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OPTIMIZATION OF LAWN FERTILIZATION WITH NITROGEN. PART I. SOIL RESOURCES, YIELD AND ORNAMETNAL VALUES OF TURF

OPTYMALIZACJA NAWOŻENIA TRAWNIKÓW AZOTEM. CZ. I. ZASOBNOŚĆ GLEBY, PLON I WALORY DEKORACYJNE MURAWY

Abstract: Study objective was the effect of increasing levels of nitrogen: 0, 50, 100, 150 and 200 mg N $\cdot$ dm^{-3} in the soil on changes in the content of components in the soil, on grass yielding, water content in plant aboveground parts and on ornamental values of turf. With the increase of nitrogen fertilization, with the doses of 150–200 mg N $\cdot$ dm^{-3}, there followed a significant decrease in the content of calcium, magnesium, copper and zinc in the soil, while the content of phosphorus and sulphates increased. With a high level of nitrogen (150 mg N $\cdot$ dm^{-3}), the salinity of soil was increasing. No effect of nitrogen fertilization was exerted on soil pH reaction and on the contents of nitrogen, potassium, iron, manganese, chlorides and sodium. Nitrogen fertilization exerted a significant effect on the growth of fresh and dry matter and on water content in the aboveground parts of grasses. Nitrogen fertilization exerted also a significant effect on the ornamental values of lawn, such as the general appearance, sodding and weeding. The general appearance determining visual attractiveness and sodding (soil covered by grass leaf blades) were the most attractive when nitrogen content was maintained within 150–200 mg N $\cdot$ dm^{-3}, while a significantly smallest number of weeds was shown by the dose of 200 mg N $\cdot$ dm^{-3}. After soil analysis by the universal method (extract of 0.03 M CH_3COOH), the doses of 100–200 mg N $\cdot$ dm^{-3} can be recommended as provisional standards of nitrogen content in soil being the optimal ones for grasses grown in green belts.

Keywords: lawn, nitrogen fertilization, ornamental values, yielding

Lawns are regarded as the basic elements of green areas and their cultivation is a testimony of the awareness that green areas exert a positive influence on human nature [1]. Thanks to their specific biological properties, they can play the main role in the

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management of degraded soils causing a positive effect on soil improvement and on anticorrosive soil-creating and decorative function [2]. Fertilization adjusted to the lawn nutritional requirement contributes to a better grass propagation, it improves the durability and density of turf and at the same time it prevents weeding. Furthermore, it stimulates the development of the root zone, increases the activity of soil processes and the number of microorganisms [3].

The objective of the presented studies was the optimization of lawn fertilization with nitrogen through the determination of the effect of an increasing N nutrition on changes in the soil resources, growth and development of turf, on lawn decorative values such as general appearance, sodding, weeding and yielding (yield of fresh and dry matter and water content in the plant aboveground parts).

Material and methods

Vegetation experiments were carried out in the years 2007–2008 in the area of the Experimental Farm of the Horticultural Department "Marcelin", University of Life Sciences in Poznan. Five increasing levels of nitrogen fertilization [mg N · dm^{-3}]: 0, 50, 100, 150, 200 corresponding to nitrogen doses of: 0, 10, 20, 30, 40 g N · m^{-2} were studied. Contents of the remaining macroelements in all tested combinations were supplemented to the standard levels [mg · dm^{-3}]: P 100, K 200, Mg 180 (year 2007) and 300 (year 2008). In the period from April to July (in midmonth), on the basis of chemical analyses, top dressing was applied using ammonium nitrate (34 % N), double superphosphate (40 % P_2O_5), potassium sulphate (50 % K_2O) and magnesium sulphate (16 % MgO). Fertilization diagram and the applied doses of nutritive components are shown in Table 1.

