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Received: 2018-08-24 ; Accepted: 2018-09-11

EFFECT OF APPLICATION OF MINERAL FERTILIZERS CONTAINING BIOLOGICAL ADDITIVES ON BOTANICAL COMPOSITION, NITROGEN STATUS AND YIELDING OF GRASS-LEGUME SWARD

Summary

The research was based in Experimental Station of the Department of Grassland and Natural Landscape Sciences at Poznań University of Life Sciences located in Brody Experimental Farm. Research on the influence of various doses of nitrogen fertilizer N-14, Physioactiv, Physiostart and PinKstart fertilizers applied in grass-legume mixture was conducted in the years 2016-2017. The following variants and doses of fertilizers were applied in the experiment: 1/ 300 kg·ha^{-1} N-14 under each regrowth (total of 900 kg·ha^{-1}) + PK; 2/ 300 kg·ha^{-1} N-14 under the first regrowth and 180 kg·ha^{-1} of ammonium nitrate 34% N under the second and the third regrowth + PK; 3/ standard fertilization – 180 kg·ha^{-1} of ammonium nitrate 34% N under each regrowth + PK; 4/ Physioactiv fertilization in a dose of 300 kg·ha^{-1} before vegetation and 180 kg·ha^{-1} of ammonium nitrate 34% N under each regrowth + PK; 5/ Physiostart in a dose of 20 kg·ha^{-1} before vegetation and 180 kg·ha^{-1} of ammonium nitrate 34% N under each regrowth + PK; 6/ PinKstart in a dose of 20 kg·ha^{-1} before vegetation and 180 kg·ha^{-1} of ammonium nitrate 34% N under each regrowth + PK; 7/ absolute control – no fertilization. The highest yield of a dry matter of a grass-legume mixture in the two years of utilization was a result of an application of a nitrogen fertilizer N-14 which was applied under every regrowth and in a variant of application just under the first regrowth, together with a dose of phosphorus and potassium. A biological additive on the basis of sea algae (Pheoflore complex) in N-14 fertilizer resulted in higher yields of the sward, despite smaller dose of nitrogen when compared to variants fertilized with ammonium nitrate. An application of a calcium fertilizer Physioactiv with aminopurine resulted in an increase in a share of white clover in the sward and in a better nutrition of plants with nitrogen which was visible in the highest values of a leaf blades greenness index both in the case of white clover and perennial ryegrass. It may be presumed that the positive effects of the application of the analyzed fertilizers might originate from their formulation due to the joint of mineral components used in traditional fertilizers with biological additives which stimulate a root system, activate soil's flora and therefore enhance the state of rhizosphere.
***Key words**: mineral fertilizers, biological additives, grass-legume mixture, sward yield*

WPŁYW STOSOWANIA NAWOZÓW MINERALNYCH ZAWIERAJĄCYCH DODATKI BIOLOGICZNE NA SKŁAD BOTANICZNY, ODŻYWIENIE AZOTEM I PLONOWANIE RUNI TRAWIASTO-BOBOWATEJ

