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LAWN COLOURS IN THE ASPECT OF HYDROGEL AND MINERAL FERTILIZERS APPLIED

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Abstract. The aim of this study was to determine the effect of hydrogel and mineral fertilizers on the lawn turf colour. Lawn experiment was conducted in the years 2002--2004 on experimental plots in the system of randomized blocks with an area of 4 m^2 (4 x 1 m) in four replications. In the conducted research experiment, the following factors were applied: botanical composition of lawn: Wembley (M1), Park (M2), Relax (M3), Półcień (M4); kind of subsoil: with the addition of hydrogel Aqua-Gel P4 (H), without the addition of hydrogel Aqua-Gel P4 (BH); type of fertilizer: Pokon (N1), Trawovit set (N2), Azofoska (N3), proposed fertilizer (N4). Each year of the study the lawn colours were evaluated. This evaluation was made according to the COBORU methodology [Domański 1992]. It was used valuation 9^o scale, where 9 meant the highest value of this feature. The colours of tested turfs to a large extent were dependent on meteorological conditions, especially the temperature and rainfall, which was confirmed in a different turf colour in each month of the growing periods. The mixture Wembley (M1) with 80% share of perennial ryegrass was characterized by the most intensive green colouration. With the decreasing of the percentage of perennial ryegrass in the mixture (irrespective of the type of substrate) the turf colouration deteriorated to the green grass colour. In subsequent years of research, intensity of the mixtures, colour slightly decreased from brown green colour (about 8^o) to the pure green (about 6^o). Applying hydrogel and proposed fertilizer to a small degree improved lawn colouration. The other fertilizers had no effect on turf colour.

Key words: green colour intensity, lawn mixtures, lawns, perennial ryegrass

INTRODUCTION

Green areas, such as lawns, enrich air in oxygen, regulate water relationships of the given region, retain and neutralize a part of atmospheric pollutions, decrease the strength of wind and raising dust, weaken the intensity of noise. They are also a place of rest for elderly people and games for children, the destination of numerous excursions

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and Saturday leisure of all families. This allows recuperation both in physical and psychological meaning.

Green is a relaxing colour and it is good for human eyesight. In devastated areas higher morbidity of people is observed, resulting from direct action of pollutions, as well as an increase in mental disorders, being a result of numerous stresses caused by the lack of contact with the natural environment [Stępczak 1997].

Green in human surrounding – not only in a workplace – has a positive impact on their psychical and mental state. Additionally it to a certain extent meets human aesthetic needs. Therefore the colour of the lawn is an important element determining its appearance [Kozłowski et al. 2000], which can change among other things under the influence of meteorological and site conditions. Difficulty in maintaining proper colours of lawn turf at unfavorable moisture conditions and insufficient nutrient content in soil can cause considerable deterioration in lawn attractiveness through the loss of its natural vividly green colour.

According to many authors [Bereś and Kałędkowska 1992, Fontano and Bilderback 1993, Hetman and Martyn 1996, Hetman and Michalak 1997], applying hydrogels may be one of methods for creating better conditions for maintaining stability of grass colour in turfs. Hydrogels provide an improvement in moisture conditions in the soil substrate under lawn turfs. In this way the negative effect of long lasting drought, which causes changes in the lawn colour from green into yellow-white is eliminated.

The aim of this study was to estimate the effect of hydrogel and mineral fertilizers on the colour of lawn turfs.

MATERIAL AND METHODS

The lawn experiment was established in autumn 2001 and carried out in 2002-2004 on experimental plots of the Department of Grassland Management and Shaping Green Areas of the Siedlce University of Science and Humanities (52°17' N; 22°28' E). The experiment was established in the randomized complete block design with an area of 4 m^2 (4 x 1 m) in four replications. The following experimental factors were used:

– the kind of lawn mixture: Wembley (M1), Parkowa (M2), Relax (M3), Półcień (M4)
– the kind of substrate: with the addition of hydrogel Aqua-Gel P4 (H), without the addition of hydrogel (BH),
– the king of fertilizer: Pokon (N1), Trawovit Komplet (N2), Azofoska (N3), the proposed fertilizer (N4).

Four lawn grass mixtures available on the market were applied in the study (Table 1), serving different purposes and with varied percentage shares of *Lolium perenne*: Wembley (80%) – M1, Parkowa (60%) – M2, Relax (40%) – M3 and Półcień (20%) – M4. Moderately intensive cultivation (the so-called Relax) was applied. The experiment was conducted in the culture-earth soil of the hortisole type formed of loamy sand (Table 2).

