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Henryk CZYŻ, Teodor KITCZAK

THE RESPONSE OF *FESTULOLIUM BRAUNII* (K. Richter) A. Camus TO THE AMOUNT OF SEEDS SOWN AND THE LEVEL OF NITROGEN FERTILISATION IN CULTIVATION FOR SEEDS

REAKCJA *FESTULOLIUM BRAUNII* (K. Richter) A. Camus NA ILOŚĆ WYSIEWU NASION I POZIOM NAWOŻENIA AZOTEM W UPRAWIE NA NASIONA

Faculty of Soil Science, Grassland Science and Environmental Chemistry, West Pomeranian University of Technology, Szczecin, Poland

Streszczenie. Badania przeprowadzono w latach 2008–2011. W badaniach uwzględniono dwa czynniki: I – ilość wysiewu nasion: 9, 12 i 15 (kg · ha^{-1}) i II – dawka azotu: 0, 60, 90 i 120 kg · ha^{-1}. Doświadczenia założono wiosną 2008 roku, z siewu w roślinę ochronną – jęczmień jary, na glebie typu brunatna, podtypu brunatnych kwaśnych, wytworzonych z piasków gliniastych lekkich, pochodzenia zwałowego – IVb klasy bonitacyjnej. Jesienią, w roku założenia doświadczenia, zastosowano: 80 kg P_2O_5 · ha^{-1}, 80 kg K_2O · ha^{-1} i 30 kg N · ha^{-1} oraz wiosną – w roku pełnego użytkowania, przed ruszeniem wegetacji, 40 kg K_2O · ha^{-1}, a nawożenie azotowe uzupełniono do wysokości zakładanej w trzecim czynniku badań. Wyniki badań nad *Festulolium braunii* odmiany Sulino wykazały, że w warunkach gleb lekkich można uzyskać średni plon nasion 13,5 dt · ha^{-1} – w pierwszym, 16,1 dt · ha^{-1} – w drugim i 15,3 dt · ha^{-1} – w trzecim roku plonowania. Z przeprowadzonych badań wynika, że przy zakładaniu plantacji nasiennej z siewu współrzędnego z jęczmieniem jarym, zasadne było zastosowanie ilości wysiewu 15 kg · ha^{-1}. W warunkach gleb lekkich zastosowanie dawek nawożenia azotowego: w ilości 60, 90 i 120 kg · ha^{-1} spowodowało zwiększenie plonów nasion *Festulolium braunii* średnio z lat badań odpowiednio o: 34,9, 46,3 i 53,3% w porównaniu z obiektami nawożonymi tylko fosforem i potasem. Zastosowane w badaniach czynniki wpłynęły również korzystnie na zwiększenie liczby kłosków i nasion w kwiatostanie.

Key words: *Festulolium braunii*, light soil, morphological features of seeds, seed yield, Sulino cultivar.

Słowa kluczowe: cechy morfologiczne nasion, *Festulolium braunii*, gleba lekka, odmiana Sulino, plon nasion.

INTRODUCTION

During the recent years, in the cultivation of forage grasses there has been a growing interest in intergeneric and interspecies mixtures within the complex of *Lolium-Festuca*. One of most important for agriculture is *Festulolium braunii* (K. Richter) A. Camus obtained by the crossing of meadow fescue with Italian ryegrass (Domański and Jokś 1999). The cultivars of

Corresponding author – Adres do korespondencji: Prof. Henryk Czyż, Department of Soil Science, Grassland Science and Environmental Chemistry, West Pomeranian University of Technology, Szczecin, Juliusza Słowackiego 17, 71-434 Szczecin, Poland, e-mail: Henryk.Czyz@zut.edu.pl

Festulolium braunii can be valuable components of mixtures for temporary grasslands or can be even used for restoring permanent meadows (Kryszak 2001, Borowiecki 2005, Wolski et al. 2006, Olszewska 2008). *Festulolium braunii* is characterised by a high yield potential and its yield level is very often superior to that of meadow fescue (Fojtik 1994, Domański and Jakoś 1999), and in some conditions it is close to Italian ryegrass (Nekrošas and Kemešyté 2007). The obtained fodder is well digestible, has a fair content of protein and soluble carbohydrates (Domański and Jakoś 1999). The characteristic feature of this crossbred is fine winter hardiness (Nekrošas and Kemešyté 2007, Šimkūnas et al. 2009) and resistance to periodic droughts (Borowiecki and Staniak 2001, Staniak 2006).

