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Original Paper

Effect of Alginite and Inorganic Fertilizers on Selected Growth-production Parameters of Turf

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The four-year-old turf experiment was carried out in the Demonstration and Research Base of the Institute of Plant Production of the Slovak University of Agriculture in Nitra (Slovak Republic). There were followed 4 treatments: 1. without application alginite and inorganic fertilizers ("control"), 2. alginite, 3. inorganic fertilizers ("NPK"), 4. alginite and inorganic fertilizers ("alginite + NPK"). There were evaluated the total height and total production of dry above-ground phytomass in the turf experiment. Turf in control and Alginite treatments were significantly lower than turf with NPK and alginite + NPK through the evaluation period. An overall comparison of the years 2015–2018 showed that significantly (p = 0.00) the highest total turf height achieved by turfs after the application alginite + NPK (538.5 mm) than turfs fertilized NPK (497.3 mm), with the application of alginite (290.9 mm) and control (280.3 mm). The significantly (p = 0.00) lowest production of dry aboveground phytomass was reached by the control (174.5 g.m^{-2}) and the turf with alginite application (201.5 g.m^{-2}) in comparison with NPK (321.8 g.m^{-2}) and alginite + NPK (389.9 g.m^{-2}) treatments in 2015–2018.

Keywords: alginite, turf, fertilizing, height, production

1 Introduction

More modern definitions cite turf as a surface layer of vegetation, consisting of earth and a dense stand of grasses and roots. In profile, turf consists of verdure, the green aerial shoots remaining after mowing (Aldous, 1999). Turfs serve a decorative function. Their uniform green appearance enhances the beauty of a landscape. Turfs also provide inviting arenas for recreational activities and relaxation and offer relief from heat-absorbing roadways, buildings, and other structures (Turgeon, 2012; Tomaškin et al., 2015; Hric, 2017; Tomaškin and Tomaškinová, 2020). The intensity of growth and the production of aboveground phytomass are some of the indicators for assessing the quality of a turf. Turf management aims to reduce the number of mowings and minimize the growth of green matter, which can be influenced by breeding new varieties. The growth and production of aboveground phytomass are influenced by site-specific conditions, nutrition, season, irrigation, intensity and method of use, composition of the grass mixture, etc. (Turgeon, 2012; Emmons and Rossi, 2015). Root biomass has a significant share in the total grass biomass (49.9–54.2%), followed by the tillering zone (33.3–36%) and with the lowest share of aboveground biomass (11.9–16.8%). It offers the greatest potential for efficient uptake of fertilizers and nutrients from the soil (Tomaškin et al., 2013). Natural compounds and various extracts containing bioactive components can be regarded as biostimulants. Humic, fulvic, and salicylic acids, mineral elements, amino acids, chitosan, vitamins, poly-, and oligosaccharides are the typical components of bio-stimulants of different natures. Typical components of biostimulants of different natures are humic, fulvic, and salicylic acids, mineral elements, amino acids, chitosan, vitamins, poly- and oligosaccharides (Bulgari et al., 2015; EL Arroussi et al., 2018). Alginite is also a possible source of humic and other biologically active substances of natural origin. It is an organic sediment representing the oil shale category. It was formed by the accumulation of organic (algae) and inorganic material, mainly clay,

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carbonates, quartz, and an amorphous modification of silicic acid in an aqueous environment 3–4 million years ago. Its fractional composition has a higher content of fulvic acids than humic acids (Solti, 1987; Kulich et al. 2001; Litavec and Barančíková, 2013; Kádar et al., 2015; Brindza et al., 2021).

This work aimed to determine the effect of the application of alginite, inorganic fertilizers, and their combination on the total height and total production of dry above-ground phytomass of the turf.