Based on the chemical analysis carried out at the Regional Chemical Station in Wesoła, it was found that the soil in the rings was characterized by neutral reaction (Table 3), a moderately high level of humus, a very high content of phosphorus, high of magnesium and moderate of available forms of potassium, total, nitrate and ammonium nitrogen [Kowaliński and Gonet 1999, Grzebisz 2009].

Table 1. Species and cultivars composition of lawn mixtures used in study
Tabela 1. Skład gatunkowy i odmianowy mieszanek trawnikowych zastosowanych w badaniach

Mixture name Nazwa mieszanki	Mixture composition Skład mieszanki	Share in mixture Udział w mieszance %	Cultivar Odmiana
Wembley (M1)	perennial ryegrass – rajgras angielski	40	Taya
	perennial ryegrass – rajgras angielski	30	Cartel
	perennial ryegrass – rajgras angielski	10	Prester
	red fescue – kostrzewa czerwona	20	Borcel
Parkowa (M2)	perennial ryegrass – rajgras angielski	40	Naki
	perennial ryegrass – rajgras angielski	20	Sakini
	red fescue – kostrzewa czerwona	30	Echo
	tall fescue – kostrzewa trzcinowa	10	Fine Lawn
Relax (M3)	perennial ryegrass – rajgras angielski	40	Naki
	red fescue – kostrzewa czerwona	15	Echo
	red fescue – kostrzewa czerwona	15	Pernille
	tall fescue – kostrzewa trzcinowa	30	Fine Lawn
Półcień (M4)	perennial ryegrass – rajgras angielski	20	Sakini/Grafitti
	red fescue – kostrzewa czerwona	10	Elanor
	red fescue – kostrzewa czerwona	10	Pernille
	red fescue – kostrzewa czerwona	20	Echo
	red fescue – kostrzewa czerwona	15	Carina
	sheep fescue – kostrzewa owcza	15	Ridu
	Kentucky bluegrass – wiechlina łąkowa	5	Balin
	Kentucky bluegrass – wiechlina łąkowa	5	Conni

Table 2. Granulometric composition of soil material
Tabela 2. Skład granulometryczny materiału glebowego

Percentage share of earth fractions (diameter in mm) Procentowy udział frakcji ziemistych (średnica w mm)								
1-0,1	0,1-0,05	0,05-0,02	0,02-0,06	0,06-0,002	<0,002	sum of fraction suma frakcji 0,1-0,02	sum of fraction suma frakcji <0,02	grain group grupa granulometryczna
76	9	5	4	4	2	14	10	psg

Table 3. Chemical composition of soil making the substrate in experiment
Tabela 3. Skład chemiczny materiału glebowego stanowiącej podłoże pod doświadczenie

pH	Content of available components, $mg \cdot 100\ g^{-1}$ of soil Zawartość składników przyswajalnych, $mg \cdot 100\ g^{-1}$ gleby			Content Zawartość %		Content, $mg \cdot kg^{-1}$ d.m. Zawartość, $mg \cdot kg^{-1}$ s.m.	
in – w KCl	P	K	Mg	N-total N-ogólny	humus próchnica	$N\text{-}NO_3$	$N\text{-}NH_4$
6.99	39.2	15.8	8.4	0.18	3.78	10.10	7.47
Results uncertainty – Niepewność wyników*							
± 3%	± 20%	± 20%	± 20%	± 20%	± 17%	± 22%	± 25%

* widened uncertainty calculated using widening index 2, which gives the confidence level 95% – niepewność rozszerzona obliczana z użyciem współczynnika rozszerzenia 2, co daje poziom ufności 95%

Granulated polyacrylamide with the commercial name Aqua-Gel P4 was applied as hydrogel. This preparation in an amount of 0.05 kg·m^{-2} was placed at a depth of 5-10 cm under the soil surface before the start of sowing grasses.

On all the experimental treatments mineral fertilization was applied in a NPK ratio of 6:2:4, in the form of the following fertilizers: Pokon (N1), Trawovit Komplet (N2), Azofoska (N3) and the proposed fertilizer (N4). Three of them were typical multi-component fertilizers intended for lawns available on the market, whereas the fourth was a mixture of one-component fertilizers proposed by the authors (in tables and the text it is referred to as the proposed fertilizer) with the NPK ratio 6:2:4, optimal for lawn fertilization [Domański 1998c]. Mineral fertilizers used in the study differed both in the rate of action and chemical composition. Pokon and Trawovit Komplet belonged to the group of fast-acting fertilizers and they were applied in two identical rates, whereas Azofoska (a slow-acting fertilizer) was sown once during the growth period. Amounts of the application of fertilizers available on the market were determined by the producer in the instructions. The proposed fertilizers, in turn, was designed on the basis of ammonium nitrate. Due to a high level of nitrogen content it was classified as a fast--acting fertilizer.