Streszczenie

Badania przeprowadzono w Stacji Doświadczalnej Katedry Łąkarstwa i Krajobrazu Przyrodniczego zlokalizowanej w RGD Brody Uniwersytetu Przyrodniczego w Poznaniu. Prace badawcze nad wpływem stosowania zróżnicowanych dawek nawozów mineralnych N-14, Physioactiv, Physiostart i PinKstart w zasiewie mieszanki trawiasto-bobowatej prowadzono w latach 2016-2017. Zastosowano następujące warianty i dawki nawożenia: 1/ 300 kg·ha^{-1} N-14 pod każdy odrost (łącznie 900 kg·ha^{-1}) + PK; 2/ 300 kg·ha^{-1} N-14 pod pierwszy odrost i 180 kg·ha^{-1} saletry amonowej 34% N pod drugi i trzeci odrost + PK; 3/ nawożenie standardowe NPK – 180 kg·ha^{-1} saletry amonowej 34% N pod każdy odrost + PK; 4/ nawożenie Physioactiv w dawce 300 kg·ha^{-1} przed ruszeniem wegetacji i 180 kg·ha^{-1} saletry amonowej 34% N pod każdy odrost + PK; 5/ Physiostart w dawce 20 kg·ha^{-1} przed ruszeniem wegetacji i 180 kg·ha^{-1} saletry amonowej 34% N pod każdy odrost + PK; 6/ PinKstart w dawce 20 kg·ha^{-1} przed ruszeniem wegetacji i 180 kg·ha^{-1} saletry amonowej 34% N pod każdy odrost + PK; 7/ kontrola absolutna – bez nawożenia. Przeprowadzone badania wykazały, że najwyższe plony suchej masy runi mieszanki trawiasto-bobowatej w ciągu dwóch lat użytkowania stwierdzono w następstwie stosowania nawozu azotowego N-14, który był podawany pod każdy odrost oraz w wariancie aplikacji tego nawozu tylko pod pierwszy odrost, wraz z dodatkową dawką fosforu i potasu. Dodatek biologiczny na bazie wyciągu z alg morskich (kompleks Pheoflore) w nawozie N-14, pomimo wprowadzania do gleby niższej dawki azotu, w porównaniu do wariantów nawożonych saletrą amonową, skutkował uzyskiwaniem wyższych plonów runi. Aplikacja nawozu wapniowego Physioactiv z dodatkiem aminopuryny wpłynęła na zwiększenie w runi udziału koniczyny białej oraz na lepsze odżywienie roślin azotem, co przejawiało się uzyskiwaniem najwyższych wartości indeksu zieloności liści, zarówno w przypadku koniczyny białej, jak również życicy trwałej. Istnieją uzasadnione przesłanki, że korzystne efekty stosowania badanych nawozów mogą być skutkiem ich formulacji ze względu na łączenie składników mineralnych wykorzystywanych w tradycyjnych nawozach wraz z dodatkami biologicznymi stymulującymi system korzeniowy roślin oraz aktywizujących florę glebową poprawiającą stan ryzosfery.
***Słowa kluczowe**: nawozy mineralne, dodatki biologiczne, mieszanka trawiasto-bobowata, plon runi*

1. Introduction and aim of the study

An aim of fertilization is to maintain soil's fertility, all the physical and chemical parameters, biological activity of microorganisms and abundance in necessary nutrients. Fertilization should be conducted with components of which there is deficiency in a soil complex and in such a way that provides maintenance of soil's fertility [11]. In order to reach yield-forming of tillage, it is crucial to regulate soil's reaction as well as to provide a plant with all the necessary mineral nutrients and water. If these requirements aren't met, not only is the yield low, but also profitability of production drops [7,8]. Changes in law and requirements concerning the use of nitrogen force agricultural producers to keep a fertilization balance which allows for cheaper production and minimizing of costs and environmental friendly actions at the same time [12]. The knowledge about nitrogen and phosphorus cycles and their balancing results in the drop of arable production waste and efficient management of these components [1]. Fertilization balance allows for the monitoring of changes in the farm concerning the application of fertilizers, doses of nitrogen and the use of a crop stubble which is rich in nitrogen [7].

Nowadays, numerous complex fertilizers are available. They contain nutrients easily available for plants and highly concentrated in a fertilizer. By distribution of complex fertilizers, both basic nutrients and many other macro- and microelements are provided. A small amount of them is crucial for proper growth and development of plants. Apart from nitrogen, potassium and phosphorus, complex fertilizers may contain Mg, Na, Ca, S and B. Currently, in formulation and production of nitrogen fertilizers, substances which enhance the speed of rooting are added, which results in the stimulation of cell division in roots or introduce culture medium which activate soil's microflora [13]. In 1980s also slow-release nitrogen fertilizers such as agramid and agroform were paid special attention to [3]. Agramid was produced on the basis of granulated urea which was coated with sulphur; therefore, the fertilizer dissolved slower when distributed in a soil. Chodań et al. [2] conducted research on its usefulness in the fertilization of cocksfoot. The aim of biological additives used in modern nitrogen fertilizers is to boost the effectiveness of their intake by plants at smaller doses when compared to traditional nitrogen fertilizers such as ammonium nitrate or urea.

