Pak. J. Agri. Sci., Vol. 52(4), 989-995; 2015
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

GERMINATION BIOLOGY AND WEED THRESHOLDS OF RYE BROME (*Bromus secalinus* L.) IN WHEAT (*Trticum aestivum* L.)

Kazimierz Adamczewski[1,*], Sylwia Kaczmarek[1], Roman Kierzek[1] and Marek Urban[2]

[1]Department of Weed Science and Plant Protection Techniques, Institute of Plant Protection - National Research Institute, Poznan, Poland; [2]IPP Regional Experimental Station, Institute of Plant Protection - National Research Institute, Trzebnica, Poland.
[*]Corresponding author's e-mail: k.adamczewski@iorpib.poznan.pl

The aim of the study was to evaluate the effect of the placement depth of caryopses as well as of the temperature and pH of the base on the germination capacity of *Bromus secalinus* caryopses. Research into injury levels in the cultivation of spring wheat and winter wheat was conducted. *B. secalinus* is becoming a serious problem in cereals grown in the minimum tillage system, particularly in winter wheat. The best and earliest emergence occurred in caryopses of rye brome that lay on the surface or were placed at a depth of 1.5 cm. The worst emergence was recorded when the caryopses were placed at a depth of 6 cm. The caryopses placed at a depth of 10 cm did not germinate at all. The applied temperature range and the water pH did not present a significant impact on the percentage of germinated caryopses, low temperatures solely differentiated the speed of the process. Increased weed infestation of winter and spring wheat significantly affected the deterioration of yield-boosting parameters of wheat. The weed thresholds of *B. secalinus* was 3-4 plants for short-straw variety cultivated in worse soil conditions up to 5-6 plants for the long-straw variety cultivated in good soil conditions.
Keywords: *Bromus secalinus*, germination, *Trtiticum aestivum,* weed thresholds

INTRODUCTION

In the past rye brome (*Bromus secalimus* L.) was a relatively common weed in cereal crops. In the second half of the 20th century it almost completely disappeared from the fields. Some botanists recognized that it was an extinct species, worthy of inclusion in the list of protected species (Warcholinska, 1981). For several years, however, the weed has re-emerged in winter wheat crops. It begins to pose a serious problem in some fields. In Poland it mainly occurs in the north-east, in the regions of Mazury and Zulawy (Korniak and Dymanowski, 2009). It can also be found in the Lower Silesia and in the Lublin region (Kapeluszny and Haliniarz, 2007) and another region in Poland (North East of Poland). The increase in infestation of numerous crops with the weed is also observed in some European countries (Ferreira *et al*., 1991; Mory *et al*., 2003). According to Szymankiewicz *et al*. (2003) the tillage intensity and plant succession are among the most significant factors that determine the occurrence of weeds, including rye brome. A factor that encourages the increase in rye brome occurrence is minimum tillage cultivation, applied by numerous farms. In some fields of winter wheat, and sometimes also of spring wheat, rye brome has become a major threat (Ferreira *et al*., 1991). The weed is difficult to control chemically, few herbicides may be recommended to reduce its incidence. In integrated crops chemical weed control with herbicides is justified only when the weed thresholds exceeds the cost of the performed procedures (Zanin *et al*., 1992).

Rye brome is an annual grass, which sometimes may be biennial, of a height of ca. 80-120 cm, germinating mainly in autumn, less frequently in spring. It tillers strongly, and during a wet spring grows intensely choking up wheat crops. Caryopses have a high germination capacity and are characterized by a high resistance to external factors. The inflorescence is a large multi spikelet panicle, of a length of 15-25 cm. One plant can deliver from 800 up to 1600 caryopses, which are quite large. It ripens at the same time as the cereal and at the time of combine harvesting contaminates the grain (Falkowski, 1982; Kozłowski *et al*., 1998). Some caryopses fall to the ground at harvest time. In the soil the rye brome caryopses retain their vitality for a relatively short time (2-3 years). The grass is most commonly found in different types of soils that are, however, rich in nutrients. Therefore, it infests winter wheat and overgrows the field of crop. In the Middle Ages rye brome caryopses were added to baked bread after milling. Before the Second World War rye brome in some areas was cultivated as food for birds.
Due to the increasing occurrence of rye brome it was undertaken to examine some aspects of the species biology, what kind of conditions favour germination of caryopses and what the weed thresholds are for winter and spring wheat.

MATERIALS AND METHODS

The rye brome seeds for research were collected from winter wheat fields in the Bociany and Paluzy in the Mazury region.