2 Material and Methods

2.1 Characteristics of the Experimental Site

The turf experiment was carried out in the Demonstration and Research Base of the Institute of Plant Production of the Slovak University of Agriculture in Nitra from 2015 to 2018. The experimental area is located in a temperate climatic zone of a warm and dry area with an altitude of 160 m above sea level. The average annual temperature is 9.7 °C and annual rainfall is 561 mm. The course of weather conditions during the study period is presented in Table 1. The soil type is a clay-loam fluvisol. The agrochemical properties of the soil of the experimental site before stand establishment are presented in Table 2.

The experiment was carried out on a long-term extensively used turf composed of red fescue and sheep fescue. The experimental treatments were arranged in a block design in three repetitions. The size of each treatment was 1.5 × 1.5 m. The experiment was carried out under irrigated conditions in a single dose of 10 mm as needed (Table 3) and according to the weather conditions in each year (Table 1).

2.2 Characteristics of treatments

In the experiment were followed 4 treatments:

1. without fertilizing and application preparations (in the text "control");
2. alginite (in the text "alginite");
3. classical NPK fertilizing (in the text "NPK");
4. alginite and classical NPK fertilizing (in the text "alginite + NPK").

Table 1 Average monthly temperatures (°C) and rainfall (mm) in 2015–2018 growing seasons

Year	Indicator	Month								Growing season	
		III	IV	V	VI	VII	VIII	IX	X	∑	Ø
2015	temperature	6.3	10.4	15.1	19.9	23.6	23.5	17.5	10.5	-	15.9
	rainfall	35.4	25.0	69.5	10.2	17.2	57.7	33.2	54.8	303.0	-
2016	temperature	6.2	11.6	16.2	20.5	22.1	19.8	17.7	9.5	-	15.5
	rainfall	14.0	20.5	87.1	94.5	154.5	72.3	48.0	79.8	570.7	-
2017	temperature	8.6	9.8	17.1	21.9	22.1	23.0	15.5	10.8	-	16.1
	rainfall	18.3	42.8	12.9	23.6	69.8	19.4	87.9	47.7	322.4	-
2018	temperature	3.4	16.0	19.4	21.0	22.3	23.4	17.0	12.9	-	16.9
	rainfall	48.6	12.4	26.0	109.0	43.1	73.7	68.9	14.1	395.8	-

Source: SHMI (2024) (modified), ∑ – sum, Ø – mean

Table 2 Agrochemical properties of soil on the experimental site in $g.kg^{-1}$

Nt	P	K	Mg	Ca	Cox	pH
1.82	0.06	0.34	0.54	0.61	7.70	6.78

Nt – total nitrogen, P – phosphorus, K – potassium, Mg – magnesium, Ca – calcium, Cox – oxidable carbon

Table 3 Irrigation dates of the experiment in 2015–2018

Month	Year			
	2015	2016	2017	2018
	day			
V	–	–	–	2, 9, 31
VI	4, 8, 12, 16, 18, 26	21, 28	2, 8, 14, 22	–
VII	7, 13, 16, 20, 23, 27	1, 27	4, 31	4, 26, 30
VIII	3, 6, 13	–	3, 17, 28	10, 21
IX	9, 17	13	–	–

Nitrogen (N) was added in the form of LAD (27% N with dolomite. P (phosphorus) was added in the form of superphosphate (19% P_2O_5). Potassium (K) was added in the form of potassium salt (60% K_2O). Alginite (from Pinciná in Slovak Republic) is a grey to grey-black organomineral layered rock that formed about six million years ago from fossil algae in what is now the Pannonian Basin (Kulich et al., 2001). It is a natural product from the category of flammable shale with excellent sorption properties, with a relatively high representation of biogenic, but also trace elements, and a low concentration of heavy metals. It contains relatively little humified organic matter despite a relatively high amount of organic carbon (OC = 5.5%). Humic acids and fulvic acids are represented in the fractional composition (Vass et al., 1997; Litavec and Barančíková, 2013; Brindza et al., 2021). Finely crushed alginite of fraction 1 mm was used in this experiment. It was obtained by sifting alginite through a sieve with a mesh size of 1 mm.

