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EFFECTS OF SOIL CONDITIONERS ON LAWN GRASS CHARACTERISTICS THROUGHOUT THE GROWING SEASON

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ABSTRACT

Background. The aim of this paper is to investigate the impact of soil conditioners on grass quality, assessed by determining lawn appearance and grass colour.
Material and methods. The field experiment was conducted in Poland between 2013 and 2015. The research was carried out in the split plot design with three replications. The following grass species were used in the experiment (factor B): *Lolium perenne* cv. Stadion, *Festuca rubra* cv. Corail, and *Poa pratensis* cv. Ani. The other experimental factors tested in the research were three soil conditioners (factor A): Humus Active Papka (HAP), Eko-Użyźniacz (EU), UGmax (UG) and one fertilizer Substral (S). In each year of the experiment, among other things, colour and general appearance of the lawn were assessed with a 9-point scale. This assessment was conducted in three seasons (spring, summer, autumn).
Results. The results showed that lawn appearance ratings varied throughout the research, both in terms of the season, species of grass, and soil conditioners. Comparing the effects of soil conditioners, grass treated with UGmax had the best colour, but that treated with Substral had the best appearance.
Conclusion. The overall appearance of the lawns and the intensity of greenness were largely dependent on the soil conditioner, the species of grass and the season. The turf of kentucky-bluegrass had the best durability of both general appearance and colour during the experiment although, on average, the highest value of the general appearance was scored by perennial ryegrass and the best colour by red fescue.

Key words: grasses, lawn appearance, lawn colour, soil conditioners

INTRODUCTION

One of the proposals to fill free spaces in areas inhabited by people are lawns. Their greenery brings revival to the monotonous world of asphalt streets, concrete blocks and steel structures – inherent attributes of progress (Stewart *et al*., 2009; Bertoncini *et al*., 2012; Ignatieva *et al*., 2015). In recent years the presence of lawns in the vicinity of residential houses and in the areas adjacent to various types of companies and workplaces is seen as a kind of positive image testifying to the standard of living of their owners and which is a good showcase for their activities (Tint *et al*., 2012; Pooya *et al*., 2013; Knot *et al*., 2017). In a situation where people are increasingly absorbed in professional work it has become a problem of limited time that can be spent on care treatments to keep lawns in good condition. Therefore, to meet these issues new solutions should be sought that would contribute to a reduction the number of treatments performed or their simplification. In this situation, a good solution is the appropriate

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choosing of grasses. Grass species and cultivars used to lay lawns should be distinguished by even sodding, high aesthetics and slow pace regrowth after mowing (Grabowski *et al*., 2003; Jankowski *et al*., 2017; Czeluściński *et al*., 2017). The most commonly used species in lawns are perennial ryegrass red fescue and kentucky-bluegrass (Wolski, 2003; Jankowski *et al*., 2012a, b, c, d; 2018a; Smith and Fellowes, 2014). So an assessment of some of the features of cultivars of these species can make a significant contribution in determining the suitability of a given variety for lawn use (Salehi and Khosh-Khui, 2004). The quality of lawns is determined not only by the species or variety of grass, but also by care treatments. One of the basic treatments performed on lawns is fertilization. Most often lawn grasses are fertilized only with NPK. Frequent mowing, however, and high biomass production can deplete the soil of microelement that are needed by the plants. This can be done by a proper selection of grass species, and also by the use of special nutrients and growth regulators (Jankowski *et al*., 2012a).

One such solution is the application of organic products called soil conditioners as they positively affect the release of soil minerals for a longer time and make it possible for plants to survive stressful conditions (Chen *et al*., 2004; Gąbka and Wolski, 2008; Urbanovičová *et al*., 2018). With the growing interest in the use of environmentally friendly products numerous soil conditioners have been approved for use in agriculture areas, fulfilling the roles of fertilizers or chemicals used in plant protection. Continuous progress in studies on soil conditioners have shown their competitiveness in relation to conventional solutions (Hamza and Suggars, 2001) However, there are few studies on the use of such substances in single-species cultivation of forage grasses, and thus on their impact on the chemical composition and nutritional value of these plants. Therefore, the presented issues have inspired an experiment in the context of the response of grasses most commonly used to sow lawns to microbiological preparations used to improve the soil (Jankowski *et al*., 2019). In the literature there is little information on the possible use of soil additives to improve lawn maintenance. The aim of this paper is to investigate the impact of such products on grass quality, assessed by determining lawn appearance and grass colour.

