Seasonal Phosphorus Dynamics in Turfgrass of Different Purposes

Mirjana HERAK ĆUSTIĆ [1]
Vid PRIVORA [2]
Igor PALČIĆ [1]
Lepomir ČOGA [1]
Petra ŠEKERIJA [3]
Tomislav KARAŽIJA [1]
Ivan ŠIMIĆ [4]
Marko PETEK [1(✉)]

Summary

Phosphorus (P) is a component of phospholipids, nucleic acids and molecules that store energy. It increases yield and water and nutrients use efficiency. Phosphorus turfgrass content is essential for root development, and, indirectly, nutrient uptake. The aim of this research was to determine soil and turfgrass blade phosphorus dynamics on two recreational (parks Bundek and Jarun) and two sports (Hippodrome and SP Mladost) turfgrasses in the city of Zagreb and determine adequate fertilization. Soil and plant material sampling was performed three times during the growing season 2012 in each of the four investigated locations. The results showed that, generally, soil phosphorus content was low or even turfgrass blade phosphorus content was on the lower end of optimal supply range. Soil phosphorus values ranged from 1.78 to 6.78 mg P_2O_5 100 g^{-1}, while turfgrass blade phosphorus content ranged from 0.15 to 0.45 % P. Sampling time does not affect turfgrass blade phosphorus content. Due to the particularly low soil and turfgrass blade phosphorus status, special attention when designing the fertilization program should be given to phosphorus application with at least 10 g of P_2O_5 m^{-2} in the early spring, and, if necessary, with 1 g of P_2O_5 m^{-2} during the growing season.

Key words

fertilization, lawn, nutrient, macroelement, soil

[1] University of Zagreb, Faculty of Agriculture,
Svetošimunska cesta 25, 10000 Zagreb, Croatia
✉ e-mail: mpetek@agr.hr
[2] Institution Managing Sports Facilities, Trg K. Ćosića 11, 10000 Zagreb, Croatia
[3] University of Zagreb, Faculty of Agriculture,
Svetošimunska cesta 25, 10000 Zagreb, Croatia, student
[4] Croatian Academy of Sciences and Arts, Trsteno Arboretum,
Potok 20, 20235 Zaton Veliki, Croatia

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Introduction

Turfgrass is a unique crop composed by different grass species whose final product is not seen soon after sowing, but several years after. It grows densely as a population, what makes it different from individual plant crops. In terms of landscaping value, it is the backbone of every well-developed space and significantly affects the sense of freedom and spaciousness of its users. Public turfgrass in urban areas offers the possibility of using it for different purposes and provides users a healthier way of life.

According to the German Standard DIN 18917 (DIN, 2002), which is used throughout the European Union for landscape architecture purposes, turfgrass is divided into: decorative, usable, intensively usable and landscape extensive turfgrass. Decorative turfgrass has representative purpose and is superbly maintained, but its load resistance is small and maintenance needs are high to very high. Usable turfgrass is typical for urban public greenery, gardens and yards. It is resistant to drought and high load, but maintenance needs are medium to high. Intensively usable turfgrass is used for sports and recreational purposes as well as for parking and can be submitted to long-term loads, and maintenance needs are medium to very high. Landscape extensive turfgrass has the widest application. It is found in public and private areas and characterized by the highest variation depending on the purpose and location. Load resistance is insufficient and maintenance requirements are low to medium.

Grass root grows deeper and reaches stationary sources of phosphorus. Phosphorus, as one of the most important macroelements, plays an important role in plants as integral part of the nucleotide which is important for energy metabolism during photosynthesis (such as ATP) and is an important component of RNA and DNA (Heydari and Balestra, 2008). Phosphorus is an essential component of plant cell elements, including membrane phospholipids, and therefore, necessary for proper cell functioning. It is the second most important biogenic element for root growth, and affects also maturation and reproduction (Heydari and Balestra, 2008; Bell, 2011).

