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INFLUENCE OF RENOVATION OF GRASSLAND ON SWARD YIELDS IN THE CONDITIONS OF ORGANIC FARMING

Summary

The aim of the research conducted in an organic field was to assess the productivity and composition of the sward renewed with the method of full tillage after ploughing and top soil loosening to the depth of 5 cm using a compact harrow. In addition, the studies verified the suitability for renovation of two commercial original legume-grass mixtures. The field experiment was carried out in the years 2013-2016 at the Agricultural Experimental Station of IUNG-PIB in Grabów (Mazowickie voivodeship, Poland) on lessive soil formed on light loam. The experimental factors were: two ways of grassland renovation: A – after ploughing, and B-after loosening the topsoil to the depth of 5 cm using a compact harrow and three legume-grass mixtures. Two of these mixtures are available on the market (Krasula + 3,5 kg white clover, Cent 4) while the third one is original. Due to the higher dry matter yields and feed taken by cows under the conditions of the research, the simplified method which involves loosening the topsoil to the depth of 5 cm by a compact harrow was found to be better for grassland renovation (treatment B) than ploughing (treatment A). Among the compared mixtures, Cent 4 yielded the lowest. To be used for grassland renovation, multi-species mixtures should include alfalfa, red clover, and orchard grass in their composition.
***Key words**: organic farming, legume-grass mixture, renovation of grassland, renovation by ploughing, the simplified method of renovation, yields, the percentage of components in the sward*

WPŁYW RENOWACJI UŻYTKU ZIELONEGO NA PLONOWANIE RUNI W WARUNKACH ROLNICTWA EKOLOGICZNEGO

Streszczenie

Celem badań przeprowadzonych na polu ekologicznym była ocena produktywności i składu gatunkowego runi odnowionej metodą pełnej uprawy roli po orce i po powierzchniowym spulchnieniu gleby na głębokość 5 cm broną kompaktową. Ponadto w badaniach weryfikowano przydatność do renowacji dwóch mieszanek bobowato-trawiastych dostępnych w handlu i mieszanki autorskiej. Doświadczenie polowe przeprowadzono w latach 2013-2016, w Rolniczym Zakładzie Doświadczalnych IUNG-PIB Grabów (woj. mazowieckie), na glebie płowej wytworzonej na glinie lekkiej (pgl. gl). Czynnikami doświadczenia były: dwa sposoby renowacji użytku zielonego: A – po orce i B – po powierzchniowym wzruszeniu gleby na głębokość 5 cm broną kompaktową, oraz trzy mieszanki bobowato-trawiaste. Dwie z nich dostępne w handlu (Krasula + 3,5 kg koniczyny białej, Cent 4) i mieszanka autorska. Ze względu na wyższe plony suchej masy i paszy pobranej przez krowy w warunkach badań lepszym sposobem renowacji użytku zielonego okazała się uproszczona metoda polegająca na powierzchniowym wzruszeniu wierzchniej warstwy gleby na głębokość 5 cm broną kompaktową (obiekt B) niż orka (obiekt A). Spośród porównywanych mieszanek najsłabiej plonowała mieszanka Cent 4. Mieszanki wielogatunkowe stosowane do renowacji użytku zielonego powinny zawierać w składzie lucernę siewną lub mieszańcową i koniczynę łąkową oraz kupkówkę pospolitą.
***Słowa kluczowe**: rolnictwo ekologiczne, mieszanki bobowato-trawiaste, renowacja użytku zielonego, renowacja metodą orki, metoda uproszczona renowacji, plonowanie, udział komponentów w runi*

1. Introduction

Grasslands are the main source of roughage in farms producing milk and live cattle. High-quality sward of grassland, cut grass and grazed upon at the optimum time, as well as fertilized and treated appropriately in the growing season may be the only source of roughage for herbivorous animals in the conditions of organic farming [21, 26]. Of particularly importance for organic farming is animal grazing on the grassland sward, which improves the health, well-being, and resistance of animals compared with indoor breeding [25]. After 2012, it was assumed that own feed produced on an organic farm has to satisfy 100% of the nutritional needs of animals [11], including 60% roughage in the case of ruminants [12]. According to Krzywiecki [18], the profitability of milk and live cattle production on the farm is ensured by a high level of yields and a high-quality sward of grasslands, which are the best and the most cost-effective source of roughage for herbivorous animals. Therefore, a low-yielding, weed-infested, and neglected sward must be restored in order to increase its productivity and to enhance the nutrient composition and mineral feed, inter alia, by enriching the sward with valuable species of small-seed legumes, and grasses [3, 5, 6, 10, 13, 16, 28]. Successful grassland renovation depends on moisture conditions and the proper selection of legume and grass species (cultivars are important too) used for undersowing sward [10, 13].

