1^{st} cut, %			
			2006*	2008	2009	2010
P1. designed	*Festuca pratensis* Huds. cv. Skra (56)	10	12	2	+	+
	Phleum pratense L. cv. Skala (24)	15	12	5	15	12
	Dactylis glomerata L. cv. Areda (32)	8	15	4	12	2
	Agrostis gigantea Roth cv. Mieta (10)	5	3	1	+	+
	Poa pratensis L. cv. Duna +Skiz (24)	(17 + 7) 24	10	38	25	43
	Festuca rubra L. cv. Atra (28)	13	3	2	3,3	6
	Lolium perenne L. cv. Argona (56)	10	35	32	31	5
	Trifolium repens L. cv. Astra (16)	15	4	+	0,2	2
	Alien grasses (mainly *Poa pratensis*, *Poa annua*)	-	2	1	0,5	1
	Herbs and weeds	-	4	15	13	28
P2. market	*Lolium perenne* L. 4N and *L. multiflorum*	45	60	48	47	9
	Festuca pratensis Huds.	15	15	4	5,5	1
	Festuca rubra L.	10	5	10	6,2	10
	Poa pratensis L.	15	5	20	20,7	38
	Trifolium repens L.	15	4	+	0,2	7
	Alien grasses (mainly *Poa pratensis*, *Poa annua*)	-	3	2	0,2	2
	Herbs and weeds	-	8	16	20	33
P3. simplified	*Poa pratensis* L. cv. Skiz (24)	40	10	66	55	48
	Lolium perenne L.cv. Mikado (56)	35	80	20	31,8	10
	Trifolium repens L. cv. Riesling (16)	25	5	+	+	2
	Alien grasses	-	1	2	3	4
	Herbs and weeds	-	4	12	10,2	36
P4 model species	*Lolium perenne* L. 4n cv. Baristra (56)	100	98	82	58,3	25
	Alien grasses (mainly *Poa pratensis*, *Poa annua*)	-	+	11	28,7	50
	Herbs and weeds	-	2	7	13	23

* in the 1^{st} main cut after three nursery mowings (06.09.2006)

Source: own study

Table 3. Floristic composition of meadow mixtures – 1^{st} cut 2006–2010

Tab. 3. Skład florystyczny mieszanek łąkowych ─ I pokos 2006─2010

Mixtures or model species (seed rate kg ha^{-1})		Share in sowing, %	Share in yields, %				
			2006*	2007	2008	2009	2010
M1 designed	*Festuca pratensis* Huds. cv. Skra (56)	19	15	9	6	11.7	2
	Festuca arundinacea Schreb. cv. Terros (56)	20	27	9	5	10	3
	Phleum pratense L. cv. Skala (24)	20	8	15	2	6.3	3
	Dactylis glomerata L. cv. Bara (32)	5	31	21	6.5	9	2
	Poa pratenis L. cv. Skiz (24)	13	8	16	35	17.7	40
	Festuca rubra L. cv. Reda (28)	10	4	20	25	13.3	15
	Trifolium hybridum (L.) cv. Ermo (16)	8	1	1	-	-	-
	Trifolium pratense L. cv. Parada (28)	5	1	1	+	+	-
	Alien grasses (mainly *Poa pratenis* L., *Holcus lanatus* L.)	-	2	3	7	3.7	5
	Alien legumes (*Trifolium repens*)	-	-	-	-	-	2
	Herbs and weeds	-	3	5	13.5	28.3	28
M2 market	*Lolium perenne* L. 4N	13	30	15	17.5	15	11
	Phleum pratense L.	20	8	10	2	3.3	2
	Festuca pratensis Huds	19	17	16	10	8.3	2
	Festuca arundinacea Schreb.	18	25	9	4	4	2
	Poa pratenis L.	10	6	20	25.5	17.7	40
	Trifolium hybridum (L.)	15	2	1	-	-	-
	Agrostis gigantea Roth	5	2	6	2	2.7	3
	Alien grasses	-	4	10	22	16	10
	Alien legumes (*Trifolium repens*)	-	-	-	-	-	2
	Herbs and weeds	-	6	13	15	33	28
M3 simplified	*Phleum pratense L.* cv. Skala (12)	50	74	70	7.5	12.3	10
	Trifolium repens L. cv. Aura (8)	50	11	8	1.5	0.5	3
	Alien grasses	-	7	15	69	55.2	59
	Herbs and weeds	-	8	7	22	32	28
M4 model species	*Dactylis glomerata* L. cv. Bara (32)	100	98		62.5	32	2
	Alien grasses	-	1	83	23.5	30	76
	Legumes	-	-	9	-	-	+
	Herbs and weeds/sedges	-	1	8	14	38	22/1

