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THE EFFECT OF EXTENSIVE UTILISATION OF MEADOW LOCATED IN DRY HABITAT ON ITS STATE AND YIELDING

Summary

The study was carried out in an area of meadow located in a proper dry meadow habitat. The soil comprised black degraded earth with the mechanical composition of heavy clayey sand and a pH of 4.4. The study involved the following methods of utilisation: mowing and harvesting the biomass, mowing and leaving the biomass on the swathe, mulching the biomass and leaving it on the swathe and leaving the meadow non-utilised. Despite significant differences in utilisation, no statistically significant differences were observed in sward density although leaving mowed biomass on the swathe contributed to a decline in sward density. The height of the mowed sward was lowest where biomass was collected and tallest where it was left after mulching. Despite the extensive utilisation and lack of fertiliser the crop yield remained relatively high, ranging from 4.3–4.7 t·ha^{-1} DMB. The different methods of utilisation did not bring significant differences in crop yield. The botanical composition of the sward deteriorated significantly with a decline in valuable grasses and the spread of dicotyledonous plants, including varieties such as the common dandelion (Taraxacum officinale F.H. Wigg.) and common sorrel (Rumex acetosa L.). This effect was particularly marked in the non-utilised meadow and the meadow where the biomass was left on the swathe. The results of the study indicate that leaving harvested biomass to mulch is more beneficial to meadow than being left non-utilised, but in the long term this leads to degradation, particularly of sward (through the spread of weeds) but also sward density (by rarefaction).
***Key words**: extensive utilisation, dry habitat, yielding, sward density, botanical composition*

OCENA WPŁYWU EKSTENSYWNEGO UŻYTKOWANIA ŁĄKI W SIEDLISKU GRĄDOWYM NA JEJ STAN I PLONOWANIE

Streszczenie

Badania prowadzono na łące położonej w siedlisku grądowym właściwym. Glebę stanowiła czarna ziemia wyługowana o składzie mechanicznym piasku gliniastego mocnego i pH 4,4. Badano następujące sposoby użytkowania: koszenie i zbieranie plonu (biomasy), koszenie i pozostawianie biomasy na pokosach, koszenie z rozdrobnieniem i pozostawianie na łące oraz łąka porzucona. Mimo znacznych różnic w sposobach użytkowania, nie stwierdzono udowodnionych statystycznie różnic w zadarnieniu łąki, mimo iż pozostawianie skoszonej biomasy sprzyjało rozrzedzeniu darni. Wysokość koszonej runi była najmniejsza na łące ze zbiorem biomasy a największa po jej rozdrobnieniu i pozostawieniu. Można zatem wnioskować o nawożącym działaniu pozostawianej biomasy. Plonowanie, mimo ekstensywnego użytkowania oraz braku nawożenia, było dość wysokie, sięgające 4,3-4,7 t·ha^{-1} s.m. Sposoby użytkowania nie różnicowały istotnie wielkości plonów. Wraz z upływem lat badań, skład botaniczny runi podlegał znacznym zmianom na niekorzyść, skutkem ustępowania wartościowych traw a rozwojem roślin dwuliściennych, w tym takich gatunków jak mniszek pospolity (Taraxacum officinale F.H. Wigg.) oraz szczaw zwyczajny (Rumex acetosa L.). Dotyczyło to zwłaszcza łąki porzuconej oraz z pozostawianiem biomasy na pokosach. Najmniej niekorzystnych zmian w składzie botanicznym runi stwierdzono na łące ze zbiorem biomasy. Uzyskane wyniki badań wskazują, że pozostawianie skoszonej runi na łące jest zabiegiem dla niej korzystniejszym niż zaniechanie użytkowania, lecz w dłuższej perspektywie czasu prowadzi do degradacji, zwłaszcza runi (zachwaszczenie), ale również darni (rozrzedzenie).
***Słowa kluczowe**: ekstensywne użytkowanie, siedlisko grądowe, plonowanie, zadarnienie, skład botaniczny*