A list of non-compound fertilizers and compound ones with additives that stimulate growth of both plants and soil microorganisms, is systematically becoming longer and longer which makes it necessary to learn their effectiveness and action in fertilizing various arable crops and grasslands. The aim of the research was to assess the influence of new generation mineral nitrogen fertilizers, starter and calcium micro-fertilizers with biological additives on a botanical composition of swards and yielding of grass-legume mixture as well as on nitrogen status of its selected plants components.

2. Material and methods

The research was carried out at the Experimental Station of the Department of Grassland and Natural Landscape Sciences at Poznań University of Life Sciences located in Brody Experimental Farm. Research on the influence of various doses of nitrogen fertilizer N-14 produced by Timac, Physioactiv, starter fertilizers Physiostart and PinKstart, phosphorus-potassium fertilizers applied in BG-6 Milkway Super grass-legume mixture produced by Barenbrug, was conducted in the years 2016-2017. N-14 nitrogen fertilizer contained 14% of nitrogen (7% in an ammonia form and 7% - in an amide form), 22% of CaO, 2% of MgO, 28% of SO_3 and Pheoflore complex. The complex is based on the extract of sea algae, rich in carbohydrates and polypeptides and, according to the producer, it activates soil's bacterial flora, which optimizes organic matter management and enhances a mineralization process, which allows for the increase in nitrogen and phosphorus available in soil for the plants. Physioactiv is a calcium fertilizer which contains 76% of $CaCO_3$ in a form of Mezocalc, 3% of MgO and aminopurine - a natural extract from sea algae which provides bio-stimulation of plants' root systems. Also starter fertilizers such as Physiostart and PinKstart in a form of a microgranules were used in the experiment. The first fertilizer contained 8% of ammonium nitrogen, 25% of $CaCO_3$, 23% of SO_3, 28% of P_2O_5, 2% of Zn and Physio+ complex which boosts physiological stimulation of early development of plants' root systems (especially of root hair). The PinKstart contained 48% of $CaCO_3$, 4.5% of SO_3, 28% of P_2O_5, 5% of K_2O and Physio+ complex (like in the first one). In this additive, cooperation of aminopurine and Mezolac (highly reactive calcium carbonate) was used, which stimulates intensive growth of plants' root systems (especially of root hair). According to the producer, its application results in more effective intake of calcium and intensive development of a root system from the beginning of vegetation. It also prevents plants from the effect of "a lazy root" as plants build a root system despite favorable conditions connected with an optimal availability of nutrients.

The following variants and doses of fertilizers were applied in the experiment: 1/ 300 kg·ha^{-1} N-14 under each regrowth (total of 900 kg·ha^{-1}) + PK; 2/ 300 kg·ha^{-1} N-14 under the first regrowth and 180 kg·ha^{-1} of ammonium nitrate 34% N under the second and the third regrowth + PK; 3/ standard fertilization – 180 kg·ha^{-1} of ammonium nitrate 34% N under each regrowth + PK; 4/ Physioactiv fertilization in a dose of 300 kg·ha^{-1} before vegetation and 180 kg·ha^{-1} of ammonium nitrate 34% N under each regrowth + PK; 5/ Physiostart in a dose of 20 kg·ha^{-1} before vegetation and 180 kg·ha^{-1} of ammonium nitrate 34% N under each regrowth + PK; 6/ PinKstart in a dose of 20 kg ha^{-1} before vegetation and 180 kg·ha^{-1} of ammonium nitrate 34% N under each regrowth + PK; 7/ absolute control – no fertilization. Phosphorus-potassium fertilization with granulated triple superphosphate 46% P_2O_5 and potassium salt containing 60% of K_2O was applied once a year, in spring, before vegetation in every variant of fertilization in doses of 80 kg·ha^{-1} P and 80 kg·ha^{-1} K, apart from an absolute control. The experiment was conducted in a soil of class IIIb formed on a light clayey sand with 30 cm thickness of a humus horizon. Physical and chemical parameters of the soil were: content of humus – 1.24%, share of floatable parts – 16%, mildly acidic reaction of a soil (pH_{KCl} = 6,5), content of macro components - 57.0 mg of P_2O_5, 20.7 mg of K_2O and 3.8 mg of Mg per 100 g of a soil.