Nitrogen was applied at a rate of 170 kg.ha^{-1}. Phosphorus and potassium were applied at a rate of 35 kg.ha^{-1} P and 70 kg.ha^{-1} K. Table 4 presents the application dates and rates of individual fertilizers and alginite per treatment.

2.3 Evaluated Parameters

When the height of turf was approximately 80 – 100 mm high, it was mowed to the required height of 50 mm. Before each mowing the turf height (mm) was determined as an average of 10 measurements in plots. Total height was expressed as the sum of height per growing season. Production of above-ground phytomass (g.m^{-2}) was determined by sampling the above-ground phytomass using of accumulation scissors from the surface of 0.1 × 1 m and subsequently drying at 105 °C. Expressed as the sum of dry above-ground phytomass increments per growing season. In 2015 was realized 9 cuts (sampling and measuring), in 2016 11 cuts, in 2017 10 cuts, and in 2018 9 cuts.

2.4 Statistical analysis

The results were statistically evaluated by the Analysis of Variance (ANOVA – Multiple Range Tests, Method: 95.0 percent LSD) using the data analysis software system STATISTICA version 10 (StatSoft. Inc. 2011).

3 Results and Discussion

The results of the total turf height in 2015, expressed as the sum of the height increments in the cuttings, are shown in Figure 1. Turfs with application NPK (345.0 mm) and alginite + NPK (367.3 mm) were significantly higher compared to treatment alginite (191.0 mm) and control (212.7 mm). In this year was observed a negative effect of the lack of rainfall (Table 1) on the general growth of the turfs. Lack of water, respectively drought stress affect the functional expressions of plants and the implementation of their growth and production process (Fang and Xiong, 2015; Fahad et al., 2017; Yang et al., 2021; Cabello et al., 2023). The treatments were divided into two growth groups in the following year. Control (376.3 mm) and alginite (377.3 mm) were significantly (p = 0.00) lower than NPK (726.7 mm) and alginite + NPK (735.3 mm). The development of the total turf height in 2017 was similar to in year 2016. Both years were characterized by detected non-significant (p = 0.8735, p = 0.7643) differences in total turf height on treatments NPK and Alginte + NPK. The treatment alginite + NPK reached significantly (p = 0.00) the highest total turf height (450.7 mm) compared to control (280.3 mm), alginite (286.7 mm), and NPK (363.0 mm). An overall comparison of the years 2015–2018 showed that significantly (p = 0.00) the highest total turf height has treatment with application alginite + NPK (538.5 mm) than turfs fertilized NPK (497.3 mm), with application alginite (290.9 mm) and control (280.3 mm). Humic and fulvic acids (components of alginite) have long been recognized that humic substances have many beneficial effects on soils and consequently on plant growth (MacCartthy et al.,1990; Makiewicz-Walec and Olszewska, 2023). Humic acids have promoted the growth of various crops (El-Sayed et al., 2017) including turfs (Hunter and Anders, 2004).

The total dry aboveground phytomass production per vegetation period in 2015 (Figure 2) was statistically (p = 0.00) highest on the treatment alginite + NPK (308.6 g.m^{-2})

Table 4 Application dates and rates of individual fertilizers and alginite per treatments

Alginite and used fertilizers	Yearly dose (g.m^{-2})	Application date and fertiliser rate (g.m^{-2})			
		beginning of vegetation	beginning of June	half of July	beginning of September
Alginite	3,000.0*	–	–	–	–
LAD	62.9	15.7	15.7	15.7	15.7
P_2O_5	42.2	42.2	–	–	–
K_2O	14.0	7.0	–	7.0	–