MATERIAL AND METHODS

The field experiment was conducted in the experimental facility of the Siedlce University of Natural Sciences and Humanities in Poland (52°17' N; 22°28' E) between 2013 and 2015. The research was carried out as a mini-plot experiment, in the split plot design with three replications. In the experiment three grass species were used (factor B): *Lolium perenne* – cv. Stadion, *Festuca rubra* – cv. Corail, and *Poa pratensis* – cv. Ani. They were sown on their own, each of them at a rate of 28 $g \cdot m^{-2}$.

The other experimental factor tested was soil conditioners or fertilizer (factor A). The composition of the soil conditioners used in the research is presented in Table 1. They are described more fully in another manuscript (Jankowski *et al*., 2018b). The soil conditioners were applied annually in spring (mid-May) at the following doses: UGmax – 0.025 $dm^3 \cdot m^{-2}$ (0.60 dm^3 in 250 dm^3 of water), Eko-Użyźniacz – 0.10 $dm^3 \cdot m^{-2}$ (10 dm^3 in 100 dm^3 of water), and Humus Active Papka – 0.25 $dm^3 \cdot m^{-2}$ (0.20 dm^3 in 10 dm^3 of water). Substral, a slow release fertilizer used on lawns, was applied at the rate of 20 $g \cdot m^{-2}$.

Three times a year, at the end of each growing season, from 2013 to 2015 an assessment of grass was carried out. Among other things, its general appearance was assessed in accordance with the methodology used by Prończuk and Żurek (2008), using a 9-point rating scale in which 1 stands for no aesthetic value; 3 for unattractive appearance; 5 for average; 7 for attractive; 9 for very attractive. Grass colour was assessed also using a 9-point rating scale where: 1 was ground with no grass and 9 was dark green.

These assessments were conducted in three seasons: spring, summer, and autumn. The test results were evaluated statistically with the analysis of variance. Tukey's test ($P \leq 0.5$) was used to find significantly different means of the effects of the experimental factors and their interaction. On the basis of the lawn appearance ratings, the standard deviation and coefficient of variation were calculated for separate seasons and for each soil conditioner as well as for Substral.

Table 1. Composition of soil conditioners and fertilizer applied in the experiment (Jankowski *et al*., 2018b)

Macronutrients, g·kg^{-1}						Micronutrients, mg·kg^{-1}				
N	P	K	Ca	Mg	Na	Mn	Fe	Zn	Cu	Mo
Substral (S)										
220	21.80	83	–	12.06	–	12	50	12.50	12.50	1
Humus Active Papka (HAP)										
0.20	1.30	4.60	3.00	0.50	–	15	500	3	1	–
Active humus with useful microorganisms										
Eko-Użyźniacz (EU)										
0.60	0.30	0.70	–	–	–	–	–	–	–	–
Endo micorhizza, fungi, bacteria, enzymes of earthworms										
UGmax (UG)										
1.20	0.20	2.90	–	0.10	0.20	0.30	–	–	–	–
Lactic acid bacteria, photosynthetic bacteria, Azotobacter, Pseudomonas, yeast, Actinomycetes										

The weather conditions are presented in another manuscript (Jankowski *et al*. 2017). The values of Sielianinov's hydrothermal coefficient (Skowera and Puła, 2004) for individual months of the experiment are shown in Table 2. The hydrothermal coefficients for this experiment are described in another manuscript (Jankowski *et al*., 2018a).

Table 2. Sielianinov's hydrothermal coefficient (K) during the growing seasons (Jankowski *et al*., 2018a)

Year	Month						
	Apr.	May	June	July	Aug.	Sept.	Oct.
2013	2.56 (vw)	3.07 (ew)	2.11 (w)	0.84 (d)	0.78 (d)	2.53 (vw)	0.60 (vd)
2014	1.36 (o)	1.87 (qw)	1.64 (qw)	0.59 (vd)	1.92 (qw)	0.64 (vd)	0.12 (ed)
2015	1.22 (qd)	2.63 (vw)	0.87 (d)	1.08 (qd)	0.18 (ed)	1.46 (o)	1.94 (qw)

$K \leq 0.4$ extremely dry (ed); $0.4 < K \leq 0.7$ very dry (vd); $0.7 < K \leq 1.0$ dry (d); $1.0 < K \leq 1.3$ quite dry (qd); $1.3 < K \leq 1.6$ optimal (o); $1.6 < K \leq 2.0$ quite wet (qw); $2.0 < K \leq 2.5$ wet (w); $2.5 < K \leq 3.0$ very wet (vw); $K > 3.0$ extremely wet (ew)

