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EFFECT OF NITROGEN FERTILIZATION ON SEED PRODUCTION OF *Lolium perenne* L. TURFGRASS CULTIVARS

NAWOŻENIE AZOTEM W PRODUKCJI NASIENNEJ GAZONOWYCH ODMIAN *Lolium perenne* L.

Abstract: The paper contains the results of field and laboratory experiments on three *Lolium perenne* L. turfgrass cultivars (Gazon, Nira and Sandra) at Malopolska Plant Breeding Station (HBP) in Skrzeszowice near Krakow (220 m a.s.l.) conducted in the years 2006–2008. The analyses assessed the effect of doses of mineral fertilization with nitrogen (60, 90 and 120 kg N · ha^{-1}) applied at early spring, the start of the earing stage and autumn on the seed yield. The highest yield was monitored by the inflorescence shoot density of cv. Nira (1895 shoots/m^2), cv. Gazon (1976 shoots/m^2) and cv. Sandra (2098 shoots/m^2). Fertilization dose of 90 kg N · ha^{-1} applied three times effected the most considerably the number of spikelets per ear and the efficiency of seed settling on the ear: from 73 % (cv. Nira) to 76 % (cv. Sandra). The highest seed yield was obtained as a result of the 120 kg N · ha^{-1} fertilizations applied three times.

Keywords: *Lolium perenne*, cultivars, fertilization, seed yield

Perennial ryegrass (*Lolium perenne* L.) belongs to the species which still raise interest of researchers, as evidenced by the most numerous collection of cultivars in Poland. It is also apparent as the ever growing market demand for this species. It has been estimated that the European Union's demand for perennial ryegrass seeds is the greatest among grasses and on average reaches 60 000 Mg a year [1]. In Poland it occupies a prominent position in the seed production, accounting for ca 35–45 % of the whole seed crop acreage. According to Martyniak [2] and Svensson and Boelt [3] seed plantations of perennial ryegrasses may provide an alternative to cereal cultivation, the overproduction of which will make farmers seek new sources of income. It is commonly known that in order to improve the profitability of seed crop production it is necessary to increase seed yield and the main element determining the productivity the most is nitrogen fertilization. It turns out that optimisation of nitrogen fertilization of perennial ryegrass plantations involves not only determining the dose in the production

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cycle but also its proper division into parts and setting proper dates of application [4, 5]. Therefore, the aim of the Author's investigations was an attempt at assessment of the nitrogen fertilization dose and its application date on the amount of the seed yield of three lawn cultivars of perennial ryegrass.

Materials and methods

The research was conducted in 2006–2008 at the Malopolska Plant Breeding Experimental Station – HPB in Skrzeszowice (220 a.s.l.) near Krakow, on degraded chernozem developed from loess.

The soil revealed the following chemical properties: pH_{KCl} – 6.5; available P – 56, K – 132 and Mg – 39 g · kg^{-1}; organic N – 1.5 and total carbon – 16.1 g · kg^{-1} of soil.

The experiment was set up in the autumn 2005 using the randomised block method in four replications. The area of each plot was 10 m^2 (1 × 10).

The object of the investigation was a seed plantation of three fodder cultivars of perennial ryegrass (*Lolium perenne*): Gazon, Nira and Sandra.

Phosphorus, dosed 30 kg P · ha^{-1} as triple superphosphate (46 % P_2O_4), was used for fertilization conducted once in spring. Potassium, in the amount of 66 kg K · ha^{-1} as high grade potassium salt (60 % K_2O), was applied once, also in spring.

Nitrogen fertilization in the doses of 60, 90 and 120 kg N · ha^{-1} was applied on the following dates:

– once in the early spring;

– twice in two equal portions (in the early spring and at the beginning of the earing stage);

– three times in three equal parts (in the early spring, at the beginning of earing and in autumn).

Chemical weed control on the seed plantation, with a dose of 1 dm^3 · ha^{-1} of Aminopielik Gold, was conducted each year at the beginning of April (when the vegetation started) and in September. Before the seed harvesting single weeds were hand removed.

In each year of the investigations, field observations and biometric plant measurements were conducted at the beginning of August. The number of plants was counted on individual plots on the area of 1 m^2, as well as the number of spikelets per spike, and seed setting efficiency in spikes was assessed. The harvesting of the seed plantations was carried out in one stage by means of Wintersteiger plot combined harvester. The harvested seed material was dried in a storeroom and subsequently cleaned on the winnower. The cleaned grains were weighed, the obtained yield was calculated per 1 ha and a thousand grain weight was determined.

The obtained results were verified statistically by means of the analysis of variance. The differences between means were estimated using the Student test at the significance level $p = 0.05$ and the correlation coefficient was calculated for selected features.