Preliminary study of germination capacity did not show any differences related to the site where the seeds were collected. Therefore, the seeds were mixed and later studied under laboratory, greenhouse and field conditions. In the laboratory the germination capacity was rated according to the temperature and water pH, in the greenhouse germination was assessed according to the soil placement depth and the injury levels were determined for spring wheat. In the field conditions, in turn, weed thresholds were determined for winter wheat.

***The laboratory experiment*:** Experiment studying the effect of the temperature and water pH on the seeds germination of *B. secalinus* was conducted in the laboratory of the Regional Inspectorate of Plant Protection and Seed Inspection in Poznan in accordance with the requirements set by the ISTA (International Seed Testing Association, 2012). 50 pieces of rye brome seeds were placed on Petri dishes in 8 repetitions. The Petri dishes were placed in thermostats, in which 4 temperature variations were applied $5^o/5^o$, $5^o/15^o$, $5^o/20^o$ and $20^o/30^oC$. During the experiment the seeds were watered with distilled water. A temperature of $5^o/15^o$ (8 hours night and 16 hours day) was applied in the experiment with varying water pH, and the seeds were watered with water of a pH of 7, 5 and 3. Water of a different pH was obtained by adding 0.1 mol/l of hydrochloric acid (Merck) for water acidification, and 0.1 mol/l of sodium hydroxide (Merck) for alkalisation, and the pH of the solution was examined with an MP 225 pH meter (Mettler Toledo 2011). Evaluation of germination was performed after 7, 14, 21 days following the placement of the seeds on Petri dishes.

***The greenhouse experiment*:** Experiment on the seed sowing depth was conducted in two series, each in 5 repetitions. Greenhouse soil and plastic pots of a height of 18 cm and a diameter of 22 cm were used for the experiment. After soil application 50 caryopses were planted in a pot and covered with soil so that they were at different depths; 0; 1.5 cm 3 cm, 6 cm and 10 cm. Evaluation of germination was performed after 7, 14 and 21 days following the sowing. The obtained results are presented in the table as averages of 10 repetitions. The experiment with weed thresholds for spring wheat was performed in two series, the first of which in 5 repetitions, and the second in 4 repetitions. The obtained results were given as averages of 9 repetitions. Greenhouse brown soil was used in the experiment. It was mixed with mineral fertilizers: ammonium nitrate and ammo-phosphate, 1 and 2 g for a pot respectively. Plastic pots of a height of 25 cm, a diameter of 32 cm and a capacity of 15 l were used. 10 caryopses of Bostona cultivar of spring wheat were sown each time, and after germination the excess was removed, leaving 8 plants in each pot. Rye brome, in turn, was pre-germinated on Petri dishes and after 3 days transferred into the pots: 1, 2, 4, 6, 8 10 plants for each pot. During the growth period the plants were watered regularly. After full maturity has been reached, the spring wheat and rye brome were collected by cutting the plants at the soil surface. Air-dry matter of plants, the number of spikes or panicles of spring wheat and rye brome, the number of grains per spike, the yield and the weight of 1000 grains were determined.

***Field experiment*:** To determine the weed thresholds for rye brome in winter wheat two types of field experiments were carried out: one in small plots, and the other in a production area, where rye brome infested winter wheat crop to a varying extent.

The experiment in small plots was conducted between 2011 and 2012 at the Experimental Station in Winna Gora. The experiment was conducted in 4 repetitions on sandy loam soil, quality class IV. After sowing winter wheat of Muszelka cultivar in plots of a size of 2.25 m^2 (1.5 x 1.5 m) different quantities of rye brome caryopses were sown. After germination adjustments of the quantities were performed, so that the plants were evenly distributed over the entire plot, leaving: 0, 2, 9, 18, 45, 90 and 135 of rye brome plants on the surface of 2.25 m^2, which corresponds to 0, 1, 4, 8, 20, 40, 60 rye brome plants per m^2. Moreover, other species of weeds were removed from small plots. Early in the spring the degree of rye brome occurrence was examined. During the maturity period winter wheat spikes and rye brome panicles were collected. The number of spikes, the number of grains per spike, the weight of 1000 grains, the grain yield and rye brome yield were determined in the laboratory. The final result is the average of 8 repetitions.