* application at the beginning of the experiment

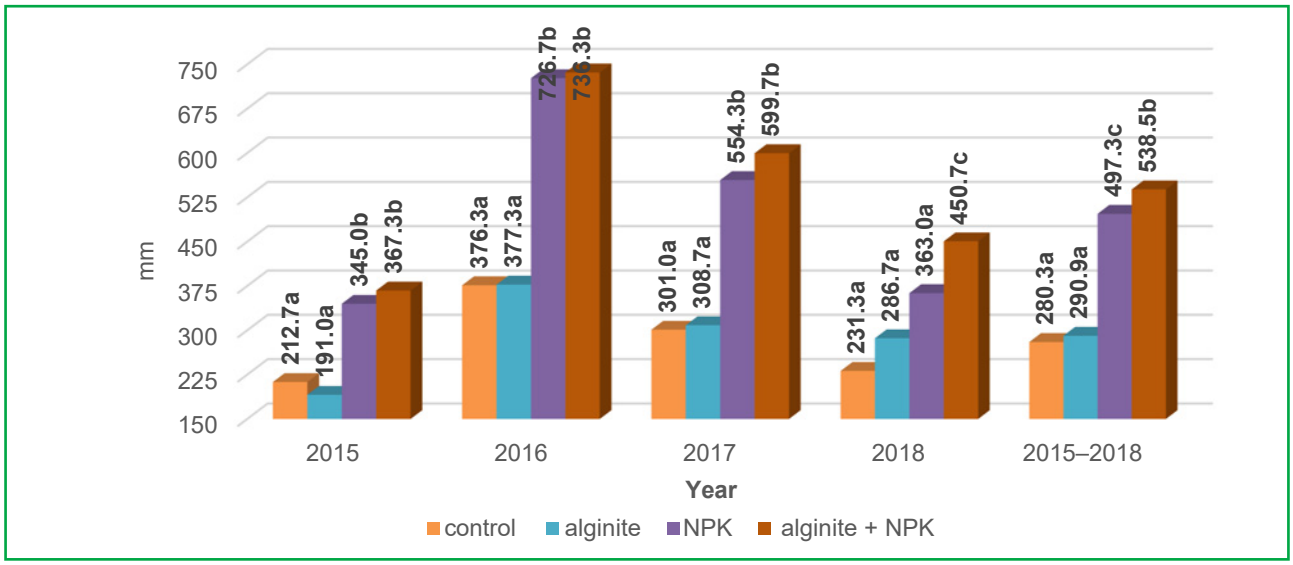

Figure 1 Total turf height in 2015 – 2018
Different index (a, b, c) means statistically significant differences within column (Fisher LSD test, $\alpha = 0.05$).

compared to the turfs with application NPK (244.2 g.m^{-2}), alginite (179.8 g.m^{-2}) and control (164.8 g.m^{-2}). The most productive was the treatment of Alginite + NPK (518.0 g.m^{-2}) in 2016. Turfs with application NPK (459.2 g.m^{-2}), alginite (230.6 g.m^{-2}), and control (220.5 g.m^{-2}) reached a lower production of dry aboveground phytomass. The total dry aboveground phytomass production per vegetation in 2017 was statistically ($p = 0.00$) highest on the treatment alginite + NPK (408.1 g.m^{-2}) compared to the turfs with application NPK (320.9 g.m^{-2}), alginite (191.0 g.m^{-2}) and control (131.3 g.m^{-2}). Similarly to previous years, the highest production in 2018 was on the treatment alginite + NPK (325.1 g.m^{-2}). The turf fertilized with NPK (262.9 g.m^{-2}) was also relatively highly productive. The lowest total of dry aboveground phytomass production was found in the treatment alginite (204.4 g.m^{-2}) and control (164.3 g.m^{-2}). The comparison of the values of the total production of dry above-ground phytomass in the observation period (2015–2018) showed the statistically ($p = 0.00$) highest production on treatment with application alginite + NPK (389.9 g.m^{-2}) compared to NPK (321.8 g.m^{-2}), alginite (201.5 g.m^{-2}) and control (174.46 g.m^{-2}). Our findings are consistent with the claim Kádár et al. (2015). The turfs were characterized by very low and low production – up to 400 g.m^{-2} (Ševčíková et