In low pH soils, phosphorus binds with aluminum and iron, while in soils high pH it binds with calcium and becomes inaccessible for the plant. Unlike other crops, turfgrass doesn't have a huge need for phosphorus in the soil, except during turfgrass formation stage (Wiecko, 2008). Some authors (Laville et al., 1992; Mathre et al., 1999) indicate that different grass species showed different phosphorus requirements. For example, *Poa pratensis*, unlike *Lolium perenne* and *Festuca rubra* spp. *commutata*, is more sensitive to low phosphorus levels during turfgrass formation. Formed turfgrass is less sensitive to phosphorus lack compared to turfgrass in formation. On sandy soils as on golf course "putting green", high concentrations of phosphorus can affect rapid root and blade growth in formed turfgrass (Heydari and Balestra, 2008). The same authors state that turfgrass stress caused by environmental factors such as drought, heat and cold, is not a reaction to phosphorus concentration reduction. However, it has been shown that cold tolerance in *Poa pratensis* and drought resistance in *Cynodon dactylon* can be increased by increasing phosphorus fertilization (Heydari and Balestra, 2008). Liu et al. (2008) indicate that the optimal phosphorus content in turfgrass dry matter ranges from 1.5 to 5.0 g P kg^{-1}. By limiting phosphorus amount, turfgrass quality and characteristics can be seriously disturbed, especially in turfgrass formation stage, which applies equally to cool-season and warm-season grass varieties. When turfgrass is formed from warm-season grass varieties, phosphorus fertilization in quantities of 10 g P_2O_5 m^{-2} will improve root and blade development. When grass growth is delayed, especially in early spring and during the beginning of the root degradation phase, a top dressing with P_2O_5 in the amount of 1 g m^{-2} is recommended (Liu et al., 2008). Cool-season and warm-season grass varieties require annual phosphorus fertilization in quantities ranging from 0.25 to 0.50 kg P_2O_5 100 m^{-2} (Cockerham, 2008). Although, plant nutrition should be planned based on soil and plant analysis, excessive phosphorus fertilization can cause antagonism with iron and zinc (Fagerness et al., 1998).

Consequently, the aim of this study was to determine the seasonal phosphorus dynamics in soil and grass blades from turfgrass of 4 different purposes in Zagreb (Croatia).

Material and methods

For this research, four public turfgrasses located in Zagreb (Croatia) were selected. Two of them with sports purpose: turfgrass at the athletic stadium of Sports Park Mladost (SP Mladost) and turfgrass used for horse jumping contests at Zagreb Hippodrome. The other two turfgrasses have recreation use: turfgrass of the multi-sensorial park at park Jarun and turfgrass near the bathing zone at park Bundek. In the above mentioned recreational turfgrasses the most common grass variety was *Lolium perenne* (70%), followed by *Festuca rubra* (20%) and other grass varieties (10%) (Privora et al., 2015). According to avaliable data, at Hippodrome turfgrass the most common grass variety was *Lolium perenne* with 45%, followed by *Festuca rubra* and *Poa pratensis* with 23% each, and other grass varieties (11%). At SP Mladost the turfgrass was composed of: *Poa nemoralis* (27%), *Poa pratensis* (25%), *Lolium perenne* (17%), *Festuca rubra* (12%), *Agrostis tenuis* (5%), and other grass varieties (14%). At each studied location, average soil samples at 0-30 cm depth in three repetitions were taken three times during the research (January 13^{th}, May 10^{th} and June 6^{th} 2012). In air-dried, milled and homogenized soil samples, phosphorus was determined by Egner-Rhiem-Domingo method (Egner et al., 1960). Average grass blade samples were randomly also taken three times during the research (April 4^{th}, May 10^{th} and June 15^{th} 2012), in three repetitions. Plant material samples were dried, grounded and homogenized, and phosphorus content (in dry matter) was determined spectrophotometrically, after digestion with concentrated HNO_3 and $HClO_4$ (AOAC, 1995). All collected data were analyzed using a linear model of analysis of variance (ANOVA). Tukey's test of multiple comparisons (Tukey's HSD) was applied to test location and sampling time effect. All analyses were performed using statistical software package SAS System for Windows Ver. 9.1 (Copyright 2002 to 2003 by SAS Institute Inc., Cary, NC, USA).

Results and discussion

In this research, obtained soil phosphorus content ranged from 1.78 to 6.78 mg P_2O_5 100 g^{-1} (Table 1). During the first sampling time, the highest content was determined on Jarun (6.78 mg P_2O_5 100 g^{-1}), while the lowest on Bundek (2.41 mg P_2O_5

Table 1. Soil phosphorus content (mg P_2O_5 100 g^{-1}) in investigated turfgrasses during growing season 2012

Location	1st Sampling time January 13, 2012	2nd Sampling time May 10, 2012	3rd Sampling time June 15, 2012	Average
SP Mladost	3.06 ab	2.17 b	2.17	2.47 b
Hippodrome	3.00 b	3.63 ab	3.17	3.27 b
Jarun	6.78 a	5.15 a	4.37	5.43 a
Bundek	2.41 b	1.78 b	2.20	2.13 b
Average	3.81	3.18	2.98	

Different letters within the same column are significantly different values according to Tukey's HSD test, p≤0,05; Values not associated with a letter are not significantly different.