Renovation of the sward of grassland in organic farms can be carried out for example. by fertilizing with PK or

manure, undersowing (sowing seed mixtures on the turf surface, or introduced into the turf using special slotted or milling sowing machines or by sowing seed mixtures after partial mechanical destruction of the old sward aimed at weakening competitiveness from the growing vegetation (low mowing of sward before sowing, harrowing, disking and rototilling) or by deep ploughing and sowing seeds of legume-grass mixtures using a grain drill [2, 4, 16, 17, 19, 21, 23, 24]. That latest method of grassland renovation (full tillage after ploughing) should not be used on organic farms due to the total destruction of plants occurring in the old sward, the decrease in the abundance of soil microorganisms, the loss of organic matter, and the emissions of greenhouse gases [14].

Grassland renovation involves using small-seed legumes and grasses available on the market or developing an original mixture of seeds of these species. The presence of legume seeds in the mixture makes it possible to bind atmospheric nitrogen by symbiotic bacteria in the process of symbiosis, which is of particular importance in farms producing feed and food organically, where using mineral nitrogen is prohibited.

In our research, conducted in ecological conditions, we used two methods of grassland renovation: after ploughing and after using a disc harrow. Sowing was performed using two commercially available mixtures Krasula and Cent 4, recommended by seed companies for cultivation under post-drought or varied-moisture conditions, as well as the original mixture.

The research hypothesis assumed increasing levels of yields and the percentage of legumes in the sward after grassland renovation with the method of soil loosening with a compact disc harrow compared to the grassland renovation with the method of full tillage (after ploughing) in the organic farming system.

The purpose of the research was to assess the productivity and species composition of the sward restored with the top soil loosening to the depth of 5 cm using a compact harrow and after plowing. The study will also verify the suitability for renovation of two legume-grass mixtures available on the market and of one original mixture.

2. Material and methods

A research on the grassland renovation according to the ecological principles was carried out at the Experimental Station of IUNG-PIB Grabów (voivodeship Mazowieckie). The study included a strict, 2-factor experiment established on the lessive soil formed on light loam. The seeds were sown in a split-block design, in four replications, on a gross area of 0.6 ha; a single plot having the size of 100 m^2.

The experiment was aimed to compare the impact of two research factors on yields and composition of legume-grass mixtures in the sword throughout three years of full use (2014-2016). The first factor of the experiment included two methods of grassland renovation: A- after ploughing + sowing the seeds of mixtures with a seed drill; B - after topsoil loosening to the depth of 5 cm with a compact disc harrow + sowing seeds of the mixtures with a seed drill. The second factor included three legume-grass mixtures: K - mixture Krasula (by Sowul & Sowul Sp. z o.o.) consisting of perennial ryegrass (25.7%), Italian ryegrass (9.19%), meadow timothy (13.79%), orchard grass (9.19%), red fescue (9.19%), tall fescue (9.19%), blue fescue (4.59%), red clover (4.59%), alfalfa (4.59%), bent grass (1.83%), + 3,5 $kg \cdot ha^{-1}$ white clover (cv. Romena, 8.11%), with the total of 15% of legumes; C - mixture Cent 4 (by company Centnas Sp. Z o.o.), consisting of: perennial ryegrass (40.0%), Italian ryegrass (10.0%), tall fescue (15.0%), meadow fescue (5.0%), meadow timothy (5.0%), meadow bluegrass (5.0%), festulolium (5.0%), alfalfa (10.0%) and white clover (5.0% %) with the total of 15% legumes; A – original mixture consisting of white clover cv. Barda (10%), hybrid alfalfa cv. Radius (20%), red clover cv. Milena (20%) (legumes accounting for 50% in total), perennial ryegrass cv. Artemis (15%), orchard grass cv. Amila (15%), meadow fescue cv. Anturka (10%), festulolium cv. Agula 10% in pure sowing, with the total of 50% of legumes of the sowing rate in pure sowing.

The seed company selling the Krasula mixture recommended sowing it together with 3,5 $kg \cdot ha^{-1}$ of white clover (cv. Romena). This mixture is intended for mowing and grazing use (30). Mixture Krasula + 3.5 kg of white clover is recommended for sowing on periodically post-drought soils due to its durability and freezing resistance.