RESULTS AND DISCUSSION

Lawn appearance, according to many authors (Prończuk and Żurek, 2008; Jankowski *et al*., 2012d; Jankowski *et al*., 2019), is a result of an interaction between the grass genotype and environmental conditions. The overall appearance of the lawn grasses (Table 3) varied both across different treatments and seasons of the year. During the spring, on average the grass looked the most favourable on plots treated with Substral (8.26°) and the least favourable after the use of Eko-Użyźniacz (6.21°). The difference between the ratings of the appearance of the lawns treated with the above soil conditioners and Substral was statistically significant. In another experiment (Jankowski *et al*., 2019), comparing the effects of the soil conditioners on all the tested grass species, UGmax and Substral had the highest impact on lawn appearance (7.90°) and Humus the lowest (6.40°). Sosnowski (2012), applying both UGmax and mineral fertilizer, observed that perennial ryegrass responded with a significant increase in the number of shoots, leaf lamina length, leaf base width, and leaf greenness index. The current study showed, after taking into account the grass species, that during spring red fescue scored the highest rating (7.51°) and perennial ryegrass the lowest (6.82°). The appearance of the kentucky-bluegrass turf was comparable to that of the perennial ryegrass.

Table 3. Assessment of the general appearance of lawn grass species in different seasons (average values 2013–2015)

Season	Species (B)	Fertiliser (A)				
		(HAP)	(EU)	(S)	(UG)	$\bar{x}$
Spring	Kentucky-bluegrass	6.00	5.10	8.13	8.37	6.90
	Perennial ryegrass	5.93	6.43	8.25	6.67	6.82
	Red fescue	6.97	7.10	8.40	7.57	7.51
		Mean effect of fertiliser				
		6.30	6.21	8.26	7.54	7.08
$LSD_{0.05}$ A = 0.415; B = 0.327; B/A = 0.654; A/B = 0.718						
Summer	Kentucky-bluegrass	6.43	6.10	8.17	7.90	7.15
	Perennial ryegrass	7.27	6.50	8.20	7.27	7.31
	Red fescue	5.67	6.57	7.33	7.27	6.71
		Mean effect of fertiliser				
		6.46	6.39	7.90	7.48	7.06
$LSD_{0.05}$ A = 0.560; B = 0.441; B/A = 0.882; A/B = 0.964						
Autumn	Kentucky-bluegrass	6.23	5.40	6.00	6.33	5.99
	Perennial ryegrass	7.03	6.93	6.83	6.97	6.94
	Red fescue	6.13	6.33	6.27	5.93	6.17
		Mean effect of fertiliser				
		6.46	6.22	6.37	6.41	6.37
$LSD_{0.05}$ A = ns; B = 0.404; B/A = ns; A/B = ns						

During the summer there was a varied reaction of the grass species to the applied treatments. It turned out that the average appearance of the lawn turf during the summer was similar to that in the spring. Different grass species, on the other hand, reacted in a completely different way. Perennial ryegrass had the most favourable appearance during this period (7.31°) and red fescue the least favourable (6.71°). Prończuk and Żurek (2008) obtained similar results, i.e. the lawn cultivars of red fescue had lower ratings for general appearance.

In the autumn, the appearance of the lawns was slightly less attractive compared to both the spring and summer periods. Taking into account the soil conditioners , the results of the studies showed that during the autumn the appearance of turf was the best after the application of Humus Active (6.46°) and UGmax (6.41°) and the worst after Eko-Użyźniacz (6.22°). Truba *et al*. (2017), also in an experiment with perennial ryegrass, found the lowest biomass increase when Humus Active Papka was applied on its own. In turn, among the species of grass in the autumn period, perennial ryegrass (6.94°) looked the best and kentucky bluegrass (5.99°) the worst. The difference in appearance between perennial ryegrass mini-lawns and the turf of other grass species was statistically significant. In another experiment in the autumn seasons (Jankowski *et al*., 2019) perennial ryegrass had the highest average appearance rating (7.30°) and red fescue the lowest (5.80°).

When analysing the durability of the appearance of lawn grasses for individual species (Table 4), the coefficient of variation for kentucky bluegrass was the lowest, indicating average variability. For ryegrass the coefficient of variation for the appearance of lawn turf was above 40%, indicating low durability, with a high mean value of colour rating (7.02°) and a standard deviation of 1.66.

According to Jankowski *et al*. (2018a), the colour, especially the intensity of greenness, is a very important factor in lawn rating. The results of the studies (Table 5) indicate that it was greatly affected by the type of fertiliser, the species of grass as well as the season of the year.

During the spring period the grass with the most intense green colour was on lawns treated with UGmax (7.03°) and with the least intense colour (5.00°) on plots where Eko-Użyźniacz was applied. Differences in the intensity of greenness of the turf between the types of soil conditioners were generally statistically significant. In the study by Jankowski *et al*. (2018a) the application of soil conditioners resulted in a significant increase in leaf blade greenness.