In the other type of experiment conducted between 2011 and 2012 samples were collected from a production area of Ostka winter wheat cultivar in the village of Kuzniczysko near Trzebnica town. In this field, winter wheat was sown on loamy soil of quality class II, that had been cultivated in a monoculture for several years in the minimum tillage system. In this field dicotyledonous weeds were controlled with herbicides of growth regulator type (MCPA). The degree of *B. secalinus* infestation in this field was varying. Spike samples were collected from an area of 2,5 m^2, from different spots, characterized by a varying degree of rye brome density (0, 4-5, 8-10, 16-18, 30-35, 50-55 and 75-80 plants per 1 m^2). For each infestation degree 5 samples (5 repetitions) were collected each year. During a 2-year period 10 samples were collected for each weed infestation degree. The final result presented in the table is the average of 10 repetitions. Next, the spikes were counted and threshed and the weight of 1000 grains was determined in accordance with methodology.

***Statistical analysis*:** The results were evaluated with Statistica 9.0 software (Statsoft Inc. 2010), with the application of variance analysis for single factor experiments in an entirely random system for laboratory and greenhouse experiments as well as for a field experiment conducted under production conditions. For the evaluation of the results obtained in the field experiment conducted on small plots in Winna Gora; however, variance analysis for single factor experiments in a randomized block design system (split plot design) was applied. For the evaluation of the existing differences the Tukey test was applied, at a confidence level of α=0,05%. A 10% decrease in the wheat yield was adopted as the weed thresholds. To calculate the number of rye brome plants causing a 10% decrease in the grain yield the Polo Plus program was used (Robertson *et al*., 2002).

RESULTS

***The effect of temperature on seeds germination*:** Caryopses of *B. secalinus* germinated early at the highest test temperature, i.e. 20/30° – 86% and 10/20° – 82%, whereas the low germination was recorded at the lowest temperature of 5/5° – 58 % (Table 1). During subsequent observations the percentage of germinated caryopses increased. The largest increase was recorded after 14 following the placement on dishes, at a temperature of 5/5°. The increase was 16%, and at a temperature of 5/15° – 15%. After three weeks of observation (21 days) at a temperature of 5/5° the percentage of germinated caryopses increased by another 12%, which was the largest increase in comparison to the remaining test temperatures. In the case of observations conducted after 7, 14 and 21 days, the effect of different temperatures on the number of germinating caryopses was demonstrated. The smallest number of caryopses germinated at a temperature of 5/5° – 86 %, whereas at the remaining temperatures the percentage of germinated caryopses was very similar (92-93 %).

Table 1. The effect of temperature on the germination of rye brome (*B. secalinus*) seeds.

Temperature (°C)	Germination after days (%)		
	7	14	21
5/5	58 a	74 a	86 a
5/15	73 b	88 b	92 b
5/20	77 c	90 b	92 b
10/20	82 d	90 b	92 b
20/30	86 e	89 b	93 b

***The effect of water pH on seeds germination*:** Three different levels of water pH applied in the experiments for watering filter paper (base) did not affect the germination rate of rye brome caryopses (Table 2). As soon as after 7 days following the placement the percentage of germinated caryopses ranged from 84 to 89. On the subsequent observation dates i.e. after 14 and 21 days, the percentage of germinated caryopses exceeded 90-92% in all objects, regardless of the pH of the water added to the Petri dishes.

***The effect of caryopsis placement depth on seeds germination*:** After the conducted evaluation it is possible to conclude that the depth of caryopsis placement significantly affected the emergence of *B. secalinus* (Table 3). After 7 days following the sowing the largest number of germinating caryopses was found in the ones that were on the soil surface (88%), followed by those placed at the depths of 1.5 cm and 3 cm, with respective percentages of 53 and 17%. During the next observation the percentage of emergence at those depths increased. The largest increase was observed when the caryopses were placed at a depth of 1.5 cm, i.e. by 17%. A 2% increase in germinated caryopses was also recorded for a depth of 6 cm. The evaluation conducted after three weeks following the sowing indicated a slight increase in rye brome emergence. No emergence of the plant was recorded from the depth of 10 cm.

Table 2. The effect of water pH on the germination of rye brome (*B. sealinus*) seeds (at a temperature 5/15).

pH	Germination after days (%)		
	7	14	21
7	89 b	92 a	92 a
5	84 a	89 a	90 a
3	85 a	91 a	91 a

Table 3. The effect of seeds placement depth in soil on rye brome (*B. secalinus*) germination.