Seeds from a grass-legume mixture were seeded manually in September 2015 in the plots of 15 m^2 each (1.5 m x 10.0 m) in randomized block design, in three replications. A seed rate of a mixture was 40 kg·ha^{-1} and its content was:

perennial ryegrass 2N – 20%, perennial ryegrass 4N – 20%, Italian ryegrass 2N – 10%, meadow fescue - 15%, tall fescue – 5%, timothy – 20%, white clover – 10%. Weather conditions in March – September in the years 2016-2017 were presented in Table 1.

Table 1. Weather conditions during the vegetation period in Brody in the years 2016-2017
Tab. 1. Warunki atmosferyczne w okresie wegetacji w Brodach w latach 2016-2017

Month	Average daily air temperature (°C)		Total rainfall (mm)	
	2016	2017	2016	2017
III	4.0	6.7	12.0	40.5
IV	8.8	7.7	26.4	25.7
V	15.3	14.0	45.9	49.2
VI	18.2	17.7	54.5	106.0
VII	19.1	18.4	57.3	160.8
VIII	17.9	18.9	53.8	150.6
IX	16.8	13.6	50.3	54.8

Source: own study / Źródło: opracowanie własne

It turned out that both an average daily air temperature and a total rainfall varied significantly in each month of a vegetation season in the following years. In the summer of 2017 rainfall was higher when compared to mean annual precipitation. In order to present moisture conditions in each vegetation month in these years, Sielianinow's hydrometrical indexes were calculated (Table 2). In the period from April to September 2016, moisture conditions were permanent - dry/fairly dry. 2017 was more favorable as conditions marked on a scale (K) in May and June were fairly dry, in September – optimal, in April and June – fairly moist and in July and August – even very moist.

Table 2. Value of hydrometrical index of Sielianinow (K) in individual months and study years
Tab. 2. Wartość współczynnika hydrotermicznego Sielianinowa (K) w poszczególnych miesiącach i latach badań

Study years	Month						
	III	IV	V	VI	VII	VIII	IX
2016	0.96	1.00	0.97	0.99	0.96	0.97	1.00
2017	1.95	1.11	1.13	1.99	2.81	2.57	1.34

The characteristics of a moisture-month determined by Skowera and Pakuła [13] depending on the K value: extremely dry <0.4, very dry – 0.4 <K <0.7, dry – 0.7 <K <1.0, fairly dry – 1.0 <K <1.3, the optimal – 1.3 <K <1.6, fairly moist – 1.6 <K <2.0, moist – 2.0 <K <2.5, very moist – 2.5 <K <3.0, extremely moist – K> 3.0