Source: own study

Lolium perenne was the most valuable and abundant (threefold increase in P1) grass in the first three years of experiment. Its rapid growth could have been associated with nutrients released from mineralization of old sward. However, in the fourth year its share decreased five- to six-fold. In studies of Łyszczarz et al. [12] its 2.5-fold decrease took place already in the third year of pasture use. The grass was replaced by *Poa pratenis* or *Festuca rubra,* the species which, according to Baryła [1], Baryła, Sawicki [3] and Kozłowska [10], occupy poor habitats growing usually on muck and mucky sands, degraded not fertilised or improperly fertilised meadows. In our experiment nitrogen fertilisation was not applied in accordance with the principles of organic farming.

Meadow mixtures. Clover plants were partly destroyed by frost in 2006 and not before autumn they recovered up to 10% share in the case of *Trifolium repens* in M3 mixture (Table 3). In the years 2007 and 2008 the share of *Trifolium hybridum* and *T. pratense* decreased to trace amounts. In M2 and M3 mixtures the two latter species were replaced by *Poa pratensis* and alien grasses, mainly *Holcus lanatus*, and weeds (up to 20% share). In the first two years an important species was *Dactylis glomerata*, whose share increased 5 to 6-fold compared with that sown but in the third and fourth year of experiment its share was only 6-9% of the sward. Results of other studies confirm an important but also more stable contribution of this species to the sward of undersown meadows [8, 14]. Baryła and Warda [4] explain this variability by the fact that in winter (at low temperatures and a lack or thin snow cover) some species may be destroyed by frost, which results in limited share *(Lolium perenne*, *Dactylis glomerata*) or complete disappearance (*Trifolium pratense*, *Lolium multiflorum*) from meadow sward in the next years.

In 2009 weeding of sward reached 30% or even 38% (in model M4 object) with the prevalence of *Poa pratensis* – the species absent in M3 mixture but typical for meadow communities on drained peatlands – with the admixture of *Holcus lanatus*, the species typical for moderately wet peat-muck soils poor in phosphorus and potassium facilitated also by low or absent nitrogen fertilisation [15].

Legumes remained in trace amount irrespective of the applied mixtures. As with pasture mixtures, sward degradation on meadows proceeded in 2010. The share of sown species and varieties decreased and plots became overgrown by not sown species (*Poa pratenis* and *Poa annua* with the admixture of *Holcus lanatus*) and weeds, mainly by *Ranunculus repens.*

Described changes in floristic composition of sward evidence the disappearance of differences resulting from different composition of sown meadow and pasture mixtures and the development of communities adapted to local habitat and thermal conditions. One may find, however, that *Festuca rubra* was a little better component of M1 mixture designed for meadows on organic soils compared with *Lolium perenne* in the market M2 mixture. The stability of undersown species in studies by Baryła and Kulik [2] was also quite variable and determined by thermal conditions, particularly in the winter time. According to these authors, the most useful species for undersowing degraded grasslands on peat-muck soils were *Lolium perenne*, *Trifolium pratense* and *Dactylis glomerata* whereas *Phleum pratense*, *Festuca pratensis*, *Festuca arundinacea* and *Lolium multiflorum* were less appropriate.

The effect of habitat conditions on the development of new communities and on the increase of the number of plants from various taxonomic groups was also described by Kryszak et al. [11]. Sowing multi-species mixtures appeared justified due to different dynamics of development of their different components in subsequent years of experiment which was also found in studies by Łyszczarz et al. [12].

3.2. Dry matter yield

Pasture mixtures. Yields mixtures in the years 2007 and 2008 were uniform. Significant differences were noted only in the 1st and 4th regrowth in 2007 in favour of P1 and P3 mixtures. Yields from the 1st regrowth were very small and constituted merely 1/3 of those from the 2nd regrowth, probably because of declining ground water level from the end of April till the middle of May and long and severe frosts. P1 mixture designed for organic farming gave the best yields. In the 4th regrowth significantly larger yields were obtained from simplified P3 mixture dominated by *Lolium perenne* (Table 4).