Placement depth (cm)	Germination after days (%)		
	7	14	21
0	88 d	97 d	97 d
1.5	53 c	70 c	72 c
3	17 b	24 b	34 b
6	0 a	2 a	3 a
10	0 a	0 a	0 a

***The effect of B. secalinus plant number on spring wheat*:** Air-dry matter of plants, the number of spring wheat spikes and rye brome panicles as well as the weight of 1000 grains and the yield level for spring wheat in the pot experiment significantly depended on the number of rye brome plants in a pot. The analysis of the obtained results indicated a nearly linear relationship between the number of rye brome plants in a pot and the evaluated parameters (Table 4). Statistical evaluation of the results showed that all the tested parameters were significantly different. Air-dry matter of the rye brome plant was significantly differentiated at all research sites, i.e. depending on the number of rye brome plants in a pot. In contrast, the number of plants in a pot rye brome did not have such a big impact on the dry matter of spring wheat plants. Tillering of both wheat and rye brome depended on the number of the rye brome plants in a pot. At the same time the degree of rye brome tillering was to a greater extent dependent on the number of plants in a pot than on the number of wheat plants. With one weed plant in a pot the number of panicles from one plant was 6.8 panicles, whereas with 10 plants it was only 1.5 panicles. In the case of spring wheat, however, the number of spikes ranged from 4.6 to 3.5, respectively, for 1 and 10 plants of rye brome in a pot. In the pots without rye brome the number of spring

Table 4. Effect of the number of rye brome (*B. secalinus*) plants on spring wheat (pot experiment).

Wheat/ Rye brome	Air-dry matter (g/l plant)		Number of spikes, panicles per plant		Number of grains per spike	1000 grain weight (g)	Grain yield (g/pot)
	wheat	rye brome	wheat	rye brome			
8/0	109.6 f	0.0 a	4.8 c	0.0 a	23.6 b	39.8 c	35.4 d
8/1	103.0 e	8.3 b	4.6 bc	6.8 d	23.3 b	39.5 c	33.7 cd
8/2	98.3 d	11.7 c	4.5 bc	6.3 d	22.7 ab	38.2 b	31.5 c
8/4	80.1 c	14.6 d	4.3 bc	4.8 c	22.4 ab	37.7 b	29.4 c
8/6	73.1 b	19.6 e	4.2 b	3.5 b	22.7 ab	37.2 ab	25.6 b
8/8	71.7 b	25.7 f	3.7 a	2.5 b	22.9 b	37.0 ab	24.1 b
8/10	67.2 a	29.2 g	3.5 a	1.5 b	21.4 a	35.7 a	21.1 a

Table 5. Effect of rye brome (*B. secalinus*) infestation degree on winter wheat (small plots experiment, average of 2 experiments).

Number of plants (*B. secalinus* per m^2)	Number of spikes (panicles per 1m^2)		Number of grains per spike	1000 grain weight (g)	Yield in g from 10 m^2	
	wheat	rye brome			wheat	rye brome
0	435.3 a	0.0 a	28.5 a	42.4 a	6853 a	0 a
1	430.0 a	7.8 b	28.4 a	42.1 a	6467 b	454 b
4	416.3 b	19.3 c	28.5 a	41.9 a	5955 c	882 c
8	402.3 c	28.8 d	27.8 ab	41.3 ab	5424 d	1448 d
20	385.0 d	45.0 e	27.6 ab	40.8 ab	4858 e	2434 e
40	348.0 e	63.0 f	26.5 b	39.8 b	4198 f	3258 f
60	298.8 f	78.8 g	23.4 c	35.6 c	3614 g	3912 g

wheat spikes was 4.8. The number of grains per spike decreased with the increase of the number of rye brome spikes, from 23.6 for the control (without rye brome) to 21.4 for objects with 10 rye brome plants per pot. The differences were statistically significant. In contrast, the differences between the remaining objects were within statistical error. The number of rye brome plants had a great impact on the weight of 1000 grains, which ranged from 39.5 to 35.7, for 1 and 10 rye brome plants in a pot respectively. The highest weight per 1000 grains was recorded for the control, and it was 39.8 g. The spring wheat grain yield ranged from 35.4 for control (without rye brome) to 21.1 g, which amounted to 62% of control yield. Statistical evaluation was applied to determine what number of rye brome plants will cause a 10% decrease in the grain yield. Figure 1 shows the decrease in the spring wheat grain yield due to an increased density of rye brome plants in a pot. The conducted statistical analysis showed that 2 plants of rye brome caused a 10% decrease in the grain yield.