Experiment was established in a systematic design. Each level of N fertilization was represented by four plots of 24 m^2 surface area (4 × 6 m). Studies were carried out on a 2-year old lawn, where a mixture of lawn grasses was sown in the amount of 25 g · m^2 composed of: perennial ryegrass (*Lolium perenne* L.) 'Grasslands Nui' (45 %), tall fescue (*Festuca arundinacea* Schreb) 'Finelawn' (25 %), red fescue (*Festuca rubra* Hack.) 'Olivia' (10 %), red fescue (*Festuca rubra* Hack.) 'Boreal' (15 %), kentucky bluegrass (*Poa pratensis* L.) 'Balin' (5 %).

During the vegetation experiment, according to the needs, the lawn was irrigated with a dose of about 10 mm of water. The lawn was systematically mown in 10–12 day intervals. Each time, the fresh matter of the aboveground plant parts defined as plant fresh matter yield was weighed. After water content measurement, the dry matter content was determined.

Before experiment establishment, using the universal method, the content of macro- and microelements in the soil was measured [mg · dm^{-3}] which showed the following values: NH_4 trace; N-NO_3 4.0; P 35.0; K 132.0; Ca 2756.0; Mg 143.0; S-SO_4 2.0; Fe 115.9; Zn 23.2; Mn 7.7; Cu 3.0; B 0.36; Na 15.0; Cl 22.0; pH 7.32 and EC 0.11 [mS · cm^{-1}]. Soil samples for analyses were taken three times in the year 2007 (on 25.04, 24.05 and 17.07) while in 2008 – 5 times (on 15.03, 15.04, 12.06, 08.07, 19.08). Each time, from the given combination, 14–18 individual samples were taken from the

Table 1

Applied doses of components [g · m^{-2}]

Component	N level														
	N-0			N-50			N-100			N-150			N-200		
	2007	2008	Σ	2007	2008	Σ	2007	2008	Σ	2007	2008	Σ	2007	2008	Σ
N	0.0	0.0	0.0	10.0	10.0	20.0	20.0	20.0	40.0	30.0	30.0	60.0	40.0	40.0	80.0
P	39.0	11.6	50.6	39.0	11.6	50.6	39.0	11.6	50.6	39.0	11.6	50.6	39.0	11.6	50.6
K	14.0	1.6	15.6	14.0	17.2	31.2	14.0	19.4	33.4	14.0	22.2	36.2	14.0	25.2	39.2
Mg	8.0	0.0	8.0	8.0	18.6	26.6	8.0	18.6	26.6	8.0	24.8	32.8	8.0	24.8	32.8
S	17.2	0.7	17.9	17.2	31.2	48.4	17.4	32.1	49.5	17.2	40.2	57.4	17.2	42.6	59.8

layer of 0–20 cm, and after mixing, a representative mixed sample (0.4–0.5 dm^3) was obtained. Available macroelement forms of sodium and chlorides were determined by universal method in 0.03 M CH_3COOH, while microelements were determined in Lindsay solution [4, 5]. Determinations were made using the following methods: $N\text{-}NO_3$, $N\text{-}NH_4$ – by microdistillation method (according to Bremner in Starck's modification), P – was measured colorimetrically with ammonium vanadomolibdate, K, Ca, Na – by flame photometry; Cl – nephelometrically with $AgNO_3$; $S\text{-}SO_4$ – nephelometrically with $BaCl_2$; B – by colorimetry with curcumin; Mg, Fe, Mn, Zn, Cu – by atomic absorption spectrometry (AAS – on Carl Zeiss-Jena apparatus), salinity [EC units] – conductometrically, at soil:water relation = 1:2 (v/v); pH – by potentiometry at soil:water relation = 1:2 (v/v).