Mixture Cent 4, according to the description on the website of Centnas Sp. Z o.o., is efficient even in the most difficult soil and climate conditions. It is suitable for mowing and grazing use, and it can be used for the latter up to 15 years (31).

In the year of sowing in May (2013), grassland was prepared for renovation. According to the research scheme, in the treatments restored with the method of full tillage, ploughing was performed down to the depth of 30 cm (treatment A), while in the treatments subject to topsoil loosening to the depth of 5 cm, a compact disc harrow was applied (treatment B). Directly before soil tillage under mixtures, fertilizers in the amount of 90 kg P/ha in the form of phosphate powder (30% P_2O_5) and 70 kg K ha in the form of potassium sulphate (50% K2O) were applied.

Sowing mixtures was carried out in the third decade of June, without cover plants. On the area of 1 ha, we sowed 40.0 kg of Krasula mixture seeds (after prior introducing white clover to the mixture); 34 kg of seed Cent 4 mixture seeds, and 23 kg of the original mixture seeds. In the year of sowing, weeds were destroyed by cutting the mixture sward after it reached the height of 30 cm. This procedure was performed twice, at the end of July and in August. In October, another sward regrowth was used for grazing of the herd of production cows. However, a small mass of this sward regrowth did allow to estimate the yield of forage for grazing, forage used, and the mass of waste fodder left by animals.

In the spring of each year of full use, at the start of vegetation, the mixtures were fertilized with manure in the amount of 10 $t \cdot ha^{-1}$, phosphorus (90 kg P/ha) and potassium (70 kg K/ha). In the years of research, after the first cut, 30 kg K/ha were applied on the mixture sward. During the three-year use, we performed 6 cuts of the sward for haysilage (most frequently, the first and third sward regrowths were cut), and organized grazing sessions for 85 and 79 cows on the remaining sward regrowths (respectively, on the second and fourth regrowth).

In the second and third year of sward use (2015 and 2016), the last, fourth regrowth of sward was small, thin, and low, and hence, not suitable for determining the yield of green and dry mass for grazing or the yield of forage used by cows, so the sward was used for grazing.

In our studies, we determined the yields of green and dry mass offered to and consumed by animals and mass of remaining's on the quarter left by animals. At the time of harvesting and grazing, two samples of green forage of the weight 0.5 kg were taken from each plot. One of them was used for calculating the drying index necessary for the calculation of dry matter yields. The second ample was subject to a simplified botanical and-weight analysis, with the division of the sward into grass, alfalfa, clover and weeds.

3. Meteorological conditions in the years of the study

The mixtures were sown on 20 June 2013 in good moisture and temperature conditions. Before sowing the mixtures, in May and June, there were large but unevenly distributed rainfalls, exceeding by, respectively, 1.9 to 1.6 times the precipitation from the many-year period; it was also warmer (Table 1). Under these conditions, mixture seeds germinated quickly, and the first emergences were observed already after 7 days after sowing. Favorable moisture and temperature conditions promoted the growth and development of weeds. Perennial weeds such as common dandelion and broad-leaved dock, especially on a renewed treatment after soil loosening to the depth of 5 cm with a disc harrow (B). In the year of sowing (2013), significant deterioration of weather conditions was recorded in July and August. Small precipitation (by, respectively, 20.8 and 11.6 mm) and temperatures higher than the average from the many-year period adversely affected the development of the mixtures. A number of weeds increased in this period. To control them, it was necessary to cut the mixtures twice. In the year of sowing (2013), in mid-October, the whole sward from the experiment was grazed to a herd of cows without prior estimation of the yields of the feed for grazing and of the feed consumed by the animals on the pasture.

In 2014 (1st year of use) the sum of precipitation for the period from March to August was considerably higher than the average for many years (Table 1). In May, rainfall was 3-fold higher compared to this average. A large amount of precipitation was also recorded in July. Thermal conditions in that year, except for March and July, were close to the multi-year average, so the mixtures had good conditions for yield and growth. Favorable weather conditions in 2014 (1st year of use) allowed for collecting 4 regrowth of mixture sward (first and second regrowths to be used for silage, while the third and fourth ones – for cow grazing).

In 2015 (the 2nd year of use) plant vegetation started early. Plant and plant hygienic and thermal conditions were observed in March and May, which resulted in high spring yield. In the later months (June, July, August) significant moisture deficiency led to a decrease in yield in subsequent runoff. Therefore, in the second year of use, 3 collections of mixtures were carried out. The first sward regrowth was destined for silage while the second and third were grazed for cows. Cow grazing was also performed on the fourth regrowth, but the yields of dry matter and of feed consumed by cows were not determined.