The effect of B. secalinus plant number on winter wheat: In the field experiment the effect of seven levels of weed infestation (0, 2, 9, 18, 45, 90 and 135 rye brome plants on an area of 2.25 m^2, i.e. 0, 1, 4, 8, 20, 40, 60 per m^2) on the growth and yield of winter wheat was evaluated. The increase in the occurrence of rye brome had the greatest impact on the number of spikes and the grain yield of winter wheat (Table 5). The density of rye brome on the surface; however, had little influence on the number of grains per spike and the weight of 1000 grains. The number of spikes for the control (without rye brome) was 435.3 pcs per 1 m^2 and at the presence of the studied weed in the amount of 60 pcs/m^2 it was 298.8 pcs, i.e. it decreased by nearly 32 %.

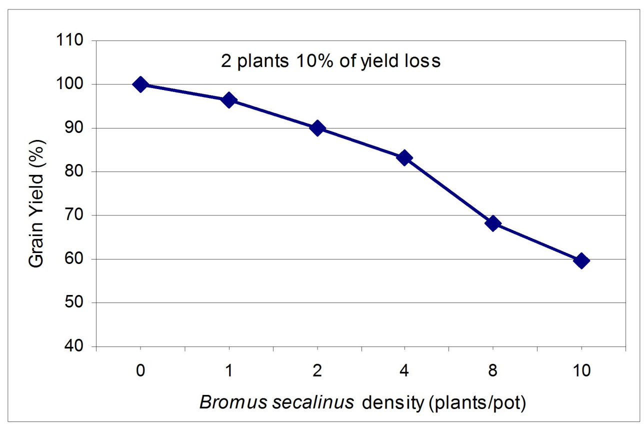

Figure 1. Effect of number of rye brome (*B. secalinus*) plants (in pots) on the spring wheat grain yield.

The grain yield at the weed infestation of 60 rye brome plants per 1 m^2 decreased by nearly 57%. The number of grains per spike and the weight of 1000 grains, however, decreased by only 16 and 18%. The data indicate that rye brome had the greatest influence on the tillering of winter wheat. This also proves that the competitive activity of rye brome is visible already at the beginning of the growth and development of winter wheat. This is because the winter wheat grain yield depends on 3 elements, i.e. the number of spikes, the number of grains per spike and the weight of 1000 grains. Therefore, the negative competitive effect of rye brome had the greatest impact on the grain yield. Statistical analysis showed significant differences in the grain yield for each rye brome infestation level. As few as 2 plants for an area of 2.25 m^2, i.e. nearly 1 plant per m^2, of the weed decreased the grain yield by 7.1%. The greatest impact on the grain yield was observed with 60 pieces of rye brome per 1 m^2. At such density of the weed the grain yield decreased by over 56%. The number of panicles and the caryopsis yield were also evaluated in the experiment. Rye brome proved to be a strongly tillering plant. However, its tillering was to a large extent dependent on the density of the plants per an area unit. At the lowest density 2 plants per 2.25 m^2 gave over 17 panicles, i.e. on average 7.8 panicles per 1 plant. At the highest density, in contrast, i.e. when there were 60 plants per m^2 (135 plants per 2.25 m^2), one plant gave on average 1.3 blades. The rye brome caryopsis yield was also strongly correlated with the number of panicles. It may, however, be noted that the caryopsis yield form one panicle was the greatest at the lowest density, from 5.8 g, for 1 plant per 1 m^2 to 5.0 g for 60 plants per m^2. Regression analysis was performed in order to determine what number of rye brome plants will cause a 10% decrease in the grain yield. As shown in Figure 2, the occurrence of 3-4 rye brome plants per m^2 caused a 10% decrease in the winter wheat grain yield.

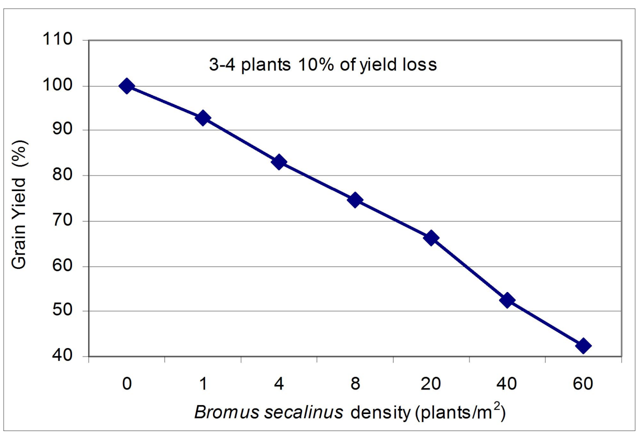

Figure 2. Effect of number of rye brome (*B. secalinus*) plants on the winter wheat grain yield (small plots experiment) (Winna Gora).