Exact estimation of the ornamental values of turf was carried out in the midmonth of July, August and September of each year of studies. The following parameters were estimated: general appearance of the turf (in a 9-degree scale, where 1^o denoted a negative appearance devoid of any decorative values, while 9^o – showed a very good and attractive appearance [6, modified], sodding, ie soil covered by the aboveground parts of grasses in a 9-degree evaluation scale, where 1^o indicated surface cover [%]: 1^o – 0–5; 2^o – 6–15; 3^o – 16–25; 4^o – 26–40; 5^o – 41–60; 6^o – 61–75; 7^o – 76–85; 8^o – 86–95; 9^o – 96–100 and weeding of turf.

Changes in the component content in soil, yielding of plants, water content in the aboveground parts of grasses and ornamental values of turf were subject to statistical analysis using Duncan's test ($\alpha = 0.05$).

Results and discusion

Content of nutritive components in soil

No significant effect of nitrogen fertilization on the mean content in soil of ammonium nitrogen, nitrate(V) nitrogen and potassium were found (Table 2). However, a significant effect was shown by the levels of 50–200 mg $N\text{-}NO_3 \cdot dm^{-3}$ on the increase of phosphorus in soil. In contrast to phosphorus, there was a significant effect of nitrogen fertilization on the decrease of calcium and magnesium contents particularly visible in the range of 150–200 mg $N\text{-}NO_3 \cdot dm^{-3}$ of soil. Content of sulphates increased under the influence of nitrogen fertilization, whereby at the levels of N-50 and N-150, the effect was significant.

Studies of microelements did not show any significant effect of increasing nitrogen fertilization on the contents of iron, manganese and chlorides in soil, or of the ballast ion represented by sodium (Table 3). On the other hand, it was found that the soil became poorer in zinc and copper content.

Fertilization with nitrogen on the levels of 100–200 mg $N\text{-}NO_3 \cdot dm^{-3}$ increased soil salinity, whereby, at the level of 150 mg $N\text{-}NO_3$, it was statistically proven (Table 3). Nitrogen fertilization did not cause any significant changes in the pH of soil. Soil reaction in the studied levels of nitrogen fertilization was alkaline – $pH_{(H2O)}$ 7.19–7.37.

Table 2

Effect of nitrogen fertilization on the content of macroelements in soil [mg · dm^{-3}]

N level	[mg · dm^{-3}]																				
	$N-NH_4$			$N-NO_3$			P			K			Ca			Mg			$S-SO_4$		
	Year																				
	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$
N-0	7.0a	10.5a	8.8a	0.0b	9.8a	4.9b	54.7b	57.7a	56.2ab	151.7a	115.0a	133.4a	2957.0a	4152.2a	3554.6a	190.0a	223.7a	206.9a	66.7b	22.4b	44.6b
N-50	8.3a	10.5a	9.4a	4.7a	11.2a	8.0ab	55.0b	38.3b	46.7b	172.7a	88.5a	130.6a	2839.0ab	4322.5a	3580.8a	188.3a	275.1a	231.7a	121.3a	111.0a	116.2a
N-100	6.0a	11.2a	8.6a	0.0b	9.1a	4.6b	60.7ab	55.5a	58.1ab	135.0a	103.5a	119.3a	2580.3ab	3534.1ab	3057.2ab	163.0a	264.8a	213.9a	68.3b	79.6a	74.0ab
N-150	8.3a	11.2a	9.8a	8.3a	14.0a	11.2a	71.7a	67.5a	69.6a	148.3a	95.5a	121.9a	2234.7b	2893.0b	2563.9b	159.0a	231.4a	195.2ab	148.3a	81.7a	115.0a
N-200	8.3a	10.5a	9.4a	0.0b	16.1a	8.1ab	74.7a	64.6a	69.7a	153.0a	82.6a	117.8a	2251.0b	2624.6b	2437.8b	150.3a	217.4a	183.9b	86.3ab	77.9a	82.1ab
$\bar{x}$	7.6	10.8		2.6	12.0		63.4	56.7		152.1	97.0		2572.4	3505.3		170.1	242.5		98.2	74.5	

Table 3

Effect of nitrogen fertilization on the content of microelements and sodium in soil [mg · dm^{-3}] and on pH and salinity