The annual precipitation total for the period of investigations ranged from 463.8 to 683.4 mm, whereas the precipitation total for the six months (April–September) from

345.2–561.7 mm. Average annual temperature reached from 6.4 to 6.9 ^{o}C and between 11.9 and 12.8 ^{o}C during the vegetation season.

The work presents the mean results for the 3 years of the investigations.

Results and discussion

The level of nitrogen fertilization is the factor affecting generative shoot formation on plantations of perennial ryegrass [6]. This thesis has been confirmed also by the results of the Author's own investigations, where nitrogen fertilization significantly modified the number of generative shoots per area unit (Table 1). The highest shoot density in Gazon cv. – 2018 and Nira cv. – 1953 shoots/m^2 was registered after a single application of nitrogen (in early spring) in the dose of 120 kg N · ha^{-1}. On the other hand in Sandra cv. the largest number of generative shoots (2098 shoots/m^2) was calculated on the object fertilized with 120 kg N · ha^{-1} applied on three dates: early in spring, at the beginning of the earing stage and in autumn.

Table 1

The mean number of generative stems of three *Lolium perenne* cultivars [units · m^{-2}]

Specification	cv. Gazon	cv. Nira	cv. Sandra
Control	1 354	1 119	1 543
N_{60} – in one dose + $P_{30}K_{66}$	1 741	1 527	1 792
N_{60} – in two doses + $P_{30}K_{66}$	1 527	1 485	1 761
N_{90} – in one dose + $P_{30}K_{66}$	1 963	1 751	1 957
N_{90} – in two doses + $P_{30}K_{66}$	1 934	1 728	1 934
N_{90} – in three doses + $P_{30}K_{66}$	1 972	1 895	2 015
N_{120} – in one dose + $P_{30}K_{66}$	2 018	1 953	2 086
N_{120} – in two doses + $P_{30}K_{66}$	1 853	1 796	2 041
N_{120} – in three doses + $P_{30}K_{66}$	1 976	1 895	2 098
LSD (p = 0.05)	101.7	127.5	148.9

Perennial ryegrass is a nitrophilous species, visibly responding to nitrogen supplied with fertilizers by showing the changes of eg morphological properties determining the amount of seed yield. In the opinion of Young et al [7] and Golinski [6], nitrogen fertilization influences the number of kernels formed per spikelet in this species. Proper plant nutrition with nitrogen determines the effectiveness of their setting in the ear [8–11]. On the basis of the Author's own research, a favourable effect of nitrogen fertilization on this feature value was observed only to the level of 90 kg N · ha^{-1} (Table 2). In conditions of nitrogen application in the dose of 120 kg N · ha^{-1} a worsening of kernel setting in ear efficiency was registered in each of the three tested cultivars. According to Marshall [12], the reason for a decline in the efficiency of kernel setting in the ear when larger nitrogen doses were applied was the competition for assimilates between the vegetative and generative shoots which follows the flowering stage and may affect a dieback of embryos and developing seeds.

Table 2

Effectiveness of embedding of seeds in spikes [%] and mean number of spikelets per spike of three *Lolium perenne* cultivars

Specification	cv. Gazon		cv. Nira		cv. Sandra	
	effectiveness of embedding of seeds in spikes	number of spikelets per spike	effectiveness of embedding of seeds in spikes	number of spikelets per spike	effectiveness of embedding of seeds in spikes	number of spikelets per spike
Control	379	2.15	306	2.28	463	2.71
N_{60} – in one dose + $P_{30}K_{66}$	527	2.32	752	2.37	759	2.79
N_{60} – in two doses + $P_{30}K_{66}$	518	2.24	746	2.34	741	2.85
N_{90} – in one dose + $P_{30}K_{66}$	764	2.45	893	2.51	885	2.83
N_{90} – in two doses + $P_{30}K_{66}$	752	2.40	875	2.31	867	2.78
N_{90} – in three doses + $P_{30}K_{66}$	781	2.28	898	2.36	894	2.80
N_{120} – in one dose + $P_{30}K_{66}$	936	2.48	974	2.52	1 026	2.94
N_{120} – in two doses + $P_{30}K_{66}$	923	2.39	961	2.46	997	2.79
N_{120} – in three doses + $P_{30}K_{66}$	948	2.40	985	2.49	1 031	2.85
LSD ($p = 0.05$)	23.9	0.16	21.8	0.17	27.9	0.17

Table 3

The mean yields [kg · ha^{-1}] and mass of a thousand seeds [g] of three *Lolium perenne* cultivars