Source: own study / Źródło: opracowanie własne

In the utilization years, three regrowths of sward were collected at the same time. Its botanical composition, yield of a dry matter of each regrowth and nitrogen status of plants were examined (the last one – with an N-tester). Yields of dry matter of sward were assessed with a method of experimental cuts in an area of 7.5 m^2 in each plot and determination of the content of dry matter in the samples of sward with a dryer-weight method using Binder's chamber dryer. A botanical composition of sward of a grass-legume mixture was examined in the third regrowth with Stebler's and Schröter's weight-botanical method modified by Filipek [4]. Samples of sward were harvested randomly from each variant of an experiment from representative places in each plot. Next, fresh plant material was divided into sward components and their percentage share in weight of green mass was determined. Plants' nutrition with nitrogen was assessed before mowing each regrowth with N-tester (0-800 scale). An index of leaf greenness, stated in a value of SPAD (Soil Plant Analysis Development) i.e. the difference between absorption of light of 650 nm and 940 nm was marked. There is a positive correlation between a content of chlorophyll dyes and the status of plants' nitrogen nutrition [5,6]. Two measurements were made on well-developed leaf blades of perennial ryegrass and white clover uptake randomly from each fertilization variant. In the first year of utilization (2016), the first regrowth was harvested on May, 31st, the second regrowth – on July, 12th, the third regrowth – on September, 6th. In the second year of utilization (2017) the regrowths were harvested as follows: May, 23rd, July, 11th, August 29th. Statistical analysis of the results was completed with Statistica, Analwar 5.2 FR and MS Excel. The significance of differences between the means were verified with Tukey's test at the level of significance of p=0.05.

3. Results and discussion

The best effects of yielding of a grass-legume mixture in the first year of the research were obtained in variants N-14 (900) + PK and PinKstart + NPK (Table 3). In both cases, an annual yield of sward per hectare reached the level of 13.4 t DM. In the second year, variants N-14 (900) + PK and N-14 (300) + PK were the most effective fertilizers with the yield of 17.27 and 16.85 t DM, respectively. Such extremely high yield in 2017 was also due to weather conditions i.e. above average amount of precipitation in the vegetation season. An impact of an applied variant of fertilization on the yield of a grass-legume mixture in both years of utilization was significant. In the analysis of an average yield of a dry matter of sward obtained in the two years of utilization, it is visible that - apart from an absolute control - the lowest yield was harvested from a variant of Physioactiv + NPK. In both cases, such a result was strongly determined by a high share of white clover in the sward, i.e. 55% and 38% in the second year, respectively (Table 6). The reaction of plants in grass communities to the application of calcium in fertilizers, has already been well recognized. The main aim of liming is to neutralize a harmful impact of aluminum and to boost the content of calcium in a soil [9].

Table 3. Effect of application of different fertilization variants on the sward yield in the successive years of use (t·ha^{-1} DM)
Tab. 3. Wpływ stosowania zróżnicowanych wariantów nawożenia na plonowanie runi w kolejnych latach użytkowania (t·ha^{-1} s.m.)

Fertilization variant	1st year of use	2nd year of use	Mean
N-14 (900) + PK	13.40	17.27	15.33
N-14 (300) + PK	12.55	16.85	14.70
NPK	12.77	15.88	14.32
Physioactiv + NPK	12.59	14.66	13.62
Physiostart + NPK	12.65	16.28	14.46
PinKstart + NPK	13.48	14.90	14.19
Absolute control	9.32	12.11	10.71
$LSD_{0.05}$	0.878	1.346	x

$LSD_{0.05}$ for mean years of use = 2.162

Source: own study / Źródło: opracowanie własne

The rate of yield increase and changes in the content of this component in the sward in a vegetation season is one of the ways to determine plants' reaction to the increase in available calcium in a soil under grasslands. A yielding effect of liming should always be assessed in the interaction with nitrogen which determines yield increase in grass sward [8]. In grass-legume sward, calcium enhances the development of legume plants by stimulating their growth and boosting their share in the sward, which was observable after an application of Physioactiv. According to the research conducted on a mountain grassland, which is naturally acidic, after an application of calcium, a yielding effect of nitrogen was much stronger which was visible in higher yields. In locations fertilized with nitrogen, it was only in the second regrowth that the content of calcium grew significantly [10].