N level (A)	[mg · dm^{-3}]																		Salinity			$pH_{(H_2O)}$		
	Fe			Mn			Zn			Cu			Cl			Na			[mS · cm^{-1}]			[-]		
	Year (B)																							
	2007	2008	$\bar{x}$ (A)	2007	2008	$\bar{x}$ (A)	2007	2008	$\bar{x}$ (A)	2007	2008	$\bar{x}$ (A)	2007	2008	$\bar{x}$ (A)	2007	2008	$\bar{x}$ (A)	2007	2008	$\bar{x}$ (A)	2007	2008	$\bar{x}$ (A)
N-0	75.5a	88.4a	82.0a	5.2a	15.8a	10.5a	31.3a	42.2a	36.8a	2.30a	4.75a	3.53a	19.3a	37.8a	28.6a	21.0a	33.0a	27.0a	0.18a	0.23a	0.21a	7.08a	7.35a	7.19a
N-50	73.4a	73.7a	73.6a	6.2a	15.7a	11.0a	19.0b	21.6b	20.3b	1.90b	2.75b	2.33b	18.0a	26.4a	22.2a	20.3a	33.7a	27.0a	0.20a	0.21a	0.21a	7.21a	7.65a	7.37a
N-100	79.6a	90.7a	85.2a	6.8a	19.2a	13.0a	16.5b	22.0b	19.3b	1.90b	2.92b	2.41b	28.6a	36.5a	32.6a	20.0a	29.8a	24.9a	0.20a	0.27a	0.24a	7.19a	7.57a	7.30a
N-150	81.2a	89.0a	85.1a	6.2a	17.7a	12.0a	16.1b	20.8b	18.5b	1.80b	3.04b	2.42b	19.7a	35.8a	27.8a	19.3a	29.7a	24.5a	0.26a	0.33a	0.30b	7.08a	7.42a	7.21a
N-200	92.4a	88.2a	90.3a	7.3a	17.2a	12.3a	20.0b	21.9b	21.0b	2.10b	3.16b	2.63b	18.0a	41.3a	29.7a	18.0a	31.7a	24.9a	0.17a	0.26a	0.22a	7.07a	7.41a	7.26a
$\bar{x}$ (B)	80.4	86.0		6.3	17.1		20.6	25.7		2.0	3.32		20.7	35.6		19.7	31.6		0.20	0.26		7.13	7.44	

Absence of any effect on the differentiation of reaction was probably the result of high calcium content in soil (2437.8–3580.8 mg Ca · dm^{-3}).

Summing up, one can conclude that nitrogen fertilization, with the maintained high levels of 150–200 mg N-NO_3 · dm^{-3}, significantly decreased the contents of calcium, magnesium, zinc and copper and it increased the content of phosphorus and sulphur. However, it did not exert any effect on the contents of nitrogen, potassium, iron and manganese. Significant decrease of the contents of calcium, magnesium, zinc and copper could have been caused by the removal of those components together with the yield of plants which was intensified by the increasing nitrogen fertilization. Increase of phosphorus content can be connected with the decrease of calcium, potassium and magnesium contents and thereby with a smaller retardation of this component. On the other hand, the increase of phosphates was the effect of potassium phosphate and magnesium phosphate application in order to maintain the correct levels of potassium and magnesium in the soil.