2016 (the 3rd year of use) proved to be drier (352.7 mm rainfall) and warmer than the multi-year average (408 mm rainfall). The lack of rainfall, observed throughout the entire growing season, limited the growth of mixture. In the third year of use, the second, third and fourth regrowths of the sward were grazed to cows. Similarly as in the previous year, due to the low sward yield, the yield of dry matter for grazing and of feed actually consumed by cows were not estimated.

Table 1. Meteorological conditions in the years 2013-2016 in AES Grabów, Poland during the growing season
Tab. 1. Warunki meteorologiczne w okresie wegetacji w latach 2013-2016 w RZD IUNG-PIB Grabów

Month	2013	2014	2015	2016	Mean for the multi-year period 1871-2000
Total monthly rainfall (mm)					
III	41,1	42,0	63,2	52,3	30
IV	29,9	56,6	34,8	45,1	41
V	112,0	154,9	107,0	39,4	57
VI	116,3	90,7	30,3	60,1	71
VII	20,8	115,3	51,7	81,9	84
VIII	11,6	98,8	6,2	53,6	75
IX	63,9	15,9	93,9	20,3	50
Average monthly air temperature°C					
III	-2,1	6,3	5,0	3,9	1,6
IV	8,3	9,9	8,1	9,2	7,8
V	15,3	13,5	12,7	14,9	13,4
VI	18,6	15,2	16,9	18,7	16,8
VII	19,7	20,4	19,7	19,2	18,4
VIII	19,2	17,9	22,1	18,1	17,3
IX	11,8	14,4	15,0	15,7	13,2

Source: own work / Źródło: opracowanie własne

4. Results and discussion

In the first year of mixture use (2014), the yields of dry matter offered and consumed by animals were similar regardless of the species composition of the mixtures (Fig. 1). There was a tendency towards better yields of mixture Krasula blend + 3.5 kg of white clover and of the original mixture compared to mixture Cent 4.

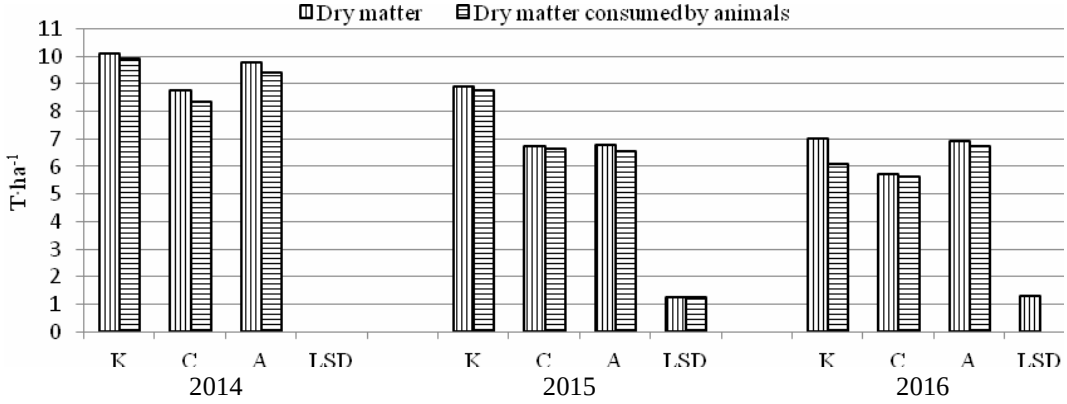
As previously shown, the yields of the mixtures used for undersowing grassland are highly influenced by their species composition [1, 13] and the percentage and durability of legumes in the mixture sown [1, 2, 3, 22, 29]. Łyszczarz i Dębek [20] stated that undersowing of grassland should be carried out with multi-species legume-grass mixtures consisting of species with different water needs, which ensures yield stability and soil protection against excessive weed infestation. Other studies have shown that even multiple undersowing of grassland by direct sowing using special seed drills may fail if the mixtures include plant species not proper for given habitat or sward use method [19]. The authors of these studies, conducted under conventional conditions, have obtained good results after application of multi-component clover mixtures: bastard clover, white clover, and red clover with grasses. In contrast, alfalfa turned out to be not a proper component for the mixtures [19]. Other studies showed a rapid yield increase after undersowing grassland with mixtures containing tetraploid cultivars of ryegrass [9, 10] and orchard grass, which tolerates rainfall deficits [15].