Differences in yields between mixtures in 2008 were insignificant but differed among particular regrowths. In the 4th regrowth the yields were significantly larger and in the 3rd (low ground water table) and 1st (low temperature) – extremely small. *Lolium perenne* (P4) yielded well in the 4th and 5th regrowth. In 2009 the yields were slightly smaller in comparison to 2008. Ground frosts in spring and proceeding degradation of sward, which in the 1st regrowth was lower by 2-3 cm than the year before, were the reasons. Most pronounced yield decline was noted in P4 object in the 1st and 3rd regrowth (significantly smaller only in the latter) (Table 4). Yields from the 1st cut were low in all mixtures being harvested in a period of unfavourable thermal conditions. The third cut gave poor yield of *Lolium perenne* (P4) sown alone, which markedly retreated in favour of alien grass species. In the year 2010 yields were uniform, irrespective of mixture and lowest in the whole study period (by 2.0-2.5 $t \cdot ha^{-1}$ compared with the yields in 2009). As in 2009, model *Lolium perenne* (P4) gave the smallest yield. The main reason for so low yields lay in an excess of water in soil and associated deficit of nitrogen in organic soil. The state of grasslands may be estimated as a long-term inundation which facilitated progressing degradation of pasture sward. The sward, regardless of applied mixture, was clearly dominated by *Poa pratense*, *Ranunculus repens* and *Poa annua* at the end of vegetation season.

Total yields of particular pasture mixtures in the years 2007-2010 were uniform (from 18.69 to 20.76 $t \cdot ha^{-1}$) but the largest yields were obtained from simplified (P3) and model (P4) mixture and the smallest – from model *Lolium perenne* P4 mixture. Yields were more differentiated among cuts and years, which suggests that they depended on thermal and moisture conditions.

Meadow mixtures. In the year 2007 the yields of both meadow and pasture mixtures were rather mean due to scanty mineral fertilisation of sward, particularly to a lack of nitrogen fertilisation. Best yield was obtained from designed mixture M1 and the worst one - from simplified mixture M3 (Table 5). Before the 1st cut (1. June) the sward of M1 mixture was highest and densest, which translated into the largest dry mass yield from among all mixtures and monoculture of *Dactylis glomerata* (P4). Yields in the year 2008 were slightly bigger and differentiated. Best yielding was from M1 mixture designed for organic farming and simplified mixture M3 and the worst yielding was from market mixture M2. Yields of M1 mixture were improved by *Dactylis glomerata*, particularly in the 1st and 3rd regrowth. Very good yields of simplified mixture M3 resulted from a high contribution of alien grasses (4-fold increase of their share). The second regrowth gave the worst yield of M3 mixture and the best yields from the third regrowth were obtained from M1 and M3 mixture (*Dactylis glomerata*). The share of alien grass species and weeds increased in both.

Table 4. Dry matter yield ($t·ha^{-1}$) of pasture mixtures
Tab. 4. Plony suchej masy ($t\ ha^{-1}$) mieszanek pastwiskowych

Year	Cut	Mixture or model species				Mean	$NRI_{\alpha=0.01}$	Grouping**	
		P1	P2	P3	P4			I	II
2007	I	0.67	0.59	0.60	0.47	0.58	0.08	1.3.2	4.
	II	1.64	1.56	1.62	1.54	1.59	0.15	n.s.	n.s.
	III	1.34	1.37	1.45	1.39	1.39	0.22	n.s.	n.s.
	IV	1.00	0.96	1.61	0.95	1.13	0.1	3.	1.2.4
	V	0.51	0.49	0.50	0.61	0.53	0.12	n.s.	n.s.
	Sum	**5.16**	**4.97**	**5.78**	**4.96**	-			
2008	I	1.05	1.00	1.11	0.90	1.02	0.18	n.s.	n.s.
	II	1.43	1.46	1.49	1.29	1.42	0.28	n.s.	n.s.
	III	0.77	0.87	0.79	0.75	0.79	0.16	n.s.	n.s.
	IV	1.69	1.58	1.68	1.66	1.65	0.14	n.s.	n.s.
	V	1.01	1.02	1.06	1.05	1.04	0.17	n.s.	n.s.
	Sum	**5.95**	**5.93**	**6.13**	**5.65**	-			
2009	I	0.40	0.38	0.41	0.27	0.36	0.12	n.s.	n.s.
	II	0.83	0.87	0.74	0.79	0.81	0.26	n.s.	n.s.
	III	1.74	1.86	1.92	1.51	1.76	0.28	3.2.1	4.
	IV	2.09	2.10	2.01	1.96	2.04	0.20	n.s.	n.s.
	V	0.56	0.53	0.54	0.52	0.54	0.15	n.s.	n.s.
	Sum	**5.62**	**5.74**	**5.62**	**5.05**	-			
2010	I	0.29	0.24	0.28	0.25	0.27	0.09	n.s.	n.s.
	II	0.27	0.31	0.27	0.24	0.27	0.14	n.s.	n.s.
	III	1.22	1.20	1.25	1.16	1.21	0.18	n.s.	n.s.
	IV*	1.43	1.39	1.43	1.41	1.42	0.17	n.s.	n.s.
	Sum	**3.21**	**3.14**	**3.23**	**3.06**	-			
Total (2007-2010)		**19.94**	**19.78**	**20.76**	**18.69**				