Specification	cv. Gazon		cv. Nira		cv. Sandra	
	yield	mass of a thousand seeds	yield	mass of a thousand seeds	yield	mass of a thousand seeds
Control	379	2.15	306	2.28	463	2.71
N_{60} – in one dose + $P_{30}K_{66}$	527	2.32	752	2.37	759	2.79
N_{60} – in two doses + $P_{30}K_{66}$	518	2.24	746	2.34	741	2.85
N_{90} – in one dose + $P_{30}K_{66}$	764	2.45	893	2.51	885	2.83
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N_{90} – in three doses + $P_{30}K_{66}$	781	2.28	898	2.36	894	2.80
N_{120} – in one dose + $P_{30}K_{66}$	936	2.48	974	2.52	1 026	2.94
N_{120} – in two doses + $P_{30}K_{66}$	923	2.39	961	2.46	997	2.79
N_{120} – in three doses + $P_{30}K_{66}$	948	2.40	985	2.49	1 031	2.85
LSD ($p = 0.05$)	23.9	0.16	21.8	0.17	27.9	0.17

Young et al (1996) state that there is an optimal nitrogen dose for each cultivar which allows for obtaining a maximum seed yield; these doses are diversified and may range from 60 to 180 kg N · ha^{-1}. In the conducted experiments, fertilization with each dose of nitrogen significantly diversified seed yield (Table 3). The highest seed yield from each cultivar was obtained as a result of 120 kg N · ha^{-1} applied in the early spring term, at the beginning of earing and in autumn. About thrice higher yields, ranging from 985 (Nira cv.) to 1031 kg · ha^{-1} (Sandra cv.) were produced on the unfertilized objects. An increase in the total nitrogen dose was usually accompanied by an increase in one-thousand-seed weight. However, these tendencies were not stabilized. A crucial importance of early spring fertilization was noted in the assessment of the seeding value of the seeds by means of one-thousand-seed weight. A single nitrogen dose applied in early spring increased one-thousand-seed weight in comparison with the control: in Gazon cv. from 7 % (60 kg N · ha^{-1}) to 15 % (120 kg N · ha^{-1}), in Nira cv. from 3 % (60 kg N · ha^{-1}) to 10 % (90 and 120 kg N · ha^{-1}) and in Sandra cv. between 2 % (60 kg N · ha^{-1}) and 8 % (120 kg N · ha^{-1}).

Conclusions

1. The highest seed yield of *L. perenne* cvs per 1 m^2 was obtained at the following flower shoot densities: 1895 in Nira cv., 1976 in Gazon cv. and 2098 in Sandra cv. at dose of the 120 kg N · ha^{-1} fertilizations applied three times.
2. Nitrogen fertilization dose of 90 kg N · ha^{-1}, applied three times (at the early spring, the beginning of earing and in autumn) increased the number of spikelets per ear and seed setting efficiency in ear to 73 % (Nira cv.) and to 76 % (Sandra cv.).
3. The increment of seed setting efficiency as a result of nitrogen fertilization at the use of 90 kg N · ha^{-1}, which decrease after treatment.
4. The highest seed yield was obtained under the influence of the 120 kg · ha^{-1} nitrogen dose.
5. The crucial importance of a single fertilization dose applied in early spring was registered in the assessment of the sowing value of seeds by means of one-thousand-seed weight.

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NAWOŻENIE AZOTEM W PRODUKCJI NASIENNEJ GAZONOWYCH ODMIAN *Lolium perenne* L.

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Abstrakt: Praca zawiera zestawienie wyników badań polowych i laboratoryjnych przeprowadzonych w Stacji Małopolskiej Hodowli Roślin – HBP w Skrzeszowicach koło Krakowa (220 m n.p.m.) w latach 2006–2008 z trzema gazonowymi odmianami życicy trwałej (Gazon, Nira, Sandra). W badaniach poddano ocenie wielkość dawki nawożenia mineralnego azotem (60, 90, 120 kg N · ha^{-1}) oraz termin jego stosowania (wczesnowiosenny, początek kłoszenia i jesienny), na wielkość plonu nasion. W przeliczeniu na 1 m^2 uzyskanie największego plonu nasion zapełniała obsada pędów kwiatowych: 1895 u odmiany Nira, 1976 u odmiany Gazon oraz 2098 u odmiany Sandra. Nawożenie azotem w dawce 90 kg N · ha^{-1} zastosowanej w trzech terminach: wczesnowiosennym, na początku kłoszenia i jesiennym najbardziej zwiększało liczbę kłosków w kłosie oraz efektywność osadzania nasion w kłosie od 73 % u odmiany Nira do 76 % u odmiany Sandra. Największy plon nasion uzyskano pod wpływem dawki 120 kg · ha^{-1}, zastosowanej w trzech terminach: wczesnowiosennym, na początku kłoszenia i jesiennym.

Słowa kluczowe: *Lolium perenne*, odmiany, nawożenie, plon nasion