Effect of date and rate of nitrogen fertilization on state of nutrition, photosynthesis rate and yielding of lawn cultivar of red fescue (*Festuca rubra* ssp. *commutata*) grown for seeds

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Abstract

Nitrogen concentration in leaves at the beginning of growth responds to nitrogen rates applied in autumn, which gives a possibility of using this indicator for predicting needs for spring fertilization. Diversification of the chlorophyll index at the beginning of shooting according to fertilization level in early spring can be useful for determination of the supplementary rate. In respect of seed yield, in the first production year applying of 20 kg N ha^{-1} in autumn and 40 kg ha^{-1} in spring during starting of growth is sufficient. For maintaining a similar productivity in the second year, at the autumn application of 20 or 40 kg N ha^{-1} it is necessary to apply not less than 60 kg ha^{-1} in early spring.

Introduction

Availability of nutrients, mainly nitrogen, is the basis for plant productivity. Monitoring of soil nitrogen availability (Hart *et al*., 2007), the chlorophyll index (Fotyma & Bezduszniak, 2000) or nitrogen content in plants (Gislum & Boelt, 1999) is useful for the optimization of nitrogen fertilization. The aim of this study was to assess the state of nutrition, photosynthesis rate and yield of red fescue grown for seeds under conditions of varied rates and times of mineral nitrogen fertilization.

Materials and methods

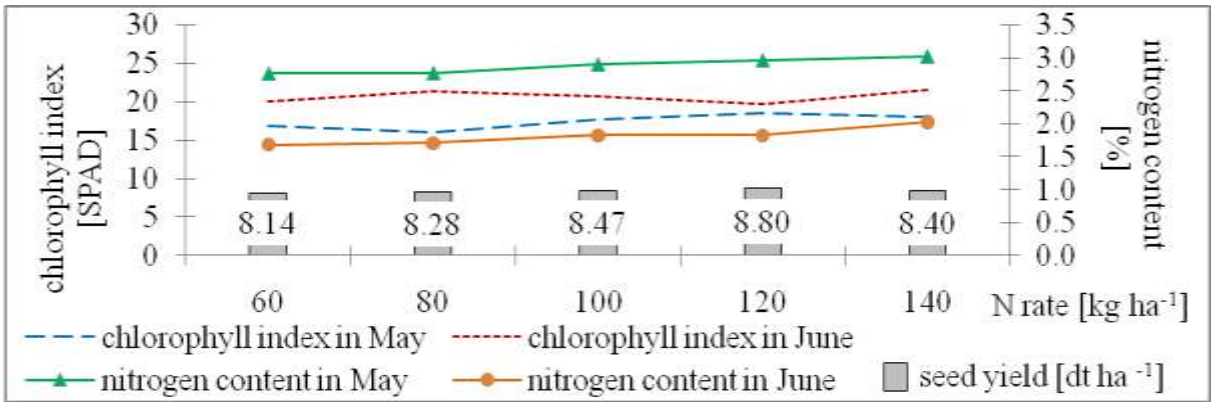
The study was based on a strict field experiment located in the Kujawy and Pomerania region (53°09' N; 17°35' E). It was established on a podzolic soil of a content of 10.2 NO_3^- and 3.57 NH_4^+ mg kg^{-1} D.M. of soil. A lawn cultivar of chewing red fescue was sown in 2004 and 2005 and then utilized for two successive years (respectively, 2005-2006 and 2006-2007). After harvesting the cover crop (spring barley) in the establishment year or seeds in the production years mineral nitrogen was applied at rates of: 20, 40 or 60 kg ha^{-1} (autumn fertilization). At the end of March/beginning of April, directly before the start of growth, 40, 60 and 80 kg N ha^{-1} was applied in a single rate or divided into half with application of 40 kg ha^{-1} at the beginning of shooting. State of plant nitrogen nutrition was determined based on total nitrogen content in leaves (the Kjeldahl method) and the chlorophyll index (leaf greenness) using a

chlorophyllometer. Measurements were made before starting of growth (April), at the beginning of shooting (May) and on the flag leaf at seed milk maturity (June). Photosynthesis rate was measured with a portable gas analyser (Li-Cor 6400). Significance of differences were determined by Tukey's test, at the level α=0.05.

Results and discussion

Highest seed yields of red fescue were obtained after the application of 120 kg N ha^{-1} per year (Fig. 1). After the application of a rate reducedby half the decrease in yield was only 7.5 %. On the basis of measurements in May and June it was indicated that an increase in the rate from 60 to 140 kg N ha^{-1} resulted in proportional growth of nitrogen concentration in leaves (coefficients of determination (R^2) 0.95 and 0.88, respectively).