Due to the favourable utilitarian traits of *Festulolium braunii*, the demand for its sowing material increases. Plot studies revealed, that the obtained yield of seeds ranged from 5.5 to 10.5 dt · ha^{-1} (Ghesquière et al. 2010).

The aim of the study was to determine the reaction of *Festulolium braunii* of Sulino cultivar on light soils to the amount of seeds sown and the level of nitrogen fertilisation, as significant factors in agricultural engineering when growing grass for seeds.

MATERIAL AND METHODS

The experiment, performed in the years 2008–2011 at the Lipki Agricultural Experiment Station in Lipnik near Stargard Szczeciński, assessed the influence of the amount of seed sown (9,12 and 15 kg · ha^{-1}) and variable doses of nitrogen (0, 60, 90, 120 kg · ha^{-1}), in comparison to uniform fertilising with phosphorus (80 kg P_20_5 ha^{-1}) and potassium (120 kg K_20 ha^{-1}) on the development and yielding ability of *Festulolium braunii* of Sulino cultivar. The experiment was founded on light soil belonging to brown soils of good rye complex (IVb valuation class). The scheme of the experiment, included two factors – the amount of seeds sown (factor I) and nitrogen dose (factor II), and was planned in split-plot system with four replications, and the size of a single plot was 12 m^2. The detailed study included: plant density after sprouting, biometric measurements (the number of generative shoots on a plant, the length of inflorescence, the number of spikelets and seeds in an inflorescence) and seed yield. The experiment was founded in spring 2008 with crops sown with a nurse crop – spring barley grown for seeds. Uniform fertilising with phosphorus in a dose of 80 kg · ha^{-1} was applied in autumn, and with potassium – 80 kg K_20 · ha^{-1} in autumn and 40 kg K_20 · ha^{-1} in spring. Nitrogen, at the doses adopted in methodology, was used in two periods – in autumn (30 kg N · ha^{-1}) and in spring (the remainder of the dose). Phosphorus was used in the form of triple superphosphate, potassium – 60% of sylvinite, and nitrogen in the form of ammonium nitrate. The results of the study showing the formation of seed yield were statistically analysed using the classical analysis of variance, and the significant difference of the results was determined with the use of Tukey's test with $p = 0.05$.

The pattern of meteorological conditions in individual years of the study was varied. In the years of the study, the greatest amount of precipitation during the growing season was recorded in 2010. That year, the total rainfall for months from April to October was 481.1 mm and it was by 111.1 mm higher than in the parallel season in the multiannual period. The highest amount of rainfall was recorded in August (184.4 mm), and the lowest in June (10.6 mm).

In the years 2009, 2011 the total rainfall during growing season was 395.6 and 381.5 respectively, and it was significantly lower than in 2010, but higher by 25.6 and 11.5 mm comparing to the parallel season in the multiannual period. In 2009, the largest amount was recorded in May and October, when the total rainfall was 70.3 mm and 82.7 mm respectively, and the lowest amount was recorded in September – 45.4 mm. In 2011, the distinctive months were July and April, when the amount of rainfall was respectively the highest (148.5 mm) and the lowest (12.5 mm). Thermal conditions were also varied in the studied years. In 2008, the average monthly temperature during the growing season ranged from 4.1ºC to 19.4ºC, and in the multiannual period the temperatures were slightly lower and ranged from 2.0ºC to 16.9ºC. The highest monthly temperature occurred in July (19.4ºC) and August (18.7ºC). The total monthly rainfall in the parallel season ranged from 9.8 mm to 108.6 mm, and the highest amount of rainfall occurred in April (108.6 mm) which was by 68.6 mm higher in comparison to the multiannual period.