1. Introduction

Permanent grassland in Poland occupied around 2,521,300 ha in 2013, representing 14.7% of total agricultural land [9] which entitled farmers to claim area payments from the European Union (EU). One condition for the receipt of these payments, a part of the EU Common Agricultural Policy, is that grassland is mowed and the biomass harvested at least once a year. [6] The compulsory harvesting of biomass is also a requirement for subsidies to packages for grassland (packages 2, 3, 4, 5 and 9 for buffer zones) as part of the current Agri-Environmental Programme [8] and the new Agri-Environmental Climate Programme for 2015–2020. This also applies to buffer zones established along watercourses and around water reservoirs whose maintenance requires the mowing and harvesting of sward. [8, 11]

The study was inspired by feedback from farmers who questioned the compulsory of harvesting of mowed biomass as overly stringent. The farmers claim that leaving mowed sward for one or even two years, particularly when it is dispersed, does not harm the meadow but is one of the acknowledged methods of mulching. This is confirmed by the fact that, as reported by Nadolna [4], in the mountainous regions of Germany the problem of the setting aside of grasslands has significantly worsened. In Germany sward is mowed once a year and the biomass is left on the field. Nevertheless, Nadolna's [4] study showed that leaving mowed sward had an inhibiting effect on the wealth and variety of flora in plant habitats. In addition, Burzyńska [1]

showed that leaving mowed biomass on dry meadow contributed to the decline of groundwater quality resulting from the migration of nitrogen, phosphorus, potassium and organic carbon outside the rhizosphere. These contrary positions indicated a clear need to study the effects of leaving mowed sward on meadows, specifically the impact on their health and crop yield. One key question is whether it is better for the qualitative state of the meadow (botanical composition and sward density), to mow the sward, leaving the biomass on the meadow, or not to mow at all. The issue of leaving meadows non-utilised was raised by Marks et al [3] who estimated the total area of non-utilised grasslands in Poland at the beginning of the 2000s at around 1 million hectares. It is anticipated that awareness of the effects of this practice will lead to a reduction in the area of unmaintained grassland, which in 2012 represented 10% of total grassland. [9] It should be mentioned that each year a proportion of the grasslands is mowed but the crop is not harvested. For example in 2012 the area of meadows that were mowed but not harvested represented: 3.2% of the first mow, 2.9% of the second mow and 2.2% of the third mow, representing a total of 83,000 ha, 75,000 ha and 57,000 ha, a total of 215,000 ha.

The current study was aimed at establishing the influence of extensive utilisation of meadows on their state, defined by sward density, the height of the main mass of sward, botanical composition and crop yield.

2. Methodology

The study was conducted on a proper dry meadow habitat. [2, 10] The soil was a black degraded earth formed of heavy clayey sand with a pH of 4.4. [12] The habitat was classified as dry, periodically dampted (Lw 5.2). [5] The meadow was not fertilised. The state of the meadow and its economic value was established according to its sward density, the height of the main mass of sward, the size of the biomass crop and its botanical composition. Supplementary measurements included the measurement of the displacement of biomass on the surface of mowed meadow and its density.

The study was conducted on test plots on a meadow utilised in the following ways: 1 – mowing and collection of biomass, 2 – mowing and leaving biomass on the swathe, 3 – mowing, mulching and leaving biomass on the field and 4 – not utilising the field. The extent of the utilisation was conditioned by the absence of fertiliser and leaving the biomass on the meadow. The sward density and the height of the main mass of the sward were established using a line gauge. The height if the main mass of the sward was measured on the day of mowing. The botanical composition of freshly mowed sward was established using the botanical-gravimetric method. The proportion of individual species in the sward was determined to within 1%. Species which represented under 1% were labelled with a "+". The results were subjected to statistical analysis using ANOVA analysis of variance, verifying the hypothesis to a statistical of significance of $p = 0.05$. The meadow was mowed once. Half of the meadow was mowed in summer (Wednesday 11 July) and half in autumn (Wednesday 24 September).