Low yields of mixture Cent 4 in own studies can result from using mixtures of alfalfa seeds (10%), which, according to Łyszczarz et al. [19] is not suitable for undersowing meadows due to the quick recession of the sward. Another cause for the low yields of mixture Cent 4 could be the lack of orchard grass in the species composition of this mixture, which adapts to different habitat conditions and may develop well during the period of rainfall deficit and inhibit

the growth of weeds in the sward [20].

In the second year of use (2015), significantly higher yields of dry matter yield and of feed consumed by cows were recorded for mixture Krasula + 3.5 kg of white clover compared the rest of the mixtures (Cent 4 and the original mixture). Similarly as in previous years, in the third year of sward use (2016), Cent 4 yielded the lowest (Fig. 1). In this year of use, the yield of feed consumed by animals was similar regardless of the species composition of the compared mixtures. In subsequent years of use, the yield of legume-grass mixtures significantly decreased. It can be attributed to worse moisture conditions in 2015 and 2016 (Table 1), thinning of the sward, the recession of the valuable species from the sward, and the increase of weed infestation. The decrease in the level of the yields of the mixture sward in further years of use was observed in our other studies [8].

In the first and third year of use (2014 and 2016), the method of grassland renovation effected the yields of dry matter offered to and taken by animals (Fig. 2). In the treatment renewed by the surface destruction of the old sward of grassland to the depth of 5 cm with a compact harrow (treatment B), the mixtures gave significantly higher yields of dry matter and of dry matter consumed than in the renewed using full tillage after ploughing (treatment A). The obtained results are confirmed by the studies of Baryła and Kulik [3, 4] carried out under conventional methods of management in terms of the high sward yields after shallow loosening of topsoil before undersowing of grassland (treatment B) compared with the yields of the sward renew with the method of full tillage after ploughing (treatment A). Similar results were obtained also by Terlikowski and Barszczewski [24]. Loosening of topsoil before undersowing the sward with legume-grass mixtures creates good conditions for the partial regrowth of grasses from the old sward, which probably contributes to better yields of this sward in comparison with the sward renewed with full tillage after ploughing.

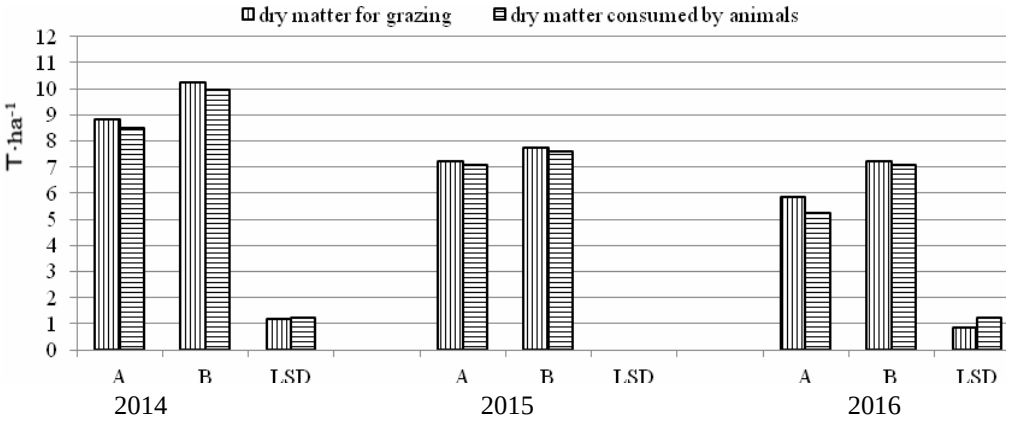


Mixtures: **K** – Krasula + 3,5 kg white clover cv. Romena consisting of: perennial ryegrass (25.7%), Italian ryegrass (9.19%), meadow timothy (13.79%), orchard grass (9.19%), red fescue (9.19%), tall fescue (9.19%), blue fescue (4.59%), red clover (4.59%), alfalfa (4.59%), bent grass (1.83%) + 3,5 kg·ha^{-1} white clover (cv. Romena, 8.11%); **C** – Cent 4 consisting of: perennial ryegrass (40.0%), Italian ryegrass (10.0%), tall fescue (15.0%), meadow fescue (5.0%), meadow timothy (5.0%), meadow bluegrass (5.0%), festulolium (5.0%), alfalfa (10.0%) and white clover (5.0% %); **A** – original mixtures consisting of: of white clover cv. Barda (10%), hybrid alfalfa cv. Radius (20%), red clover cv. Milena (20%) (legumes accounting for 50% in total), perennial ryegrass cv. Artemis (15%), orchard grass cv. Amila (15%), meadow fescue cv. Anturka (10%), festulolium cv. Agula 10% in pure sowing