Experiment in the production area: To evaluate the effect of weed infestation on the yield a field of winter wheat was selected, where the occurrence of rye brome was varied. Therefore, it was possible to determine the sites with a different degree of the weed infestation. This, in turn, gave an opportunity to determine the effect of the weed infestation degree on the grain yield and to set the weed thresholds. In order to determine the grain yield spikes of rye brome were collected from 7 sites, which were characterized by a different number of rye brome plants per m^2 (Table 6).

Table 6. Effect of rye brome (*B. secalinus*) infestation degree on winter wheat (field experiment, average of 2 experiments).

No. of rye brome plants (pcs/m^2)	No. of spikes (pcs/m^2)	No. of grains per spike	1000 grain weight (g)	Grain yield in g from 10 m^2
0	353 e	39.5 e	41.8 b	5452 f
4-5	339 e	38.6 de	40.1 ab	5144 ef
8-10	320 d	37.2 cd	40.1 ab	4797 e
16-18	305 cd	35.5 bc	39.7 a	4442 d
30-35	288 c	34.5 b	39.9 ab	4026 c
50-55	255 b	33.9 b	39.1 a	3537 b
75-80	227 a	31.7 a	38.8 a	3013 a

At the time of sampling the number of winter wheat spikes per 1 m^2 was determined. Next, caryopses in spikes were counted and the weight of 1000 grains as well as the yield were determined. The rye brome occurring in the field had the greatest effect on winter wheat tillering i.e. on the number of spikes. The weed had a slightly lesser effect on the number of grain per spike, and the least negative effect on the weight of 1000 grains. The smallest number of spikes, 227 pcs/m^2, was recorded under conditions of the most abundant occurrence of rye brome, which was ca. 65% of the number of spikes (353 pcs/m^2) at the spot where the presence of the weed in winter wheat was not observed. The number of grains per one spike ranged on average from 38.6 with the lowest weed infestation to 31.7 at the highest weed infestation. The largest number of grains in spikes was recorded in spikes collected at the spots where rye brome did not occur, i.e. nearly 40. The weight of 1000 grains was the least differentiated, ranging from 38.8 to 41.8 g. The number of spikes had the greatest effect on winter wheat yield. Other elements of the yield structure, the number of grains per spike and the weight of 1000 grains had a lesser impact. At the spots where rye brome was absent, the grain yield of winter wheat was ca. 5452 g/10m^2, which corresponds to 5.45 tons per hectare. The grain yield of winter wheat decreased with the increase in the weed infestation. At the infestation of 4-5 rye brome plants per 1 m^2 the obtained yield was nearly by 5.6% lower than at the spots where the weed did not occur. The observed difference, however, was within statistical error. The level of winter wheat grain yield obtained at the remaining degrees of rye brome infestation differed statistically. The lowest yield was obtained when the rye brome infestation was 75-80 plants per m^2 and was at a level of ca. 55% of the yield when compared to the spots where the weed did not occur. To determine how many rye brome plants will cause a 10% decrease in the grain yield a regression analysis was conducted, whose results are presented in Figure 3. The performed calculations indicate that 5-6 rye brome plants caused a decrease in the grain yield by 10%.

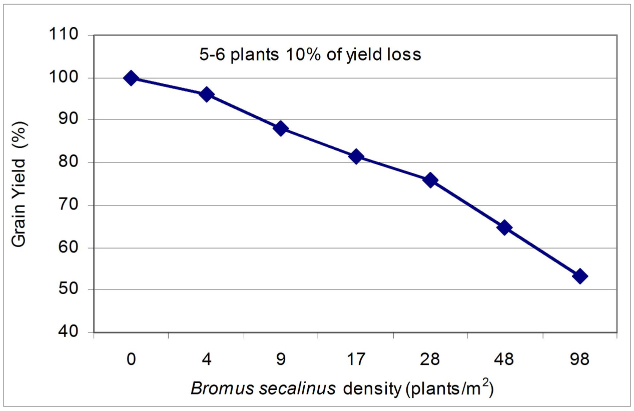

Figure 3. Effect of number of rye brome (*B. secalinus*) plants on the winter wheat grain yield under field production conditions (Kuzniczysko).