In order to better use nitrogen applied in mineral fertilizers and present in soils, control of a status of plants' nutrition is necessary. A fast measurement of this status is possible owing to an index of a leaf blades greenness. On the basis of conducted research it was observed that an impact of application of calcium in Physioactiv fertilizer used at the beginning of vegetation season on SPAD index, was favorable. In the first year, the highest SPAD index in leaf blades of a white clover was found in variant Physioactiv + NPK in the 1st and 3rd regrowth; 637 and 603 respectively (Table 4). Index SPAD for white clover in this variant was also the highest in an annual average (609). High values of SPAD index were also observed in white clover with supplement fertilization (apart from standard NPK fertilizers) with starter fertilizers Physiostart and PinKstart containing calcium. In the case of perennial ryegrass, the highest values of SPAD index (above 440) in the first regrowth were observed in variants: N-14 (900) + PK, N-14 (300) + PK and Physioactiv + NPK. The highest greenness index of perennial ryegrass (377), alike white clover, was obtained with NPK + Physioactiv - calcium fertilizer. Lack of fertilization resulted in very low values of greenness index for perennial ryegrass (Table 4).

In the second year, white clover from Physioactiv + NPK fertilization variant reached the highest values of SPAD index in all regrowths and in an annual average (Table 5). The lowest indexes of leaf blades greenness were found in the white clover under control (ca. 531). Perennial ryegrass had the best reaction to fertilization which was visible in the index higher than 380 in N-14 and Physioactiv variants. A statistical analysis of SPAD values confirmed a strong influence of fertilization variants on the leaf blades greenness of white clover and perennial ryegrass in all regrowths in the first and the second year of utilization of a grass-legume mixture. Values of the index are specific in the years of utilization, as the effects turned out to be invalid for the years of the research.

On the basis of the analysis of a botanical composition of sward, it was observed that the applied fertilization variants determined the share of each species in the sward (Table 6). The highest share (42%) of perennial ryegrass in the sward was found in the variant N-14 (300) + PK and of Italian ryegrass (over 20%) – in the variants N-14 (900) + PK and NPK standard fertilization. The lowest share of this species (8%) was observed under control. A share of white clover in variants with nitrogen fertilizers ranged from 12 to 16%. One exception to it was a variant in which apart from standard NPK fertilization, additional calcium fertilizer Physioactiv was applied in spring – this made white clover boost to 24%. In the sward under absolute control, a share of white clover was 44% and of perennial ryegrass – 19%.

In the second year of utilization, the share of white clover in the sward in variants with nitrogen fertilizers ranged from 24 to 26%. In the plots where calcium fertilizer Physioactiv was applied, an average share of white clover increased from 24% (in the first year) to 38% which made it dominant in the sward. However, the highest share of the species was observed in the variant of absolute control (without fertilization), just like in the first year. An average share of this species in the third regrowth was 55%, whereas a share of perennial ryegrass under control dropped to 15%.

Positive influence of Soleflor calcium fertilizer and a high share of white clover and timothy grass in the sward were also observed by Zielewicz et al. [14]. This fertilizer, alike Physioactiv, contained an extract from sea algae (Pheoflore complex), and $CaCO_3$ as Mezocalc.

Table 4. SPAD index in white clover and perennial ryegrass leaf blades under the influence of different fertilization variants in the first year of use

Tab. 4. Indeks SPAD w blaszkach liściowych koniczyny białej i życicy trwałej pod wpływem zróżnicowanych wariantów nawożenia w pierwszym roku użytkowania

Fertilization variant	White clover				Perennial ryegrass			
	1st cut	2nd cut	3rd cut	Mean	1st cut	2nd cut	3rd cut	Mean
N-14 (900) + PK	613	562	463	546	447	276	352	358
N-14 (300) + PK	610	553	478	547	448	321	342	370
NPK	608	584	475	555	436	272	348	352
Physioactiv + NPK	637	589	603	609	442	263	426	377
Physiostart + NPK	612	591	583	595	438	246	390	364
PinKstart + NPK	614	578	546	579	434	282	352	356
Absolute control	587	529	577	587	224	212	264	233
$LSD_{0.05}$	3.690	2.429	1.528	x	10.304	3.920	7.864	x