Source: own work / Źródło: opracowanie własne

Fig. 1. The annual yield of the dry matter for grazing and feed consumed by animals in the years of use depending on the species composition of mixtures (t·ha^{-1})

Rys. 1. Roczny plon suchej masy do wypasu oraz paszy pobranej przez zwierzęta w latach użytkowania w zależności od składu gatunkowego mieszanek (t·ha^{-1})



A – ploughing and mixture sowing with a seed driller; B – compact harrow and mixture sowing with a seed drill

Source: own work / Źródło: opracowanie własne

Fig. 2. Yields of dry matter offered to and consumed by cows depending on the method of mixture sowing

Rys. 2. Plony suchej masy do wypasu i suchej masy pobranej w zależności od sposobu siewu mieszanek

In this study, we recorded a decrease in the level of mixture yields in the subsequent years of use, which in the third year amounted to 3-4 $t \cdot ha^{-1}$ in the case of dry matter yield and about 4-5 $t \cdot ha^{-1}$, respectively, for feed consumed by cattle (Fig. 2). Lower yields in subsequent years after sowing have also been observed in other studies concerning legume-grass mixtures [8].

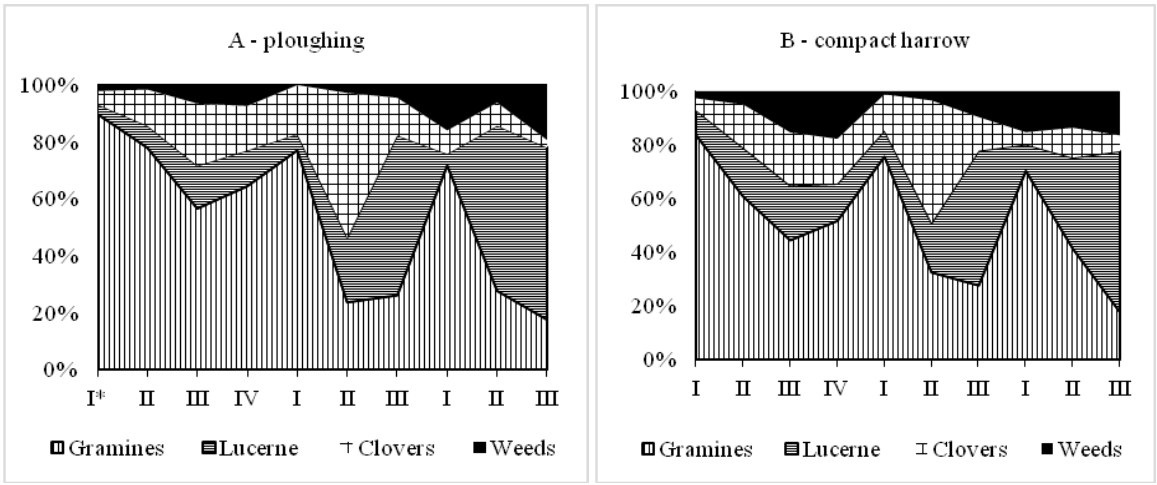
From the point of view of feed and nutrition value, the best feed for ruminants is obtained from the mixtures where grasses and legumes have a balanced percentage, 50% each. However, agrotechnological and weather conditions, a method of the use sward of meadows and pastures, and the competitiveness and durability of the species, cause dynamic changes in the proportions of components in individual regrowths of the sward and years of use [7, 8]. Under favorable conditions, certain legume species, i.e. white clover, can appear spontaneously [13]. Approximately 20-30% share of legume in a pasture sward is the most suitable for grazing animals [14].

In the first year of mixture use (2014) in the treatments after ploughing (treatment A) and after a compact harrow (treatment B), the mixture sward was dominated by grasses (about 83 to 89%), and alfalfa was outnumbered by clover (Fig. 3). In the treatment renewed with full tillage after ploughing (treatment A), weed infestation in the first and fourth regrowth in the first year of use sward (2014) was approximately 2.5 to 7.6% (Fig. 3). A larger percentage of weeds in the sward was observed when the sward was renewed with the method of destroying old sward to the depth 5 cm with a compact harrow (treatment B). Probably a part of the weeds from the old sward of this treatment (treatment B) regenerated and regrew, so it was more weed-infested than one renewed with full tillage after ploughing (treatment A). In the year of the sowing, clovers dominated among legumes (Fig. 3).