DISCUSSION

Rye brome is a weed which in the past 10 years has become a more common problem in winter wheat cultivation in Poland. The range of rye brome occurrence increases annually (Rzymowska *et al*., 2010). It is related to the introduction of limited tillage, commonly referred to as minimum tillage, where plough cultivation is eliminated. Moreover, rye brome is a species which is not easily controlled by many commonly applied graminicides. There is little research on rye brome. Much more research has been conducted on barren brome (*B. sterilis*) and drooping brome (*B. tectorum*) (Beckstead *et al*., 1996; Hilton 1984; Kaczmarek and Adamczewski, 2007).

The results of our research as well as the data from literature (Casus *et al*., 1994) indicated that *B. secalinus*, like most grasses germinates best when the caryopses are near the soil surface. The data demonstrated that the conditions created by minimum tillage are favourable for rye brome emergence. There is therefore a high probability of an increase in rye brome infestation in the fields where farmers apply tillage limitations. The situation is similar to the case of barren brome (Kaczmarek and Adamczewski, 2007).

The effect of temperature on the germination of caryopses was not significant. It was only observed that at a temperature of 5/5° the number of germinated caryopses was the smallest, whereas at the remaining temperatures the percentage of germinated caryopses was very similar. A similar effect of temperature on the germination of caryopses of the *Bromus secalinus* was obtained by Andersen *et al*. (2000) in Sweden and by Kapeluszny and Haliniarz (2007) in Poland.

The determined weed thresholds for monocotyledonous weeds apply mostly to the species that pose a threat on large acreages, i.e. *Alopecurus myosuroides* and *Avena fatua* (Mennan *et al*., 2003). There are, however, no data for weed thresholds of *B. secalinus* for winter wheat and spring wheat. The presented research results are thus filling the gap.

To evaluate the harmfulness of rye brome a 10% decrease in the grain yield was adopted as the weed thresholds for this species of weed. *B. secalinus* proved to be a very competitive species for spring wheat. Spring wheat is a species with a weaker tillering than winter wheat. Nevertheless, the increase in the number of rye brome plants in pots had the greatest effect on spring wheat tillering. The density of rye brome in a pot, in turn, had a significantly lower effect on the number of grains per spike and on the weight of 1000 grains. The results obtained in the pot experiments cannot, however, be applied to field conditions. Nevertheless, the grain yield depends on the number of spikes, the number of grains per spike and on the weight of 1000 grains. A 10% decrease in the grain yield was observed when there were 1 up to 2 rye brome plants in a pot. The data indicate a significant negative effect of the weed species on the growth of spring wheat plants. This took place in the pot experiment. But, undoubtedly, this will also take place under field conditions.

Under field conditions rye brome had the greatest effect on winter wheat in the experiment conducted on small plots. Rye brome is a heavily tillering high plant, which outgrows the crops, which undoubtedly has a great competitive effect on winter wheat, reflecting in the grain yield. Therefore, its control is economically justified (Ferreira *et al*., 1991). The weed thresholds for rye brome in the small plots experiment was 3-4 plants, and in the experiment conducted in a production area it was 5-6 plants per m^2. The observed differences probably result from different soil and tillage conditions of different cultivars. The soil in the experiment conducted on small plots in Winna Gora was weaker, and less rich in nutrients. Moreover, the Muszelka cultivar is a much lower plant than rye brome. Therefore this cultivar competes with *B. secalinus* less strongly. Hence a smaller number of the weed (3-4 plants per m^2) had a much greater influence on the winter wheat grain yield. In contrast, in a production area in the Kuzniczysko, the soil was good and rather rich in nutrients, and the Ostka cultivar is a quite a high plant and thus can compete with rye brome much better. For these reasons a 10% decrease in the winter wheat grain yield was observed at a higher weed infestation, i.e. 5-6 plants of *B. secalinus* per 1 m^2. A study conducted by Kaczmarek and Adamczewski (2007) showed that the weed thresholds for barren brome (*B. sterilis*) was 10-15 pcs/m^2. In contrast, Zanin *et al*. (1992) in their study determine the weed thresholds for barren brome at <40 szt/m^2. According to Mennan *et al*. (2003) the differences in weed thresholds resulted from different soil and climatic condition and from cultivar differences. The studies by Koscielny *et al*. (1990, 1991) indicated that the effect of rye brome on winter wheat yield also depend on the time of sowing and the amount sown, row spacing and the cultivar. Rye brome proves to be a more competitive weed than barren brome. It results from the fact that rye brome is a plant of a greater height and a longer vegetative season than barren brome.