Table 2. Turfgrass blade phosphorus content (% P) in dry matter of investigated turfgrasses during growing season 2012

Location	1st Sampling time April 5, 2012	2nd Sampling time May 10, 2012	3rd Sampling time June 15, 2012	Average
SP Mladost	0.15 d	0.18 d	0.15 c	0.16 c
Hippodrome	0.45 a	0.38 b	0.37 b	0.40 a
Jarun	0.26 c	0.33 c	0.33 b	0.31 b
Bundek	0.32 b	0.44 a	0.46 a	0.41 a
Average	0.30	0.33	0.33	

Different letters within the same column are significantly different values according to Tukey's HSD test, p≤0,05; Values not associated with a letter are not significantly different.

100 g^{-1}). During the second sampling time, the statistically significant highest value was once again measured in Jarun and it was (5.15 mg P_2O_5 100 g^{-1}), while the lowest statistically significant value was measured once again in Bundek (1.78 mg P_2O_5 100 g^{-1}). During the third sampling time, the lowest value was measured in SP Mladost (2.17 mg P_2O_5 100 g^{-1}), while the highest in Jarun (4.37 mg P_2O_5 100 g^{-1}).

During all sampling times, the statistically significant highest average soil P_2O_5 value was determined in Jarun (5.43 mg P_2O_5 100 g^{-1}), while there was no statistically significant difference between the other turfgrasses. Through all investigated locations, no significant differences between sampling times were determined.

Table 2 shows turfgrass blade phosphorus content in dry matter. Determined values ranged from 0.15 to 0.46% P. During the first sampling time, statistically significant the highest content was determined in Hippodrome (0.45% P), while the lowest in SP Mladost (0.15% P). During the second sampling time statistically significant the highest content (0.44% P) was determined in park Bundek, while the lowest once again in SP Mladost (0.18% P). During the third sampling time statistically significant the highest content was determined in park Bundek (0.46% P), while the lowest in SP Mladost (0.15% P)

Average turfgrass blade phosphorus content during the 2012 growing season showed that statistically significant higher values were determined in Hippodrome and park Bundek (0.40 and 0.41% P), while the lowest average value was determined in SP Mladost (0.16% P). Through all investigated locations, no significant differences between sampling times were determined.

Hull and Martin (2004) reported that optimal turfgrass blade values range from 0.30 to 0.55% P, while Bergmann (1992) reported that phosphorus blade content for turfgrass composed of *Lolium* grass species ranged from 0.35 to 0.50% P, and for mixture made of *Festuca pratensis, Lolium* spp. and *Poa pratensis* ranged from 0.30 to 0.60% P. McCarty et al. (2003) reported optimal values for *Lolium perenne*, and it range is from 0.35 to 0.40% P. All measured values in this research are generally lower than reported optimal values, especially in SP Mladost and park Jarun. Especially low average value was determined on SP Mladost (0.16% P) and it is significantly lower than the blade critical value of 0.21% P reported by Nus et al. (1993). It all suggests the need of an analysis based fertilization program.

It can be noted that all turfgrasses phosphorus content is inadequate in relation to their use purposes, especially sports turfgrasses (SP Mladost and Hippodrome). In order to achieve high-quality turfgrass, apart from normal maintenance practiced including mowing, it is necessary to design a specific fertilization program, especially for trufgrasses raised on heavier soils with insufficient nutrient content. A well designed fertilization program should consider all nutrients and their interactions. It can be recommended that medium to high-quality turfgrass can be mainteined with three to four fertilizer applications during the growing season, which was also confirmed in previous researches (Herak Ćustić et al., 2011; Petek et al., 2011).

Conclusion

Based on the results of repeated soil and turfgrass blade sampling and chemical analysis of samples from four turfgrasses in the City of Zagreb, phosphorus soil and turfgrass blade content is generally low, but the best nutritional status was determined on park Bundek, while the worst on SP Mladost. Parks Bundek and Jarun as representatives of recreational turfgrasses showed a slight increase in phosphorus blade content during the researched period. Average turfgrass blade phosphorus content on above mention turfgrasses (Jarun 0.31 % P and Bundek 0.41 % P) was on the lower end of optimal values range. Hippodrome and SP Mladost represent sports lawns. Hippodrome was well supplied with phosphorus (0.40 % P) as opposed to SP Mladost (0.16% P) whose average value was very low and generally lower than other trufgrasses throughout the growing season. Sampling time does not affect turfgrass blade phosphorus content.

Due to the particularly low soil and turfgrass blade phosphorus status, it is recommended to fertilize researched turfgrasses with at least 10 g P_2O_5 m^{-2} early in the spring time, and as topdressing during the growing season with 1 g P_2O_5 m^{-2} using easy-soluble phosphorus fertilizers if such need is noted.

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