3. Results

3.1. Sward density (%)

The sward density of the meadow is a measure of its economic value. It was an initial assumption of the study that extensive utilisation, a single mow where the biomass is left on the field, will lead to a decline in sward density. It was found that in a dry meadow the influence of this type of utilisation caused only minor differences between the sward density of meadows mowed in summer and autumn (table 1). The highest sward density was observed in the first year of the study, which resulted from production use in the years prior to the study. A significant decline in this parameter was observed in the first year of the study, irrespective of the mowing time and the treatment of the mowed sward, but also on the non-utilised meadow (table 1). Nevertheless in the third year of the study sward density stabilised at around 80% on the meadow where mowed biomass was collected (method 1), 75–76% on the meadow where biomass was mowed in the summer and left on the swathe (method 2) and 72–74% where the biomass was fragmented and left on the swathe (method 3).

Table 1. Meadow sward density (%)
Tab. 1. Stopień zadarnienia łąk (%)

Years	Ways of utilisation			Meadow not utilised	$LSD_{0.05}$
	1	2	3		
Summer mowing					
2010	82.8	83.6	76.0	81.4	8.6 NS
2011	75.4	71.2	66.2	78.4	20.8 NS
2012	80.0	76.0	73.8	83.6	15.7 NS
2013	80.4	74.6	73.2	81.2	15.8 NS
Mean	79.7	76.4	72.3	81.2	
LSD	11.9 NS	18.7 NS.	14.1 NS	19.5NS	
Autumn mowing					
2010	87.2	83.8	80.4	81.4	9.6 NS.
2011	82.0	79.6	70.2	78.4	24.2 NS
2012	79.0	81.2	68.8	83.6	15.9 NS
2013	75.4	74.2	94.6	81.2	12.9 *
Mean	80.9	79.7	71.0	81.2	
LSD	18.6 NS.	17.2 NS.	13.2 *	19.5 NS	

Ways of utilisation: 1 – mowing and collection of biomass, 2 – mowing and leaving biomass on the swathe, 3 – mowing, mulching and leaving biomass on the field; NS – not significant difference

Source: own study / Źródło: opracowanie własne

More significant differences were observed in meadows mowed in autumn, between the different years of the study and between methods of utilisation. The non-utilised meadow showed the highest sward density. The decline in sward density observed in the second year was mainly caused by leaving the biomass on the swathe and partly by changes in the botanical composition of the sward (especially the decline of perennial ryegrass from the sward). In subsequent years this process underwent stabilisation while sward density increased on the meadow which was mowed in autumn where the biomass was mulched and left on the swathe (table 1). In summary, it was observed that leaving mowed biomass on the meadow reduced the level of its sward density compared to the meadow from which the biomass was harvested, which was not observed on the non-utilised meadow (a slight improvement in sward density). Nevertheless no statistical differences were proven.

3.2. The height of the main mass of sward (cm)

The height of the sward varied between methods of utilisation and years of the study. Of the grasses, in the first year of the study the height of the main mass of the sward comprised perennial ryegrass (*Lolium perenne L.*) and tall oat grass (*Arrhenatherum elatius* (L) P. Beauv. Ex Presl et C. Presl.) while in subsequent years it was dominated by tall oat grass. As the perennial ryegrass declined, a significant expansion of common dandelion (*Taraxacum officinale* F. H. Wigg.) and common sorrel (*Rumex acetosa* L.) was observed. The shortest sward was observed in the first year on the meadow which was mowed in autumn. This is explained by the desiccation of all generative and some vegetative shoots of the dominant species listed above, and a high incidence of lodging which impeded the measurement of their height. The tallest sward overall was observed in the final year of the study in meadows 1 and 2, in meadow 3 and the non-utilised meadow in the second year after the summer mow and in meadows 2 and 3 in the second year with meadow 3 and the non-utilised meadow in the third year after the autumn mow (table 2). Height differences in the main mass of sward during the study in this habitat were proven statistically in the case of meadows 1 and 3 when mowed in summer and for all meadows mowed in autumn.