In the second year of use (2015), a percentage of grasses decreased significantly, especially in second and third regrowth of sward, up to about 24% after ploughing in treatment A, and to 32% after using a compact harrow in treatment B. In that year of use, in the third regrowth of sward renewed with the method of full tillage after ploughing (treatment A) and after using a compact harrow (treatment B), the percentage of alfalfa increased by up to 56% (in treatment A) and up to 50% (treatment B), while the percentage of clover decreased to 12-13% (Fig. 3). Probably, a prolonged drought affected the changes in the proportion of components in the mixture sward and decreased the yields of clover in the sward. There was a large weed infestation of the sward renewed with the method of soil loosening to a depth of 5 cm after using a compact harrow (treatment B) compared to the sward after ploughing (treatment A).

In the spring regrowth in the third year of use (2016) grasses dominated in the sward, however, in summer and autumn, under moisture deficit in the soil and air temperatures above the mean of the many-year period, alfalfa was the most abundant in the sward (about 60%), a percentage of grasses increased, and weed infestation in the sward was approximately from 16% when the sward renovation was performed by soil tillage to a depth of 5 cm (treatment B) to about 20% after the traditional renovation of grassland after ploughing and full tillage (treatment A) (Fig. 3). According to Terlikowski and Barszczewski [24], renewing grassland with the method of full tillage (ploughing) effectively protects the sward against weeds in the year of sowing, however, in further years, after the recession of valuable species from the sward, their place is taken by herbs and weeds. In the year of undersowing, annual weeds are eliminated by sward cutting performed twice [19].

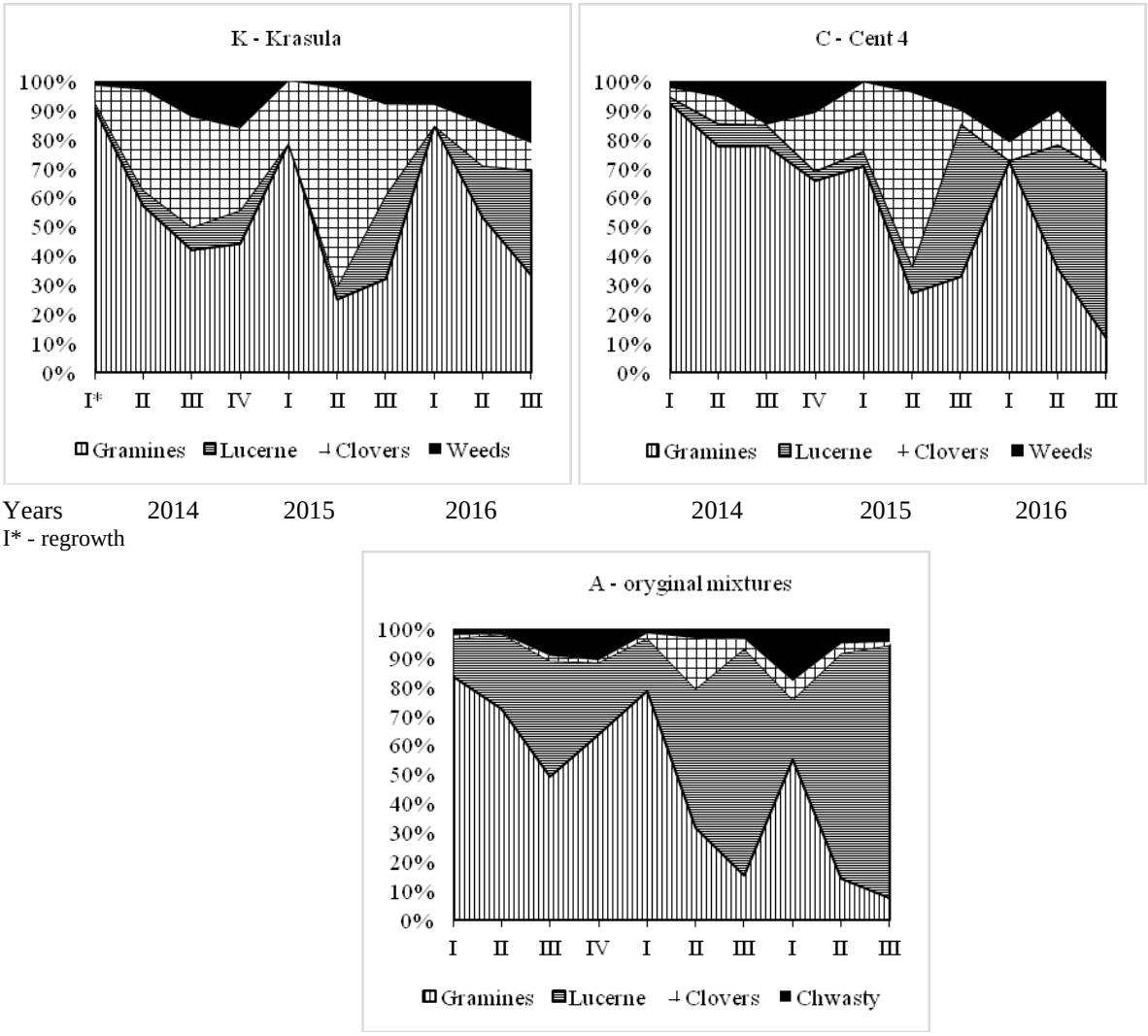
Species composition of the mixtures and weather conditions affected the proportions of components in the sward of legume-grass mixtures (Fig. 4). In the spring of each year of use, the sward of the compared mixtures was dominated by the grasses, which in the summer and autumn, under worse moisture conditions (Table 1), receded from the sward, and their place was taken by legumes. In the years of the research, in the summer and autumn, mixture Krasula + 3.5 of kg clover white and the original mixture had the most balanced (i.e. close to 50%) share of grasses and legumes in the sward. During this period, mixtures Krasula and Cent 4 were more weed-infested than the original mixture, especially in the third year of use which saw a significant moisture deficit in the soil (Fig. 4).