Figure 1. Chlorophyll index, N content and seed yield of red fescue depending on total rate of mineral nitrogen, mean from first and second production year



Nitrogen content in leaves at the beginning of growth and shooting was similar and decreased at seed milk maturity (Table 1). Decrease in nitrogen concentration in ontogenic development makes it difficult to use this measure to estimate plant nutrition state (Fotyma & Bezduszniak, 2000). In production years, at the beginning of growth nitrogen concentration in leaves was the largest if 60 kg N ha^{-1} was applied in autumn. A similar response to this level of autumn nitrogen fertilization is also reported by Gislum and Boelt (1999). In the present study, at the beginning of shooting (in May) an increase in the spring rate of nitrogen from 40 to 60 kg ha^{-1} and also from 60 to 80 kg ha^{-1} caused an increase in nitrogen concentration in leaves, but the differences were significant only in the first production year.

Chlorophyll index increased from April to June (Table 1). No response of this index to nitrogen rates applied in autumn was observed. In production years, at the beginning of shooting the chlorophyll index was significantly higher after a single application of 80 kg N ha^{-1} as compared

with 40 kg. A similar reaction was indicated on the flag leaf (in June), but only in the first harvesting year.

Nitrogen fertilization level in autumn and early spring did not have an effect on the photosynthesis rate of the flag leaf in seed milk maturity in the first or the second production years (Table 2). In the second year of seed harvesting the application of half of 80 kg N ha^{-1} at the beginning of shooting caused an increase in photosynthesis rate of the flag leaf in relation to the single application of 40, 60 or 80 kg N ha^{-1} in early spring.

Table1. Nitrogen content and chlorophyll index of red fescue prior to starting of growing in spring (April), at the beginning of shooting (May) and of flag leaf at milk stage (June)

Nitrogen rate [kg ha^{-1}]		Nitrogen content [%]					Chlorophyll index [SPAD]					
		Time of measuring										
		April		May		June	April		May		June	
		Year of production										
		I	II	I	II	I	I	II	I	II	I	II
autumn	20	3,06	3,33	3,24	2,50	1,84	7,70	5,84	20,1	15,7	20,8	23,1
	40	2,93	3,41	3,20	2,55	1,76	7,46	7,01	19,0	16,7	20,4	22,6
	60	3,32	3,76	3,31	2,60	1,88	7,25	6,89	19,7	16,4	19,7	21,2
LSD		0,22	0,32	ns	ns	ns	ns	ns	ns	ns	ns	ns
spring	40	-	-	3,10	2,40	1,69	-	-	17,1	15,2	18,4	23,7
	60	-	-	3,25	2,58	1,72	-	-	19,5	16,0	20,6	20,6
	80	-	-	3,40	2,67	1,85	-	-	22,3	17,6	21,7	21,1
	40+40	-	-	-	-	2,05	-	-	-	-	20,4	23,7
LSD		-	-	0,14	ns	ns	-	-	3,21	2,05	3,00	ns

ns - not significant

Table 2. Photosynthesis rate of flag leaf and seed yield of red fescue

Nitrogen rate [kg ha^{-1}]		Photosynthesis rate [μmol CO_2 m^{-2}s^{-1}]		Seed yield [dt ha^{-1}]	
		Year of production			
		I	II	I	II
autumn	20	8,83	6,09	8,72	8,42
	40	11,03	6,90	8,82	8,32
	60	10,64	6,54	8,66	7,94
LSD		ns	ns	ns	0,35
spring	40	9,62	2,08	8,48	7,39
	60	11,65	3,45	8,81	8,45
	80	8,31	3,80	8,77	8,60
	40+40	11,09	16,70	8,87	8,46
LSD		ns	2,09	ns	0,81

ns - not significant

In the first year, no significant effect of autumn and spring fertilization levels on seed yield was indicated (Table 2). In the second year, following the autumn application of 20 or 40 kg N ha^{-1}, application of at least 60 kg was necessary in spring. After the application of 40 kg ha^{-1} during starting of growth, seed yield was the smallest, but an additional application of 40 kg at shooting stage, at a high photosynthesis rate of the flag leaf during seed formation, significantly increased the yield. The study conducted indicates that the total level of nitrogen fertilization should not be more than 60 kg ha^{-1} in the first production year and 80 kg in the second. Similar rates for red fescue (55-80 kg ha^{-1}) are recommended by Fairey (2006).

Conclusions

1. Red fescue at the beginning of growth shows the response of nitrogen content in leaves to the level of autumn fertilization with nitrogen, and at the beginning of the shooting stage of the chlorophyll index to the rates applied in early spring. Analysis of plant nutrition state by means of those indexes may be useful for determination needs for spring fertilization with nitrogen in production years.
2. Increasing rates of autumn fertilization with nitrogen above 20 kg ha^{-1} do not result in a significant increase in yield in the production years. Spring rate of 40 N ha^{-1} applied during starting of growth in the first year of seed harvesting is sufficient, whereas in the second year it should be increased up to 60 or 80 kg N ha^{-1}

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