RESULTS AND DISCUSSION

The factors modifying the growth of plants and consequently their yielding ability were the agricultural techniques, including the amount of seed sown and nitrogen inputs (Hampton and Fairej 1997, Kozłowski and Goliński 2000, Goliński et al. 2008, Czyż and Kitczak 2009). In the study performed by the authors (Table 1) when sowing 9 kg · ha^{-1} of seeds, 140.0 plants per 1 m^2 were obtained after sprouting, while when increasing the amount of seed sown by 3 kg, plant density has increased by 50.2 of plants (35.6%). When sowing 15 kg · ha^{-1}, which meant an increase by 6 kg in comparison to the lowest amount of seed sown, the number of plants increased by 96.1 per 1 m^2 (68.7%).

Table 1. Plant density after sprouting [pcs. · m^{-2}]
Tabela 1. Obsada roślin po skiełkowaniu nasion [szt. · m^{-2}]

The amount of seeds sown [kg · ha^{-1}] Ilość wysianych nasion [kg · ha^{-1}]			Mean Średnia
9	12	15	
Plant density Obsada roślin			
140.0	190.2	236.1	188.8

When analysing the selected morphological features of plants, it should be noted that generally the plants which were in their first year of full use were characterised by the lowest values, which referred to the length of their inflorescences as well as the number of spikelets and seeds in inflorescences. The best developed generative shoots were found in the second year of full use (2010), which was characterised by the highest amount of rainfall during the growing season. The plants located on the plots with varying amount of seed sown (Table 2) were characterised by high stability of morphological features. The plants subjected to the influence of nitrogen underwent major modifications. For example, on the plot treated only with phosphorus and potassium, the number of generative shoots per plant was 4.7. When applying 60 kg N · kg^{-1}, 7.9 pieces were obtained, and on the plots with the dose of N – 120 kg · ha^{-1} – 9.3 pieces per one plant (Table 2).

Table 2. The influence of the studied factors in the years of study on the chosen parameters of *Festulolium* plants (arithmetic means for years 2009–2011)
Tabela 2. Wpływ badanych czynników i lat badań na wybrane parametry roślin *Festulolium* (średnie z lat 2009–2011)

Specification Wyszczególnienie		The number of generative shoots on a plant Liczba pędów generatywnych na roślinie	The length of inflorescence Długość kwiatostanu	The number of spikelets in inflorescence Liczba kłosków w kwiatostanie	The number of seeds in inflorescence Liczba nasion w kwiatostanie
Years of research Lata badań	2009	7.8	16.1	12.0	38.8
	2010	8.1	21.9	14.0	40.8
	2011	7.1	19.7	14.0	39.0
The amount of seeds sown Ilość wysiewu nasion [kg · ha^{-1}]	9	7.3	18.6	13.2	38.7
	12	7.8	19.4	13.6	39.5
	15	7.9	19.7	13.2	40.3
Dose of nitrogen Dawka azotu (kg · ha^{-1})	0	4.7	16.0	9.7	34.3
	60	7.9	19.5	13.1	39.9
	90	8.8	20.4	14.7	41.6
	120	9.3	20.1	12.6	42.3

The same regularity related to the number of seeds per inflorescence, whereas in case of the number of spikelets per inflorescence and the length of inflorescence, the sufficient dose of nitrogen was 90 kg N · ha^{-1} (Table 2). According to Goliński (2002) nitrogen fertilisation is one of the most important factors stimulating the use of the biological seed potential of grass. Nitrophile forage grass, eg. of *Lolium* genus, respond very well to nitrogen fertilisation, which has a positive impact on the formation and the growth of generative shoots (Falkowski et al. 1986, Goliński 2002). When Janicka and Stypiński (2001) were researching the Czech varieties of *Festulolium pabulare*, they found no effect of different doses of nitrogen on the rate of growth of generative shoots, however their number was increasing with the growing dose of nitrogen. The positive effect of nitrogen on the number of generative shoots and spikelets in inflorescence of *Festulolium braunii* of Felopa cultivar was recorded by Czyż and Kitczak (2009). In her studies, Rzeźnik (2012) obtained the highest increase in the number of shoots (by 74.3% in comparison to the control) after applying nitrogen at the dose of 70 kg · ha^{-1}. The author also found a beneficial effect of nitrogen on the number of caryopses in a spikelet.