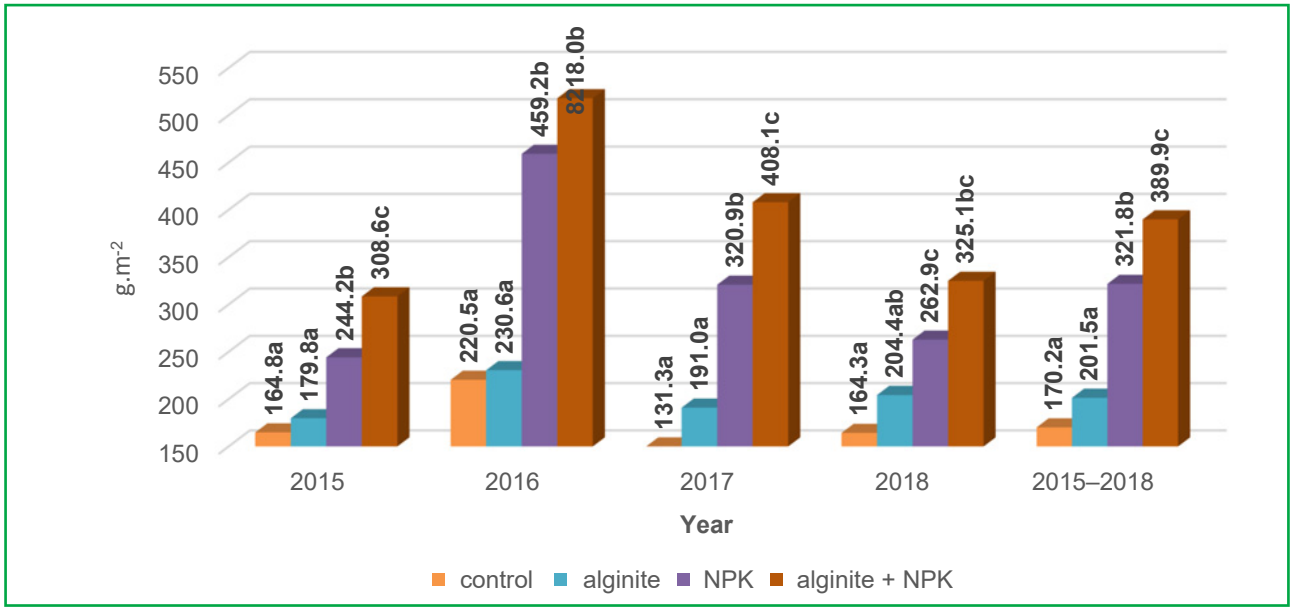

Figure 2 Total production of dry above-ground phytomass in 2015 – 2018
Different index (a, b, c) means statistically significant differences within column (Fisher LSD test, $\alpha = 0.05$)

al., 2002). Kovár et al. (2022) state that species with low aboveground phytomass production include red fescue and sheep fescue. These species accounted for almost 100% of the experimental turfgrass mixture. Found that the combination of alginite and nitrogen fertilization significantly increased (5-fold) the production of dry aboveground phytomass of triticale. They also found that the treatment with alginite application slightly increased dry aboveground phytomass production compared to the control treatment. Similar findings were also arrived at by Lee and Barlette (1976), Albuzio et al. (1994), Yldirim (2007), and Ali et al. (2014) who found an increase in the dry weight of aerial parts of plants of different crops with the application of humic acids. Experimental results Arnacon et al. (2003) and Ali et al. (2014) show that both humic acids and NPK application have a significant effect on plant dry weight.

4 Conclusions

Based on the results, it use of alginite increased the minimum values of total turf height and total production of dry above-ground phytomass. The application of inorganic fertilizers (NPK) increased the rate of growth and production of the turf. A combination of inorganic fertilizers (NPK) and alginite most increased values of total turf height and total production of dry above-ground phytomass in every monitored year of the experiment.

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