REFERENCES

Anderson, L., P. Milberg, W. Schutz and O. Steimantz. 2002. Germination characteristics and emergence time of annual *Bromus* species of differing weediness in Sweden. Weed Res. 42: 135–147.

Cussans, G.W., F.B. Cooper, D.H.K. Davies and M.R. Thomas. 1994. A survey of the incidence of the *Bromus* species as weeds of winter cereals in England, Wales and parts of Scotland. Weed Res. 34: 361–368.

Beckstead, J., S. Meyer and S. Allen. 1996. *Bromus tectorum* seed germination: Between-population and between-year variation. Can. J. Bot. 74: 875–882.

Falkowski, M. (ed.). 1982. Trawy Polskie. PWRiL Warszawa: pp.565.

Ferreira, K.L., T.F. Peerer and F.M. Epplin. 1991. Economic returns from cheat (*Bromus secalinus*) control in winter wheat (*Triticum aestivum*). Weed Technol. 4: 306–313.

Hilton, J.R. 1984. The influence of temperature and moisture status on the photoinhibition of seed germination in *Bromus sterilis* L. by the far-red absorbing form of phytochrome. New Phytol. 97: 369–374.

Kaczmarek, S. and K. Adamczewski. 2007. *Bromus sterilis*– expansive weed, germination and weed thresholds. Annales UMCS, sec. E: 17–22.

Kapeluszny, J. and M. Haliniarz. 2007. Selected element of germination biology of flaxweed (*Descurainia sopha* Webb. Ex Prantl.) and rye brome (*Bromus secalinus* L.). Annales UMCS, sec. E: 226–233.

Korniak, T. and P. Dynowski. 2009. *Bromus secalinus*- zanikający czy rozprzestrzeniający się chwast upraw zbożowych w północno-wschodniej Polsce. Conference Proceedings "Migracja gatunków i rola chwastów migracyjnych w zbiorowiskach segetalnych oraz biologia gatunków z rodziny Poaceae". Siedlce, 3–4 wrzesnia 2009: 17.

Koscielny, J.A., T.F. Peeter, J.B. Solie and S.G. Solomon. 1990. Effect of wheat (*Triticum aestivum*) row spacing, seedling rate, and cultivar on yield loss from cheat (*Bromus secalinus*). Weed Technol. 4: 487–492.

Koscielny, J.A., T.F. Peeter, J.B. Solie and S.G. Solomon. 1991. Seeding date, seeding rate and row spacing affects wheat (*Triticum aestivum*) and cheat (*Bromus secalinus*). Weed Technol. 5: 707–712.

Kozlowski, S., P. Golinski and A. Swędrzynski. 1998. Trawy. Wyd. Liter. PARNAS Inowrocław: pp.344.

Mennan, H., M. Bozoglu and D. Isik. 2003. Economic thresholds of *Avena* spp., and *Alopecurus myosuroides* in winter wheat fields. Pak. J. Bot. 35: 147–154

Mory, R., A. Buchse and K. Hurle. 2003. Bromus species in winter wheat-population dynamics and competitiveness. Commun. Agric. Appl. Biol. Sci. 68 (4 PtA): 341–352.

Robertson, J.R., H.K. Preisler and R.M. Russell. 2002. Polo Plus. Probit and Logit Analysis user's guide 2002. Le Ore Software. Petaluna, CA. pp.36.

Rzymowska, Z., J. Skrzyczynska and A. Affek-Straczewska. 2010. Occurrence and some morphological features of *Bromus secalinus* L. in agrocenoses of the Podlaski Przelom Bugu Mesoregion. Fragm. Agron. 27: 102–110.

Statsoft Inc. 2010 STATISTICA (data analysis software system) Version 9. Available online at www.sstatsoft.com

Szymankiewicz, K., D. Jankowska and S. Derylo. 2003. Effect of crop rotation, monocultural and soil tillage on biodiversity of flora infestating winter triticale. Acta Agrophys. 4: 767–772.

Warcholinska, A.U. 1981. Stan i zagrożenie niektórych gatunków chwastów polnych z rodziny Gramineae w środkowej Polsce. Lodz. Tow. Nauk. 31 : 1–8.

Zanin, G., A. Berti and L. Toniolo. 1992. Estimation of economic thresholds for weed control in winter wheat. Weed Res. 33: 459–467.