When analysing the individual species of grass it was found that during the spring period red fescue had the most intense green colour (7.76°), with kentucky bluegrass having the least intense green (5.30°). The differences in the assessment of the colour of the turf of the grass species were statistically significant. In the study by Jankowski *et al*. (2018a) in regard to soil conditioner effects it was observed that in spring the grass was most intensely green on plots where Substral was applied, and the least intensely green as a result of Eko-Użyźniacz or Humus Active Papka application. According to Knot *et al*. (2017) and Braun *et al*. (2016) the colour of a lawn is an unstable characteristic, depending, among others, on habitat conditions, the content of macro- and micronutrients in the soil, and on their availability for plants. Soil conditioners make absorption of nutrients easier, which affects the metabolism of plants.

In the summer, compared to other seasons, on average the grass turf was the most intense green for all treatments and grass species. After analysing the impact of the treatments it was found that the greenest turf was after UGmax application (8.91°) with a slightly weaker response to Substral (8.86°). A significantly less intense leaf blade greenness was after the use of Eko-Użyźniacz (7.43°) and Humus Active (7.53°). Studies conducted by Talar-Krasa and Świerszcz (2015) confirm the stimulating properties of humic acids present in soil conditioners on plant growth and development as well as on grass colour.

During this period, there were no significant differences in colour between the different grass species although red fescue was the greenest (8.38°), as it was in the spring. In the study by Jankowski *et al*. (2018a), red fescue had the best green colour in summer seasons, but it was not significantly different to the other species. However, in the studies of Starczewski and Affek-Starczewska (2011) the cultivars of perennial ryegrass were characterized by the most intensive green at the beginning of the growing season (vivid green in May), and the least

favorable colour in the summer months (grey, dirty green) compared to other species.

During the autumn period the lawn turf had a less intense leaf-blade greenness than in the summer. Among the soil conditioners, Eko-Użyźniacz had the greatest impact on the greenness of the lawns (6.64°), with a significantly weaker response of grass to Substral (5.84°). In the study by Jankowski *et al.* (2018a) that compared types of soil conditioners in autumn, Eko-Użyźniacz application also resulted in the best colour of grass.

Table 4. Standard deviation and coefficient of variation of general appearance

Species	Min. value of colour rating	Max. value of colour rating	Mean values of colour rating	Standard deviation	Coefficient of variation
Kentucky-bluegrass	2.00	9.00	6.79	2.28	29.80
Perennial ryegrass	3.80	9.00	7.02	1.66	42.30
Red fescue	3.10	9.00	6.79	1.96	34.60

Coefficient of variation: 0–20% small variation, 20–40% moderate variation, 40–60% large variation, > 60% very large variation

Table 5. Assessment of the colour of lawn grass species in different seasons (average values 2013–2015)

Season	Species (B)	Fertiliser (A)				
		(HAP)	(EU)	(S)	(UG)	$\bar{x}$
Spring	Kentucky-bluegrass	5.15	3.00	6.40	6.65	5.30
	Perennial ryegrass	5.45	4.70	5.30	6.90	5.59
	Red fescue	7.30	7.30	8.90	7.55	7.76
		Mean effect of fertiliser				
		5.97	5.00	6.87	7.03	6.72
$LSD_{0.05}$ A = 0.449; B = 0.357; B/A = 0.225; A/B = 0.249						
Summer	Kentucky-bluegrass	7.33	7.33	8.83	8.93	8.11
	Perennial ryegrass	7.33	7.13	8.87	8.93	8.07
	Red fescue	7.93	7.83	8.87	8.87	8.38
		Mean effect of fertiliser				
		7.53	7.43	8.86	8.91	8.18
$LSD_{0.05}$ A = 0.505; B = NS; B/A = ns; A/B = ns						
Autumn	Kentucky-bluegrass	6.33	6.70	5.33	7.00	6.34
	Perennial ryegrass	6.90	7.33	6.60	5.93	6.69
	Red fescue	5.63	5.90	5.60	5.27	5.60
		Mean effect of fertiliser				
		6.29	6.64	5.84	6.07	6.21
$LSD_{0.05}$ A = 0.514; B = 0.405; B/A = 0.810; A/B = 0.891						

In the autumn period there was a significant change in the colour of individual grass species. Perennial ryegrass was the greenest (6.69°), with red fescue being of the weakest colour (5.60°). The differences in the assessment of this trait for both grass species were statistically significant. In the study by Jankowski *et al*. (2018a) in autumn seasons, there were significant differences between grass species in their shades of green, but perennial ryegrass had the best colour. In the studies by Grabowski *et al.* (2003) cultivars of perennial ryegrass also achieved the highest marks for colour assessment in the autumn periods. In the study by Jankowski *et al*. (2018a) grass treated with Substral had the most favourable lush green colour, but when it was treated with Humus Active Papka the rating was the lowest, with a blue shade of green. Braun *et al.* (2016) studied the stability of the dark green colour of grass leaves over the entire period of vegetation together with greenness durability into late autumn and observed that it was also dependent on the application of proper fertilizers.