*- only 4 cuts due to excess moisture; **- grouping mixtures with respect to the significance of differences
n.s. –not significant

Source: own study

Table 5. Dry matter yields ($t·ha^{-1}$) of meadow mixtures – years 2007-2010
Tab. 5. Plony suchej masy ($t\ ha^{-1}$) mieszanek łąkowych - lata 2007-2010

Years	Cut	M1	M2	M3	M4	Mean	$NRI_{\alpha=0.01}$	Grouping*		
								I	II	III
2007	I	3.03	1.97	1.79	2.05	2.21	0.29	1.	4. 2. 3.	
	II	1.49	1.86	1.22	1.71	1.57	0.18	2. 4.	1.	3.
	III	2.29	1.94	1.79	2.05	2.02	0.31	1.	4. 2. 3.	
	Sum	**6.81**	**5.77**	**4.8**	**5.81**					
2008	I	3.60	2.95	3.96	3.08	3.40	0.31	3. 1.	4, 2.	
	II	3.22	3.04	2.78	3.40	3.11	0.46	n.s.	n.s.	
	III	1.67	1.26	1.17	1.72	1.45	0.31	4. 1.	2. 3.	
	Sum	**8.49**	**7.25**	**7.91**	**8.2**					
2009	I	3.02	2.29	2.71	2.04	2.51	0.35	1. 3.	2. 4.	
	II	2.55	2.33	2.53	1.94	2.34	0.49	n.s.	n.s.	
	III	2.11	1.80	1.79	1.79	1.87	0.44	n.s.	n.s.	
	Sum	**7.68**	**6.42**	**7.03**	**5.77**					
2010	I	0.91	0.75	0.82	0.53	0.75	0,24	1. 3. 2.	4.	
	II	2.20	2.29	2.03	1.61	2.03	0,27	2. 1. 3.	4.	
	III	1.15	1.40	1.69	1.31	1.39	0,37	n.s.	n.s.	
	Sum	**4.26**	**4.44**	**4.54**	**3.45**					
Total (2007-2010)		**27,24**	**23.88**	**24.28**	**23.23**					

* Grouping objects with respect to the significance of differences
n.s. –not significant

Source: own study

In the year 2009 the yields of mixtures were slightly smaller and markedly worse than in the 1st cut of the year before due to low temperatures in spring and proceeding sward degradation. The most pronounced yield decline was noted in model object M4 (mainly in the 1st and 2nd cut) and the largest yield was obtained from designed mixture M1. In the 2nd regrowth the differences were insignificant, probably due to a high percent of alien grass species and weeds in sward while in the 3rd one – M1 mixture gave the best yields again though the differences were statistically insignificant. Due to excessive soil moisture in 2010 the yields from all mixtures were lowest from among all study years. The yield were smaller by 2-3 $t \cdot ha^{-1}$ compared with the previous year and markedly smaller than usually noted already in the 1st cut. The smallest yields were obtained from M4 object with model species *Dactylis glomerata* which was practically absent from experimental plots. Other mixtures gave comparable yields.

The biggest total yield for the years 2007-2010 was obtained from M1 mixture (27.24 $t \cdot ha^{-1}$). Yields from other mixtures were similar ranging from 23.23 to 24,28 $t \cdot ha^{-1}$ of dry matter. They were smaller by about 12% of the crop mix designed.

4. Conclusions

1. Five years after sowing of legume-grass mixtures on mud-peat-muck organic soils the smallest changes of botanical composition as a percentage of alien grasses, herbs and weeds were found in mixtures composed of 6-7 grass species and 1-2 legumes, specially designed for organic farming and adapted for habitat conditions. Most important from not sown grasses were *Poa pratensis* and *Poa annua* and from weeds - *Ranunculus repens.*
2. Most stable in pasture management were *Poa pratensis*, *Phleum pratense*, *Festuca rubra* while *Festuca pratensis*, *Agrostis giganthea* and *Trifolium repens* retreated from sward. *Lolium perenne* and *L multiflorum* maintained a high share for 4 years of experiment.
3. Most stable on meadows were *Poa pratensis* , *Festuca rubra* and *Lolium perenne*. Legumes *Trifolium hybridum*, *T. pratense* retreated while T. *repens* maintained a 10% share for 2 years. Percentage share of *Dactylis glomerata* was very high for 2 years and high for the next 2 years. Similarly high was the share of *Festuca pratensis* and *Phleum pratense*.
4. Dry mass yields depended more on thermal and moisture conditions than on the type of mixture but the largest dry mass yield for 4 study years was obtained from meadow designed M1 mixture - *Festuca pratensis* (19%), *Festuca arundinacea* (20%), *Phleum pratense* (20%), *Dactylis glomerata* (5%), *Poa pratenis* (13%), *Festuca rubra* (10%), *Trifolium hybridum* (8%), *Trifolium pratense* (5%).
5. Observed changes and results evidence the disappearance of differences resulting from the composition of sown mixtures and the development of communities adapted to habitat conditions. However, proper selection of species and varieties and multi-species composition of mixtures may slow down this process in subsequent years due to diverse developmental dynamics of particular components.