Fresh matter yield of the aboveground grass parts

Significant effect of nitrogen fertilization was found to be exerted on the fresh matter of aboveground grass parts (Table 4). Yielding dynamics in the successive years of studies is shown in Figure 1. The presented data indicate a strong yield-creating influence of top dressing with nitrogen on the yield of the aboveground parts of plants. Data available in literature show higher yielding of grasses with smaller doses of nitrogen in case of top dressing. It is reported the best yielding of perennial ryegrass (*Lolium perenne* L.), being the basic species in the studied mixture of grasses, in a peat-mursh soil with nitrogen fertilization by the dose of 120 kg N · ha^{-1} (corresponding to 60 mg N · dm^{-3}) [7]. The most intensive fertilization of perennial ryegrass in the first year after seeding improved the aesthetical values of plants [8]. It is reported that best yielding of red fescue (*Festuca rubra* L.) was obtained by them also with the dose of 120 kg N · ha^{-1} [9]. Those authors showed that nitrogen fertilization exerted a favourable influence on the morphological features of grasses, among others on the height and length of inflorescences. Earlier studies reported that for some species and cultivars of grasses (among others the *Festulolium* hybrids originating from the

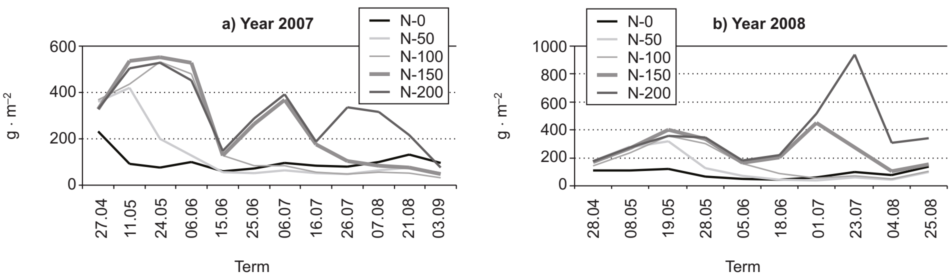

Fig. 1. Yield dynamics of aboveground grass parts, depending on nitrogen fertilization

Table 4

Effect of nitrogen fertilization on the yield of fresh and dry matter and on water content in the aboveground parts of grasses

N level	Fresh Yield [$g \cdot m^{-2}$]			Dry Mass Yield [$g \cdot m^{-2}$]			Water content [%]			
	Term									
	2007	2008	$\bar{x}$	2007	2008	$\bar{x}$	June	July	August	$\bar{x}$
N-0	1221.2d	871.0d	1046.1e	366.4c	261.3c	313.8c	65.4b	70.1ab	74.5a	70.0ab
N-50	1566.9c	1245.7c	1406.3d	504.5bc	401.1b	452.8b	65.5b	68.1b	69.9b	67.8b
N-100	2357.4b	1554.9c	1956.2c	711.9b	469.6b	590.8b	68.5ab	68.7b	72.3a	69.8b
N-150	3192.2ab	2529.3b	2860.8b	852.3a	675.3ab	763.8ab	74.3a	73.5a	72.0ab	73.3a
N-200	3765.1a	3659.1a	3712.1a	960.1a	933.1a	946.6a	74.1a	77.5a	72.0ab	74.5a

Mean values marked with the same letter, for the particular columns, do not differ significantly.

cross-breeding of species from *Festuca* and *Lolium*), the most effective was the nitrogen dose of 150 kg N $\cdot$ ha^{-1} (75 mg N $\cdot$ dm^{-3}) [10].

A significant effect of nitrogen fertilization on the increase of water content was found in the aboveground parts (Table 4). The smallest amount of water content was determined in the combinations N – 0; N – 50 and N – 100 (70.0; 67.8 and 69.8 %, respectively), while the significantly highest water content was found in combinations N – 150 and N – 200 (73.3 and 74.5 %, respectively)