Source: own work / Źródło: opracowanie własne

Fig. 3. The percentage of components in the dry matter yield depending on the method of mixture sowing in the years 2014-2016

Rys. 3.Udział komponentów w plonie suchej masy w zależności od sposobu siewu mieszanek w latach 2014-2016



Source: own work / Źródło: opracowanie własne

Fig. 4. The percentage of components in the dry matter yield depending on species composition of mixtures in the years 2014-2016

Rys. 4. Udział komponentów w plonie suchej masy w zależności od składu gatunkowego mieszanek w latach 2014-2016

In the first and second year of use, sward of mixture Krasula + 3.5 kg of white clover contained very small amounts of alfalfa, but its large quantities appeared in the third year of use (Fig. 4). In the sward of the original mixture, which included white clover (10%), red clover and alfalfa (20% of each species), a different situation was observed (Fig. 4). The composition of this mixture was dominated by alfalfa, which in the second and third year of use (2015 and 2016), almost completely eliminated grasses species from the sward, while clover (white and red) occurred only in small quantities (Fig. 4). Quick clover recession from the sward of mixtures has been confirmed also by the studies of Jankowska-Huflejt [15], carried out in ecological conditions. The author has shown that bastard clover died out in 2 years after the undersowing, while red clover frozes after 4 years of use of the undesown sward [14]. Other researchers also highlighted a low durability of legumes after sward renovation with legume-grass mixtures [24]. In literature, we can find contrasting information on the increasing percentage of red clover in the subsequent years of sward use [2, 23, 27].

Among legumes, alfalfa is the most resistant to soil moisture deficits, probably due to, as our research showed, the dominance of the species in the sward. Another view on the durability of alfalfa is presented by Łyszczarz et al. [19] and Dembek and Łyszczarz [5] who found almost complete disappearance of alfalfa in the sward of renewed grassland. This phenomenon intensified under cattle grazing. Another view on this topic is presented by Gaweł [7], who showed good durability, high percentage in the sward, and better yields of the mixtures with alfalfa compared with red clover mixed with grasses.

4. Conclusions

1. Under ecological conditions, the renovation of sustainable grassland by means of a simplified method of loosening the topsoil to a depth of 5 cm with a compact disc harrow (treatment B) turned out to be more favorable due to higher yields of dry matter and animal feed compared to the conventional sowing of legume-grass mixtures and full tillage (treatment A).

2. The assessment of the suitability of the compared legume-grass mixtures for grassland renovation showed that mixture Krasula + 3.5 kg of white clover and the original mixture were the most suitable under conditions of periodic soil moisture deficits compared to mixture Cent 4 .
3. Regardless of the method of grassland renovation or the species composition of the mixtures, in the first year of use and in the spring regrowth in the subsequent years, the renewed sward had a high percentage of grasses. However, due to the deteriorating moisture conditions starting from the second year of use, legumes (red clover, white clover, and alfalfa) dominated the mixture sward. Mixture Krasula + 5 kg of white clover and the original mixture had the most balanced composition after grassland renovation.
4. Multi-species mixtures containing alfalfa or red clover were found to be suitable for undersowing grassland, while orchard grass determined the success of this operation.

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