5. References

[1] Domański J.P., Urbaniak K., Czeladzka M. (1998): Metodyka badania wartości gospodarczej odmian (WGO) roślin uprawnych. 1. Rośliny rolnicze, 1.4. Trawy pastewne. Wyd. I, COBORU, Słupia Wielka.

[2] Høgh-Jensen H., Loges R., Jørgensen F.V., Jensen E.S., Vinther F.P. (2004): An empirical model for quantification of symbiotic nitrogen fixation in grass-clover mixtures. Agricultural Systems, Vol. 82, 81-194.

[3] Jurczuk S. (2007): Warunki wodne ograniczające straty masy organicznej na łąkach o glebach torfowo-murszowych. Woda-Środowisko-Obszary Wiejskie, T. 4, z. 2a (11), 379-394.

[4] Kamiński J. (2002): Przydatność wybranych gatunków traw do podsiewu łąk wiechlinowych na glebie torfowo-murszowej. Woda-Środowisko-Obszary Wiejskie, 2, 1: 89-100.

[5] Kamiński J. 2008: Zróżnicowanie florystyczne i walory przyrodnicze łąk 2-kośnych na zagospodarowanym torfowisku w zależności od warunków wilgotnościowych. Woda-Środowisko-Obszary Wiejskie, T. 8, Z. 2a(23), 87-104.

[6] Kryszak A., Grynia M., Kryszak J., Budziński M., Grzelak M. (2004): Zmiany różnorodności florystycznej nadwarciańskich łąk zalewanych. Woda-Środowisko-Obszary Wiejskie, T. 4, z. 1 (10), 209-218.

[7] Martyniak J. (2009): Poziom krajowego nasiennictwa traw pastewnych a stan biologiczny użytków zielonych w Polsce. Woda-Środowisko-Obszary Wiejskie, t. 9, z. 1 (25), 21-38.

[8] Łyszczarz R., Dembek R., Suś R., Zimmer-Grajewska M., Kornacki P. (2010): Renowacja łąk trwałych położonych na glebach torfowo-murszowych. Woda-Środowisko-Obszary Wiejskie, t. 10, z. 4 (32), 129-148.

[9] Kozłowska T. (2005): Zmiany zbiorowisk łąkowych na tle różnicowania się warunków siedliskowych w charakterystycznych obszarach dolin rzecznych Polski Centralnej. Woda-Środowisko-Obszary Wiejskie. Rozprawy naukowe i monografie, nr 14.

[10] Baryła R. (2004): Przydatność *Lolium perenne* do mieszanek łąkowych w siedlisku pobagiennym. Łąkarstwo w Polsce, nr 7, 9-20.

[11] Baryła R., Sawicki J. (1998): Porównanie różnych metod regeneracji zdegradowanego zbiorowiska łąkowego. Łąkarstwo w Polsce, nr 1, 99–104.

[12] Zielewicz W. (2005): Reakcja *Holcus lanatus* na trudne warunki siedliskowe. Łąkarstwo w Polsce, nr 8, 237-247.

[13] Baryła R., Warda M. (1999): Wpływ czynników siedliskowych na udział *Lolium perenne* L. w zbiorowiskach trawiastych na glebie torfowo-murszowej. Łąkarstwo w Polsce, 2: 9–14.

[14] Sawicki J. (2004): Renowacja runi łąkowej na glebie torfowo-murszowej poprzez nawożenie i zmienne użytkowanie oraz podsiew różnymi gatunkami traw. Wyd. AR Lublin, 283.

[15] Baryła R., Kulik M. (2006): Ocena przydatności gatunków traw i roślin motylkowatych do podsiewu zdegradowanych zbiorowisk trawiastych w siedliskach pobagiennych. Zeszyty Naukowe Uniwersytetu Przyrodniczego we Wrocławiu Rolnictwo LXXXVIII nr 545, 13-19.