3.3. The botanical composition of the sward

The height of the main mass of the sward, the sward density of the meadow and its crop yield is influenced by its botanical composition. The meadow features outlined in the two sections above indicate that the transformation of the botanical composition of the sward developed in different ways in the different meadows. As time progressed in the studied habitat, the proportion of grasses in the sward declined, giving way to herbs and an increased number of weeds (table 3). Extensive utilisation combined with the absence of fertiliser proved exceptionally hard on the perennial ryegrass (*Lolium perenne L.*) which, after four years, regardless of the utilisation method, represented only a few percent of the biomass. The tall oat grass (*Arrhenatherum elatius* (L) P. Beauv. Ex Presl et C. Presl.) fared rather better, its share of the sward increasing to 39% in the meadow mowed in summer where biomass was collected and on the meadow where biomass was mulched and left on the swathe. The proportion of oat grass sward on the meadows mowed in autumn was slightly smaller. A small increase was noted in the proportion of common meadow grass (to 14%).

The biggest changes over the four year period of the study took place on meadows mowed in autumn, where weeds represented around 40% of biomass. This applies to all the utilisation methods including the non-utilised meadow. In the herb and weed group the common dandelion (*Taraxacum officinale* F. H. Wigg.) and common sorrel (*Rumex acetosa* L.) dominated. Other varieties represented only a few percent of the total. Weed proliferation was particularly prevalent on the meadow which was mowed in summer and the biomass was left on the swathe and on the meadow which was mowed in autumn and the biomass was fragmented and left on the swathe. The extensive utilisation of the meadow only led to an increased number of herb and weed varieties in the sward. In the meadow mowed in summer their number increased by 4–5 varieties and 4–6 in meadow mowed in autumn. Meanwhile the botanical composition of the sward on the non-utilised meadow increased by seven varieties (table 3).

Table 2. Height of the main mass of the sward (cm)
Tab. 2. Wysokość głównej masy runi (cm)

Years	Ways of utilisation			Meadow not utilised	$LSD_{0,05}$
	1	2	3		
Summer mowing					
2010	47.8	48.4	51.4	48.6	6.8 NS
2011	49.8	50.6	61.2	54.4	19.3NS
2012	39.0	41.0	48.8	41.6	11.7 NS
2013	51.0	54.6	56.2	53.2	10.4 NS
Mean	46.9	48.7	54.4	49.5	
LSD	10.1 *	17.2 NS	9.4 **	17.9 NS	
Autumn mowing					
2010	26.2	25.2	23.8	23.4	8.2 NS
2011	42.2	52.2	49.4	46.6	28.2 NS
2012	43.6	43.4	47.0	47.6	10.6 NS
2013	38.6	39.4	42.2	41.2	7.8 NS
Mean	37.7	40.1	40.6	39.7	
LSD	15.8 *	12.0 **	11.9 **	20.2 *	

Ways of utilisation: 1 – mowing and collection of biomass, 2 – mowing and leaving biomass on the swathe, 3 – mowing, mulching and leaving biomass on the field; NS – not significant difference *Source: own study / Źródło: opracowanie własne*

Table. 3. Changes in botanical composition of sward (%)
Tab. 3. Zmiany składu botanicznego runi (%)

Plant groups	Ways of utilisation						Meadow not utilised	
	1		2		3			
Year	2010	2013	2010	2013	2010	2013	2010	2013
Summer mowing								
Grasses:	84	78	85	60	86	84	85	57
in this: *Lolium perenne*	*58*	*9*	*57*	*5*	*58*	*9*	*53*	*2*
Arrhenatherum elatius	*14*	*39*	*11*	*25*	*14*	*39*	*13*	*26*
Legumes	6	+	1	+	6	1	1	+
Herbs and weeds, in this: *Taraxacum officinale*	10	22	14	40	8	15	14	43
	5	*7*	*4*	*15*	*5*	*6*	*3*	*19*
Rumex acetosa	*3*	*7*	*4*	*15*	*2*	*4*	*4*	*16*
Nomber of species	13	17	12	16	13	18	12	19
Autumn mowing								
Grasses:	87	54	89	51	87	44	85	57
in this: *Lolium perenne*	*61*	*3*	*60*	*3*	*61*	*2*	*53*	*2*
Arrhenatherum elatius	*5*	*20*	*11*	*22*	*5*	*15*	*13*	*26*
Legumes	2	1	1	2	4	2	1	+
Herbs and weeds, in this: *Taraxacum officinale*	11	45	10	47	9	54	14	43
	3	*18*	*2*	*19*	*3*	*25*	*3*	*19*
Rumex acetosa	*4*	*18*	*4*	*21*	*3*	*17*	*4*	*16*
Nomber of species	12	16	12	18	12	17	12	19