The coefficient of variation of color calculated in these studies (Table 6) indicates that during the entire experiment it was the lowest for kentucky bluegrass (39.20%), and at that time its mean value of colour rating was 6.58°. The highest value of the coefficient of variation was for red fescue (58.00%) with a colour rating of 7.25°.

Table 6. Standard deviation and coefficient of variation of grass colour

Species	Min. value of colour rating	Max. value of colour rating	Mean value of colour rating	Standard deviation	Coefficient of variation
Kentucky-bluegrass	3.00	8.93	6.58	1.68	39.20
Perennial ryegrass	4.70	8.93	6.78	1.34	50.60
Red fescue	5.27	8.90	7.25	1.25	58.00

Coefficient of variation: 0 – 20% small variation, 20 – 40% moderate variation, 40 – 60% large variation, > 60% very large variation

CONCLUSIONS

1. The overall appearance of the lawns and the intensity of greenness were largely dependent on the soil conditioner, the species and the season.
2. Substral had the greatest effect on the general appearance of the lawns, especially during the spring and summer, while grass had the best colour on plots with UGmax. In the autumn period, the overall appearance was to the highest extent affected by the use of Humus Active and colour by Eko-Użyźniacz.
3. The general appearance rating was the highest for red fescue during the spring and for perennial ryegrass in the summer and autumn. In turn, the highest ratings for the colour of the lawns in the spring and summer periods were assigned to lawns with red fescue and in the autumn to lawns with perennial ryegrass.
4. The turf of kentucky-bluegrass had the best durability of both general appearance and colour during the experiment, although on average the highest value of the general appearance was scored by perennial ryegrass and the best colour by red fescue.

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ODDZIAŁYWANIE UŻYŹNIACZY GLEBOWYCH NA CECHY JAKOŚCIOWE MURAW TRAWNIKOWYCH W RÓŻNYCH PORACH ROKU

Streszczenie

Celem prowadzonych badań była ocena wpływu użyźniaczy glebowych na ogólny wygląd i intensywność zabarwienia muraw trawnikowych. Badania realizowano w oparciu o doświadczenie polowe założone w roku 2012 i prowadzone w latach 2013–2015. Doświadczenie mikropoletkowe (1 × 1m) założono w trzech powtórzeniach, w układzie split-plot. Analizowane murawy trawnikowe tworzyły jednogatunkowe zasiewy takich traw gazonowych (czynnik B), jak: życica trwała odmiana Stadion, wiechlina łąkowa odmiana Ani i kostrzewa czerwona odmiana Corail. Kolejny czynnik w doświadczeniu stanowił rodzaj zastosowanego preparatu nawozowego (czynnik A): Substrat, Humus Active Papka, Eko-Użyźniacz i UGmax. W każdym roku badań w trzech porach roku (wiosna, lato, jesień) oceniano m.in. kolorystykę oraz aspekt ogólny muraw trawnikowych, stosując 9-stopniową skalę. Wyniki badań pokazały, że ogólny wygląd badanych muraw trawnikowych oraz intensywność zieloności były w dużym stopniu zależne zarówno od rodzaju zastosowanego nawożenia, jak i gatunku trawy czy pory roku w ciągu okresu wegetacyjnego. Spośród stosowanych preparatów nawozowych największy wpływ na aspekt ogólny muraw trawnikowych, zwłaszcza w okresie wiosennym i letnim, miało użycie Substralu, a na kolorystykę użyźniacz UGmax. Z kolei w okresie jesiennym ocena aspektu ogólnego w najwyższym stopniu była determinowana użyciem użyźniacza Humus Active, a kolorystyka Ekoużyźniaczem. Najkorzystniejszą trwałość zarówno aspektu ogólnego, jak i kolorystyki w badanym okresie uzyskały murawy wiechliny łąkowej, chociaż średnio najwyższą wartość aspektu ogólnego uzyskały murawy życicy trwałej, a kolorystyki – kostrzewy czerwonej.

Słowa kluczowe: aspekt ogólny, kolorystyka, użyźniacze glebowe, trawy gazonowe