At selection of the amount of all the applied mineral fertilizers, the rule of providing for all the lawns the same yearly nitrogen rate, equal to 120 kg N·ha^{-1} per year.

Lawn colours were assessed in each year of the study. The assessment was carried out according to the methods of COBORU [Domański 1998a]. The 9^{o} quality scale was used, where 9 meant the highest value of the feature. At stated times (15-20 day of the month) from May to October the assessment of colour was made on all the plots from the blocks.

Numerical markings of colours were attributed to verbal expressions, according to the catalog* RHS Colour Chart [Domański 1998b].

Colour*	Catalog number
1 – yellow-green	144 A, B, C, D
2 – olive green	138 A, B, C, D I 137 A, B, C, D
3 – bright green	134 A, B, C, D
4 – green-grey	133 A, B, C, D
5 – vivid green	132 A, B, C, D
6 – green	131 A, B, C, D
7 – grassy green	135 A, B, C, D
8 – brown-green	136 A, B, C, D
9 – emerald	127 A, B, C, D

Meteorological data from the years 2002-2004 were obtained from the Hydrological and Meteorological Station in Siedlce. To determine the temporal and spatial variability of meteorological elements and the assessment of their effect on the course of plant growth, Sielianinow's hydrothermal coefficient (K) was calculated [Bac *et al.* 1993], multiplying the total monthly precipitation by one tenth of the total mean daily temperatures for this month (Table 4).

The obtained results of the study were subjected to the three-factorial analysis of variance using the random model (synthesis from the years) and for significant sources of variability, a detailed comparison of means was carried out with Tukey's test, at the significance level $P \leq 0.05$ [Trętowski and Wójcik 1992].

Table 4. Sielianinow's Hydrothermal index (K) in individual months of growth seasons
Tabela 4. Współczynnik hydrometryczny (K) Sielianinowa w poszczególnych miesiącach okresów wegetacyjnych

Month – Miesiąc	Year – Rok		
	2002	2003	2004
April – kwiecień	0.85	0.42	1.30
May – maj	0.52	0.47	0.67
June – czerwiec	1.30	1.48	1.22
July – lipiec	0.89	0.91	0.72
August – sierpień	1.32	0.52	1.10
September – wrzesień	0.81	0.83	0.92
October – październik	2.58	2.69	2.78

K <0.5 – high drought – silna posucha, 0.51-0.69 – drought – posucha, 0.70-0.99 – week drought – słaba posucha, K >1 – no drought – brak posuchy

RESULTS

Analyzing colours of the studied lawn turfs (Table 5), it may be concluded that all the assessed mixtures showed a slightly more intensive colouration (ranging from 7.4--7.7°) in the first year of the study, whereas the weakest in the third year of the experiment. The difference in colouration between the lawn mixtures was statistically significant.

Table 5. Turf colours (in 9° scale) depending on kind of lawn mixture with different substrate
Tabela 5. Kolorystyka muraw trawnikowych (w skali 9°) w zależności od rodzaju mieszanki trawnikowej przy różnym podłożu

Rodzaj podłoża Kind of substrate	2002				2003				2004			
	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4
Hydrogel Hydrożel	8.0	7.7	7.5	7.5	7.3	7.4	7.3	7.3	7.2	7.6	7.5	7.1
No hydrogel Bez hydrożelu	7.4	7.6	7.2	7.5	7.4	7.5	7.3	7.3	6.9	7.4	7.2	7.1
$\bar{x}$	7.7	7.7	7.4	7.5	7.4	7.5	7.3	7.3	7.1	7.5	7.4	7.1
Mean of years Średnia z lat	7.4	7.7	7.4	7.3	7.4	7.5	7.3	7.3	7.1	7.5	7.4	7.1

$LSD_{0.05}$ – $NIR_{0,05}$ for – dla:
years – lat (L) ns – ni
mixture – mieszanki (B) 0.21
hydrogel – hydrożelu (A) ns – ni
interaction – interakcji: L x A ns – ni L x B 0,36 L x A x B ns – ni A x B ns – ni

M1-M4 – mixture – mieszanka

According to many authors [Prończuk 1993, Domański 1998b, Jankowski *et al.* 20011] the leaf colour is one of more essential features of the functional value of lawn grasses. More valuable traits are the stability of colour during the growth period and resistance of cultivars to changing colours under the influence of stress generating factors.