Ways of utilisation: 1 – mowing and collection of biomass, 2 – mowing and leaving biomass on the swathe, 3 – mowing, mulching and leaving biomass on the field; NS – not significant difference

Source: own study / Źródło: opracowanie własne

3.4. Crop yields

The data in table 4 indicate that leaving mowed sward on the meadow did not inhibit or stimulate crop yield. A somewhat greater crop yield was obtained on meadows where scattered biomass was left after the summer mow and where the biomass was collected after an autumn mow. Nevertheless these differences were very minor and not statistically significant. The differences between crop yields in different years were also minor, equally in the case of summer and autumn mowing.

Table 4. Dry matter yields, $t \cdot ha^{-1}$
Tab. 4. Plony suchej masy, $t \cdot ha^{-1}$

	Ways of utilisation			$LSD_{0,05}$
	1	2	3	
Summer mowing				
2010	5.45	5.73	5.43	
2011	4.18	4.12	4.79	
2012	3.38	3.27	3.96	
Mean	4.34a	4.35a	4.73b	0.38 *
Autumn mowing				
2010	2.67	2.43	2.43	
2011	5.25	5.05	5.22	
2012	3.62	3.35	3.70	
Mean	3.85a	3.61a	3.78a	0.38 r.n.

Source: own study / Źródło: opracowanie własne

It is noteworthy that the yield from meadows cultivated using every method of utilisation and mowed in the summer declined systematically from year to year, which was not observed in meadows mowed in autumn (table 4). In the first year crops from meadows mowed in autumn were less than half of those mowed in summer. This is explained by the notable lodging of the sward and its partial decomposition, but also changes in the botanical composition, characterised by the significant intrusion of weeds with low crop yields such as the common dandelion (*Taraxacum officinale* F.H. Wigg.) and common sorrel (*Rumex acetosa* L.).

The mowed biomass covered the surface of the meadow to different degrees because two different types of mower were used. The first, a traditional mower which dropped the biomass on the swathe and a mulching mower which evenly distributed biomass across the entire mowed surface.

The output of the conventional mower covered a little over half of the mowed surface while the mulched biomass covered its entirety (table 5). There was therefore a difference in the thickness of its coverage. The thickness of conventional mower cuttings was around 9cm while the thickness of the mulched cuttings was around 5cm (table 5). The biomass did not significant differences in the sward density of the meadow (slightly worse in the case of mulched biomass), the height of the main mass of the sward or the crop yield.

Table 5. Mean coverage of the meadow surface by mowed biomass (mean from years of study)
Tab. 5. Średni z lat badań stopień pokrycia powierzchni skoszoną biomasą

Term of mowing	Ways of utilisation		
	1	2	3
Surface coverage (%)			
Summer mowing	0	51.3	100
Autumn mowing	0	53.0	100
The thickness of mowed biomass (cm)			
Summer mowing	0	9.2	5.4
Autumn mowing	0	8.7	4.8

Source: own study / Źródło: opracowanie własne

4. Conclusions

1. It was demonstrated that leaving mowed biomass on a meadow reduced its sward density compared to meadows where the biomass was harvested. This was not observed on the non-utilised meadow which saw a minor improvement in sward density.
2. The shortest sward was observed on meadows where the biomass was harvested which leads to the conclusion that the biomass acts as a fertiliser, especially in its mulched form.

3. Leaving mowed biomass on a meadow led to the degradation of the sward, marked by the decline of valuable grasses and the spread of herbs and weeds, particularly common dandelion (*Taraxacum officinale* F.H. Wigg.) and common sorrel (*Rumex acetosa* L.).
4. In the habitat studied leaving mowed biomass on the meadow did not inhibit or stimulate crop yield but year-on-year differences were observed.
5. The results obtained have stimulated further research into the ecological aspects of this form of meadow utilisation.

5. References

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