Decorative values

A positive tendency in the improvement of the general appearance (including the colour of leaves) and the degree of turf sodding were found with the increasing nitrogen fertilization (Table 5). In the second year of studies (2008), there was a distinct improvement in the lawn condition, in comparison with the previous state (in 2007). The most favourable decorative values were shown by lawns in the combinations N-150 and N-200; less good results were shown by the combinations N-100 and the worst effect was found after the application of combinations N – 0 and N – 50. Together with the duration of the vegetation period, there appeared a tendency, typical of lawns, to a decrease of the decorative values, which was confirmed by the studies [11]. Those authors mentioned that among the factors exerting an effect on lawn attractiveness (including sodding), the species composition of grass mixtures also plays an important role. In spring, the best sodding was shown by mixtures containing 35–40 % of perennial ryegrass, 40–55 % of Kentucky bluegrass and 10–20 % of red fescue. In summer, the degree of soil cover did not depend on the composition of grass mixtures. In autumn, the worst sodding was shown by the turf containing over 50 % of perennial ryegrass. It was showed that a good quality of lawns can be obtained by the adequate selection of species and cultivars [12]. The most aesthetic appearance was represented in the spring period by mixtures containing at least 50 % of perennial ryegrass. Different conclusions than those obtained in our studies referring to the effect of nitrogen fertilization were formulated [13]. In the opinion of the mentioned author, in case of a renovation of a turf, very effective were low nitrogen doses 50 kg N $\cdot$ ha^{-1} (25 mg N $\cdot$ dm^{-3} of soil) which exerted a positive effect on the attractiveness of turf and on sodding.

One can recommend as a provisional standard the following contents of nutritive components in soil for lawns [mg $\cdot$ dm^{-3}]: N 100–200; P 100; K 200; Mg 180–300. The conventional maximum single application of slow release N is 73 kg N $\cdot$ ha^{-1} (36.5 mg N $\cdot$ dm^{-3}) – but some fertilizer manufacturers recommend a single season long application rate of 146 kg N ha (73 mg N $\cdot$ dm^{-3}) [14]. The same authors confirmed our observations that in case of the absence of N fertilization, the appearance of lawns significantly deteriorated. The best turf density is obtained with the use of an annual dose of 300 kg N $\cdot$ ha^{-1} (corresponding to 150 mg N $\cdot$ dm^{-3} of soil) [15].

A significant effect of nitrogen fetrtilization was found to be exerted on lawn weeding (Table 5). The greatest weeding was found in the control combination (N – 0), while the least number of weeds was recorded in the combinations: N – 150 and N –

Table 5

Effect of nitrogen fertilization on the decorative values of a lawns (2007, 2008)

Term	N level (A)					$\bar{x}$
	N-0	N-50	N-100	N-150	N-200	
Appearance of lawn [in degrees]						
July	6.00 (6.25)	6.50 (6.25)	6.50 (6.25)	8.75 (7.25)	8.50 (8.25)	7.15a (6.85)a
August	4.25 (4.25)	5.00 (4.75)	5.25 (5.25)	5.00 (7.25)	6.00 (7.75)	5.10b (5.85)ab
September	5.00 (5.00)	4.20 (4.20)	4.75 (4.75)	6.00 (7.00)	5.75 (7.50)	5.15b (5.69)b
$\bar{x}$	5.08b (5.17)b	5.08b (5.07)b	5.50b (5.42)b	6.58a (7.17)a	6.75a (7.83)a	
Sodding [in degrees]						
July	4.00 (4.25)	4.50 (4.75)	5.50 (5.25)	7.50 (7.50)	7.50 (8.25)	5.80a (6.00)a
August	5.50 (5.75)	5.75 (6.25)	6.00 (7.75)	5.75 (7.75)	6.50 (8.00)	5.90a (7.10)a
September	4.00 (4.50)	4.75 (5.25)	4.50 (6.25)	5.50 (7.00)	4.75 (7.25)	4.70b (6.05)a
$\bar{x}$	4.50c (4.83)c	5.00bc (5.42)b	5.33b (6.42)b	6.25a (7.42)a	6.25a (7.83)a	
Weeding [number of weeds · m^{-2}]						
July	1.29	1.17	1.13	0.58	0.33	1.29 a
August	1.25	1.25	1.08	0.42	0.17	1.25 a
September	1.17	1.21	1.08	0.42	0.17	1.17 a
$\bar{x}$	1.24 a	1.21 a	1.10 a	0.47 b	0.22 b	

Mean values marked with the same letter, for the particular years of studies, do not differ significantly. Data in brackets refer to year 2008.