The results in Table 3 illustrate the formation of seed yield in individual years depending upon the used research variant. The average results of the used combinations indicate that the highest seed yield was obtained in the second year of full use (2010), which was distinguished by the amount of precipitation. The lowest yield of seed was recorded in the first year of the full use (2009). A similar pattern was found when characterising the morphological features of plants (Table 2). Positive correlation between the formation of generative shoots and the yield of seed was found by Falkowski et al. (1996) in the studies on perennial ryegrass, Italian ryegrass, meadow fescue and red fescue. The studies conducted by the authors of the paper confirmed this pattern on the plots with nitrogen input (Table 3).

Table 3. The influence of the studied factors and the years of study on the seed yield [dt · ha^{-1}]
Tabela 3. Wpływ badanych czynników i lat badań na plon nasion [dt · ha^{-1}]

Year Rok	The amount of seeds sown Ilość wysiewu [kg · ha^{-1}]	Dose of N – Dawka N [kg · ha^{-1}]				Mean Średnia
		0	60	90	120	
2009	9	10.2	12.4	14.4	14.9	**13.0**
	12	10.7	12.8	15.0	15.6	**13.5**
	15	11.4	13.4	15.6	16.0	**14.1**
Mean – Średnia		**10.8**	**12.9**	**15.0**	**15.5**	**13.5**
2010	9	11.6	15.8	17.3	18.3	**15.8**
	12	12.0	16.3	17.2	18.4	**16.0**
	15	12.3	17.0	18.0	19.3	**16.7**
Mean – Średnia		**11.9**	**16.4**	**17.5**	**18.6**	**16.1**
2011	9	10.2	15.2	15.8	16.7	**14.5**
	12	11.0	16.3	16.8	17.4	**15.4**
	15	11.5	16.9	17.6	18.2	**16.1**
Mean – Średnia		**10.9**	**16.1**	**16.7**	**17.4**	**15.3**
2009 – 2011	9	10.7	14.5	15.8	16.6	**14.4**
	12	11.2	15.1	16.3	17.1	**15.0**
	15	11.7	15.8	17.1	17.8	**15.6**
Mean – Średnia		**11.2**	**15.1**	**16.4**	**17.2**	**15.0**
LSD $_{0.05}$ for: – NIR $_{0,05}$ dla:			2009	2010	2011	2009–2011
I			0.83	0.37	0.44	0.36
II			0.34	0.51	0.41	0.27
I x II			n.s.	n.s.	n.s.	n.s.
II x I			n.s.	n.s.	n.s.	n.s.

n.s. – not significant – nie istotne.
I and II: factors of research – czynniki doświadczenia.

The increased doses of nitrogen had a positive effect on the number of spikelets and seeds per inflorescence, which reflected the yield of seed. In all of the years, the increased doses of nitrogen were accompanied by an increase in seed yield, with the largest increases of seed yield on a plot with a dose of nitrogen at 60 kg · kg^{-1}. The average yield of the three years of studies on a plot treated only with phosphorus and potassium was 11.2 dt · ha^{-1}. On a plot with a dose of nitrogen of 60 kg · ha^{-1} the increase of yield was 34.8%. Furhter increase of the dose to 90 and 120 kg N · ha^{-1} allowed for obtaining an increase by 46.4% and 53.6% respectively, in comparison to the plot without nitrogen (Table 2). According to the study by Czyż and Kitczak (2009) as well as Gūtman and Adamovicš (2009), *Festulolium braunii* responds with an increase of seed yield with the proper use of nitrogen fertilisation. Gūtman and Adamovicš (2009) found in their study a positive effect of nitrogen used in doses of 90 and 120 kg N · ha^{-1}, on a seed yield of *Festulolium braunii* as well as *Festulolium pabulare*. When conducting their study on *Festulolium braunii* of Felopa cultivar, Czyż and Kitczak (2009) obtained an increase of yield by 176.3% in comparison to the unit with phosphorus and potassium, using the dose of nitrogen of 120 kg · ha^{-1}. When conducting her research also on the Felopa cultivar, Rzeźnik obtained highest seed yield when applying a dose of nitrogen of 100 kg · ha^{-1}.