Taking into consideration the kind of the used substrate, in the first and third year of the study lawn mixtures grown on the substrate with hydrogel were characterized by a better colouration of turfs. Similarly, in the study of Wolski *et al*. [2006] a favorable effect of hydrogel on turf colouration was indicated. On the substrate with hydrogel, the mixture Wembley (M1) showed the most intensive colour – brown green (8.0°) in 2002, and in the following years the intensity of its colouration decreased systematically. In the third year of the study, in turn, the mixture Parkowa (M2) had the most intensive green colour – grassy green (7.6°).

In the successive years of the study, irrespective of the kind of substrate, a downward tendency of the colour intensity of lawn turfs was indicated.

Analyzing the intensity of mixture turf colouration (Tables 5, 6), a high variability of the turf green was also observed in individual months and years of the study. The differences in turf colouration between individual months were statistically significant. In the studied period, the mixture Wembley (M1) with 80% share of perennial ryegrass in 2002 was characterized by the highest intensity of green colouration up to emerald (8.9°). This study was confirmed by the results of other experiments conducted by Jankowski *et al*. [1999], where cultivars of perennial ryegrass obtained the highest colour assessment among many species of lawn grasses. In contrast, the mixture Półcień (M4) with 20% share of perennial ryegrass, shown the worst colouration in the third year of the study (on average 6.9°). In almost all the months of this growth period, turfs on the substrate with hydrogel were characterized by more intensive green (from 5.9 to 8.5°). A high variability of the studied trait values for individual grass mixtures both on the substrate with and without hydrogel was obtained in all the months of the study throughout the research period.

Table 6. Turf colours (in 9° scale) depending on the kind of substrate
Tabela 6. Kolorystyka muraw trawnikowych (w skali 9°) w zależności od rodzaju podłoża

Month Miesiąc	2002			2003			2004			$\bar{x}$
	H	BH	$\bar{x}$	H	BH	$\bar{x}$	H	BH	$\bar{x}$	
May Maj	7.9	7.6	7.8	8.0	8.0	8.0	7.9	7.9	7.9	7.9
June Czerwiec	8.2	8.3	8.3	7.0	7.0	7.0	7.5	7.1	7.3	7.5
July Lipiec	7.0	6.3	6.7	8.0	8.0	8.0	7.4	7.1	7.3	7.3
August Sierpień	8.0	8.0	8.0	5.0	4.9	5.0	7.1	7.1	7.1	6.7
September Wrzesień	6.9	6.4	6.7	7.9	8.1	8.0	6.4	6.2	6.3	7.0
October Październik	8.0	8.0	8.0	7.9	8.1	8.0	7.8	7.6	7.7	7.9
$\bar{x}$	7.7	7.4	7.6	7.3	7.4	7.3	7.4	7.1	7.3	7.4

$LSD_{0.05}$ – $NIR_{0,05}$ for – dla:
hydrogel – hydrożelu (A) ns – ni
years – lat (L) ns – ni
month – miesięcy (B) 0.25
interaction – interakcji: L x D 0.43 A x D ns – ni L x A x D ns – ni

H – with hydrogel – z hydrożelem
BH – without hydrogel – bez hydrożelu

Irrespective of the kind of mixture and substrate (Table 6), the lawn mixtures were the most intensively coloured (brown-green) in October and May (7.9°), and the least intensively – grassy-green – in August (6.7°). These results indicate that the colours of lawn turfs during the period of the study were also determined by the air temperature and moisture conditions (Table 4). Slightly different results were obtained in the study by Jankowski *et al*. [2001], where the highest score (9°) was obtained by turfs during the spring and summer assessment irrespective of the years of the study, whereas in the autumn period this feature highly diversified the studied species and cultivars.

In the study by Kwietniewski [2006], in turn, it was indicated that among sheep fescue cultivars, both in pure sowing and in inter-species mixtures, no distinct differences were observed in the turf colour either in spring or in autumn.

Irrespective of the kind of mixture (Table 6) in individual months, generally more intensive colour was obtained by turfs brown on the substrate with hydrogel in the first and third hear of the study. The differences in turf colours in individual months were statistically significant.