200. With the nitrogen fertilization increase, the weed species composition was changed. In the control combination, there occurred: common dandelion (*Taraxacum officinale* F.H. Wigg.); ribwort plantain (*Plantago lanceolata*); white clover (*Trifolium repens* L.). In the N-50 and N-100 combinations, there occurred: common dandelion, ribwort plantain, while in the combination N-150 and N-200, only common dandelion was found. It is reported that the factor which prevents weeding is the adjustment of mineral fertilization to the nutritive requirements of plants which contributes to a better propagation of grasses, improves the durability and density of turf [3]. Significant effect on lawn degradation is exerted by water deficit and too rare lawn grass mowing [16].

On the basis of our studies, one can conclude that one of the factors causing a degradation and deterioration of lawn appearance in the green belts can be the fact that mineral fertilization of plants is not properly adjusted to the nutritional requirements of plants. In order to optimize the cultivation and to improve the appearance of lawns, a controlled fertilization based on chemical soil analyses is recommended.

Conclusions

1. A significant effect of increasing nitrogen fertilization on the levels of 150–200 mg $N\text{-}NO_3 \cdot dm^{-3}$ was found to be exerted on the increase of phosphorus and sulphur content in soil. On the other hand, the contents of calcium, magnesium, zinc and copper decreased. No significant changes were found in the contents of nitrogen, potassium, iron and manganese.

2. Nitrogen fertilization exerted a significant effect on the increase of fresh and dry matter yield and on water content in the aboveground parts of grasses.

3. The most favourable appearance and the highest sodding of turf was obtained when the nitrogen content was maintained in the range of 150–200 mg $N\text{-}NO_3 \cdot dm^{-3}$ of soil. The least weeding was found at N content of 200 mg $N\text{-}NO_3 \cdot dm^{-3}$.

4. Doses of 100–200 mg $N \cdot dm^{-3}$ can be recommended as provisional standards of nitrogen content in the soills for lawns.

References

[1] Gospodarczyk F.: Mat. konf. z VIII Targów Ziel. Miejsk. Ogrodnic. TARAGRA 99 "Kształtowanie, pielęgnacja i ochrona zieleni Miejskiej", 28–29.05.99, Wrocław 1999, 9–10.

[2] Frey L.: *Trawy niezwyciężone*. Łąkarst. Polsce 2000, **3**, 9–20, Poznań, Polskie Towarzystwo Łąkarskie.

[3] Rutkowska B. and Hampel A.: Trawniki. PWRiL, Warszawa 1986, 122–145.

[4] IUNG: Metody badań laboratoryjnych w stacjach chemiczno-rolniczych. Cz. III. Badanie gleb, ziem i podłoży spod warzyw i kwiatów oraz części wskaźnikowych roślin w celach diagnostycznych. IUNG, Puławy 1983, 28–81.

[5] Breś W., Golcz A., Komosa A., Kozik E. and Tyksiński W.: *Nawożenie roślin ogrodniczych*. Wyd. Uniwersytetu Przyrodniczego w Poznaniu, Poznań 2008, 5–189.

[6] Domański P.: *Metodyka badania wartości gospodarczej odmian (WGO) roślin uprawnych*. COBORU, Słupia Wielka 1998, 12–17.

[7] Baryła R.: *Ocena przydatności Lolium perenne L. do mieszanek pastwiskowych na gleby torfowo-murszowe*. Ann. UMCS 2005, **LX**, 249–261, Lublin.

[8] Radkowski A. and Styrc N.: *Ocena wartości trawnikowej życicy trwałej przy dwóch sposobach użytkowania*. Zesz. Nauk. Uniw. Przyrod., Wrocław 2006, Rolnictwo **LXXXVIII**(545), 255–260.