When analysing the relationship between the amount of seed sown and the size of seed yield, it should be noted that in all the years of the study, the yield was increasing with the growing amount of seed sown, although the increase was not large, it was statistically significant (Table 2). The most significant relationship occurred in the third year of full use (2011).

Statistical analysis of the average results for the researched years confirmed the significance of the differences between the seed yield obtained on plots with the applied amount of seed sown (Table 2). On a plot with 9 kg · ha^{-1} seed sown, the average seed yield was 14.4 dt · ha^{-1}, and with 12 i 15 kg · ha^{-1} of seed sown the seed yield was respectively 15.0 and 15.6 dt · ha^{-1}, with an increase by 4.2% and 8.3% in comparison to the smallest amount of seed sown. There was no significant interaction between the amount of seed sown and the dose of nitrogen (Table 3). According to Kozłowski and Goliński (2000) the recommended amount of seeds sown of *Festulolium braunii* is 15–20 kg. There is no unambiguity in this case, since Deleuran et al. (2010) argue, on the basis of their studies, that the use of amounts of 8, 12 and 16 kg · ha^{-1} of seeds sown did not affect the yield of seed.

CONCLUSIONS

1. With the positive effect of the amount of seed sown and nitrogen fertilising on the seeds yield, there was no significant interaction between these agricultural techniques.
2. The increase in seed yield under the influence of the amount of seed sown was shown mainly by the increased number of plants on a unit area, while nitrogen differentiated the yield increasing the number of generative shoots, the number of spikelets and seeds per inflorescence.
3. When establishing the seed orchard of *Festulolium brunii* of Sulino cultivar by companion planting with spring barley on light soil, it was recommended to use the amount of seed sown of 15 kg · ha^{-1} and the nitrogen dose of 120 kg · ha^{-1}.

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Abstract. The study was conducted in the years 2008–2011. Two factors were taken into account in the research: I – the amount of seeds sown: 9, 12 and 15 (kg · ha^{-1}) and II – nitrogen dose: 0, 60, 90 and 120 kg · ha^{-1}. The experiment was founded in the spring of 2008, with sowing with a nurse crop – spring barley, on brown soil of brown acidic subtype formed of light clayey sand of glacial origin – IVb soil valuation class. In the autumn of the year when the experiment was founded the following were applied – 80 kg P_2O_5 · ha^{-1}, 80 kg K_2O · ha^{-1} and 30 kg N · ha^{-1}, and in spring – in the year of complete use, before vegetation, 40 kg K_2O · ha^{-1} was applied and nitrogen fertilisation was replenished up to the amount assumed in the third factor of the research. The results of the study over *Festulolium braunii* of Sulino cultivar showed that on light soils it is possible to obtain an average seed yield of 13.5 dt · ha^{-1} – in the first year, 16.1 dt · ha^{-1} – in the second, and 15.3 dt · ha^{-1} – in the third year of yielding. The research revealed that when founding a seed orchard by companion planting with spring barley it was recommended to apply the amount of seeds sown of 15 kg · ha^{-1}. On light soils the use of nitrogen fertiliser in doses of 60, 90 and 120 kg · ha^{-1} caused an increase in *Festulolium braunii* seed yield in the years of the study on average by 34.9, 46.3 and 53.3% respectively in comparison to the units fertilised only with phosphorus and potassium. The factors used in the research had also a favourable effect on the increased number of spikelets and seeds per inflorescence.