According to Rutkowska and Hempel [1986], proper mineral fertilization determines maintaining the vivid green colour of leaves for all the growth period and prolonging lawn green stability up to the late autumn. In the present study (Table 7), however, no significant effect of the applied mineral fertilizers on changing in lawn turf colour intensity was observed. Nevertheless, the proposed fertilizer (N4) and Trawovit Komplet (N2) in the mixture Wembley (M1) grown on the substrate with hydrogel in the first year of the study had the highest effect on the intensity of colouration (brown-green colour) of the studied mineral fertilizers. The study of Wolski *et al*. [2006] indicates that introducing acrylic polymer into the substrate and mineral NPK fertilization significantly improved the turf colouration. The weakest effect in the improvement of colour was obtained as a result of the application of the fertilizer Trawovit Komplet (N2) also on the turf Wembley (M1) in the third year of the study, irrespective of the kind of substrate (6.5-6.8°). In the first and third year of the study – irrespective of the kind of fertilizer – turfs grown on the substrate with hydrogel were characterized by the most intensive colouration – from brown-green to grassy-green. Generally, in the successive years of the study the intensity of lawn turf colour deteriorated irrespective of the mineral fertilizer.

Irrespective of the kind of mixture and substrate, the most favorable, brown-green, colour (7.7°) – had turfs fertilized with the proposed fertilizer (N4) in the first year of the study, whereas the weakest (7.1°) – with the fertilizer Trawovit Komplet (N2) in the third year.

Considering the applied mineral fertilizers, on average in all the period of the study it was indicated that the best brown-green colouristic effect after their application was obtained by the mixture Parkowa (M2) irrespective of the kind of substrate. Of the applied fertilizers, generally the proposed fertilizer (N4) had the largest effect on the intensity of grass leaf colour.

CONCLUSIONS

1. In the successive years of the study the colour intensity of the studied lawn mixtures was deteriorated from brown-green (about 8°) to pure green (about 6°).

2. The mixture with 80% share of perennial ryegrass was characterized by the most intensive green colouration. Along with a decrease in the percentage share of perennial ryegrass in the mixtures (irrespective of the kind of substrate) the colouration of turfs deteriorated up to obtaining the grassy-green colour.

3. Hydrogel applied in the soil substrate had only a small effect on an improvement of lawn turf colouration in the first and third year of the study. The applied four mineral fertilizers in general did not diversify the intensity of lawn mixture colour, although the best colouristic effect – between the grassy green and brown-green colour – was obtained after the application of the proposed fertilizer.

4. Colouration of the studied lawn turfs to a large extent depended on the course of meteorological conditions, particularly on the temperature distribution and precipitation in individual months of the successive growth periods.

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KOLORYSTYKA MURAW TRAWNIKOWYCH W ASPEKCIE ZASTOSOWANEGO HYDROŻELU I NAWOZÓW MINERALNYCH

Streszczenie. Celem pracy było określenie wpływu hydrożelu i nawozów mineralnych na kolorystykę muraw trawnikowych. Doświadczenie trawnikowe prowadzono w latach 2002-2004 na poletkach doświadczalnych Katedry Łąkarstwa i Kształtowania Terenów Zieleni Uniwersytetu Przyrodniczo-Humanistycznego w Siedlcach w układzie losowanych bloków, o powierzchni poletka 4 m^2, w czterech powtórzeniach. Zastosowano następujące czynniki badawcze: rodzaj mieszanki trawnikowej: Wembley (M1), Parkowa (M2), Relax (M3), Półcień (M4); rodzaj podłoża: z dodatkiem hydrożelu Aqua-Gel P4 (H), bez dodatku hydrożelu Aqua-Gel P4 (BH) oraz rodzaj nawozu: Pokon (N1), Trawovit Komplet (N2), Azofoska (N3), nawóz autorski (N4). W każdym roku badań oceniano kolorystkę trawników według metodyki COBORU [Domański 1992]. Stosowano 9^o skalę bonitacyjną, w której 9 oznaczało najwyższą wartość cechy. Kolorystyka badanych muraw trawnikowych w dużym stopniu zależała od przebiegu warunków meteorologicznych, a zwłaszcza od rozkładu temperatury i ilości opadów (stwierdzono zróżnicowane zabarwienie muraw w poszczególnych miesiącach kolejnych okresów wegetacyjnych). Najbardziej intensywnym zielonym zabarwieniem odznaczała się mieszanka Wembley (M1) z 80% udziałem życicy trwałej. W miarę zmniejszania się procentowego udziału życicy trwałej w mieszankach, niezależnie od rodzaju podłoża, pogarszała się kolorystyka muraw aż do uzyskania barwy trawiastozielonej. W kolejnych latach badań intensywność zabarwienia badanych mieszanek trawnikowych ulegała nieznacznemu pogorszeniu – od zieleni brunatnozielonej (ok. 8^o) do czystej (ok. 6^o). Stosowanie hydrożelu i nawozu autorskiego w niewielkim stopniu poprawiało kolorystykę trawników. Pozostałe nawozy nie miały wpływu na barwę murawy.

Słowa kluczowe: intensywność zieleni, mieszanki trawnikowe, trawnik, życica trwała

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