[9] Kitczak T. and Czyż H.: *Wpływ nawożenia azotem na plon nasion dwóch odmian Festuca rubra L.*. Ann. UMCS, 2004, **LIX**(3), 333–339, Lublin.
[10] Stypiński P., Janicka M. and Rataj D.: *Wpływ zróżnicowanego nawożenia azotowego na plonowanie wybranych gatunków i odmian traw*. Pamięt. Puław. 2001, **125**, 13–20.
[11] Grabowski K., Grzegorczyk S., Kwietniewski H. and Kozikowski A.: *Walory użytkowe wybranych gatunków i odmian traw przeznaczonych na trawniki rekreacyjne*. Łąkarst. Polsce 2006, **9**, 41–50.
[12] Prończuk S. and Prończuk M.: *Nasiennictwo traw dla rekultywacji traw terenów trudnych*. Łąkarst. Polsce 2000, **3**, 129–139.
[13] Pawluśkiewicz B.: *Kształtowanie zbiorowisk trawiastych na terenie starych parków dworskich na przykładzie Zespołu Pałacowo-Parkowego w Falentach*. Ann. UMCS 2006, **LXI**, 277–283, Lublin.
[14] Soldat D.J., Petrovic A.M. and Barlow J.: *Turfgrass response to nitrogen sources with varying nitrogen release rates*. Acta Horticult. 2008, **783**, 453–462.
[15] Wilkins P.W., Lovatt J.A. and Hayes R.C.: *Effect of a stay-green locus on the dry-matter yield, nitrogen yield and shoot density of perennial ryegrass*. J. Compilat. 2007, Grass Forage Sci., **62**, 453–458, Blackwell Publishing Ltd.
[16] Haber Z. and Urbański P.: Kształtowanie terenów zieleni z elementami ekologii. Wyd. Akademii Rolniczej, Poznań 2005, 129–145.

OPTYMALIZACJA NAWOŻENIA TRAWNIKÓW AZOTEM. CZ. I. ZASOBNOŚĆ GLEBY, PLON I WALORY DEKORACYJNE MURAWY

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Abstrakt: Badano wpływ wzrastających poziomów azotu: 0, 50, 100, 150 i 200 mg N · dm^{-3} gleby na zmiany zawartości składników w glebie, plonowanie traw, zawartość wody w częściach nadziemnych roślin i walory dekoracyjne murawy. Wraz ze wzrostem nawożenia azotem, przy poziomach 150–200 mg N · dm^{-3}, znacznemu obniżeniu ulegała zawartość wapnia, magnezu, miedzi i cynku w glebie, a wzrastała zawartość fosforu i siarczanów. Przy wysokim poziomie azotu (150 mg N · dm^{-3}) wzrastało zasolenie gleby. Nie stwierdzono wpływu nawożenia azotem na odczyn pH gleby oraz zawartość azotu, potasu, żelaza, manganu, chlorków i sodu. Stwierdzono istotny wpływ nawożenia azotem na wzrost plonu świeżej i suchej masy oraz zawartość wody w częściach nadziemnych traw. Stwierdzono istotny wpływ nawożenia azotem na walory dekoracyjne trawnika, takie jak: aspekt ogólny, zadarnienie oraz zachwaszczenie. Aspekt ogólny, określający jego atrakcyjność wizualną oraz zadarnienie (pokrycie gleby blaszkami liściowymi) były najlepsze przy utrzymywaniu zawartości azotu na poziomach 150–200 mg N · dm^{-3}, natomiast najmniejsze zachwaszczenie było przy zawartości 200 mg N · dm^{-3}. Jako tymczasowe standardowe zawartości azotu w glebie, optymalne dla wzrostu traw na terenach zieleni, można zalecać 100–200 mg N · dm^{-3} gleby, przy analizie gleby metodą uniwersalną (wyciąg 0,03 M CH_3COOH).

Słowa kluczowe: trawnik, nawożenie azotem, wartość dekoracyjna, plonowanie