Source: own study / Źródło: opracowanie własne

Table 5. SPAD index in white clover and perennial ryegrass leaf blades under the influence of different fertilization variants in the second year of use

Tab. 5. Indeks SPAD w blaszkach liściowych koniczyny białej i życicy trwałej pod wpływem zróżnicowanych wariantów nawożenia w drugim roku użytkowania

Fertilization variant	White clover				Perennial ryegrass			
	1st cut	2nd cut	3rd cut	Mean	1st cut	2nd cut	3rd cut	Mean
N-14 (900) + PK	648	589	502	579	514	428	238	393
N-14 (300) + PK	658	575	487	573	501	425	226	384
NPK	627	576	489	564	468	432	211	370
Physioactiv + NPK	668	591	517	592	482	448	235	388
Physiostart + NPK	652	564	498	571	472	439	227	379
PinKstart + NPK	632	552	509	564	451	426	224	367
Absolute control	609	536	448	531	311	378	189	292
$LSD_{0.05}$	14.552	11.901	10.392	x	14.987	12.039	12.071	x

$LSD_{0.05}$ for years of study: white clover = ns, perennial ryegrass = ns

Source: own study / Źródło: opracowanie własne

Table 6. Effect of different fertilization variants on the sward botanical composition in the successive years of use (%)

Tab. 6. Wpływ stosowania zróżnicowanych wariantów nawożenia na skład botaniczny runi w kolejnych latach użytkowania (%)

Sward components	N-14 (900) + PK		N- 14 (300) + PK		NPK		Physioactiv + NPK		Physiostart + NPK		PinKstart + NPK		Absolute control	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Perennial ryegrass	37	28	42	37	35	32	32	26	38	36	38	29	19	15
Italian ryegrass	22	18	18	16	24	18	15	9	15	15	14	17	8	8
Tall fescue	12	14	9	11	16	10	8	12	14	14	14	14	12	8
Meadow fescue	8	11	12	8	6	7	12	8	12	8	10	11	8	6
Timothy	2	2	4	2	2	2	6	3	4	1	4	2	5	6
White clover	15	26	13	24	12	25	24	38	16	24	16	24	44	55
Shepherd's purse	1	0	1	1	2	3	1	2	1	1	1	1	1	1
Chickweed	2	0	1	1	2	2	2	2	0	0	2	1	2	1
Common dandelion	1	1	0	0	1	1	0	0	0	1	1	1	1	0

Source: own study / Źródło: opracowanie własne

4. Conclusions

1. The highest yield of a dry matter of a grass-legume mixture in the two years of utilization was a result of an application of a nitrogen fertilizer N-14 which was applied under every regrowth and in a variant of application just under the first regrowth, together with a dose of phosphorus and potassium.
2. A biological additive on the basis of sea algae (Pheoflore complex) in N-14 fertilizer resulted in higher yields of the sward, despite smaller dose of nitrogen when compared to variants fertilized with ammonium nitrate.
3. An application of a calcium fertilizer Physioactiv with aminopurine resulted in an increase of a share of white clover in the sward and in a better nutrition of plants with nitrogen which was visible in the highest values of a leaf blades greenness index both in the case of white clover and perennial ryegrass.
4. It may be presumed that the positive effects of the application of the analyzed fertilizers might originate from their formulation due to the joint of mineral components used in traditional fertilizers with biological additives which stimulate a root system, activate soil's flora and therefore enhance the state of rhizosphere.

5. References

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Acknowledgements

Research funded under grants to maintain research potential of Department of Grassland and Natural Landscape Sciences 508.108.00 "Multi-functionality of grassland and grass communities in agriculture, environmental protection and natural landscape".