

THE COMPARISON OF COMPETITIVE ABILITY AGAINST WEEDS OF 10 VARIETIES OF RYE CULTIVATED IN ORGANIC SYSTEM

Summary

In the study 9 varieties of winter rye: *Bosmo*, *Dańkowskie Amber*, *Dańkowskie Diament*, *Dańkowskie Złote*, *Daran*, *Kier*, *Rostockie*, *Stanko*, *Walet* and one summer and winter sown variety - *Bojko* cultivated in organic system were compared. The research was conducted in 2012-2013 in two different locations: Grabów (Masovian voivodeiship) and Taraskowo (Podlasie voivodeship). The number of weeds and their dry matter were analyzed in two growing stages of rye: tillering and dough stage. Moreover the analysis of height, number of tillers and yielding of rye varieties were done. In dough stage number of weeds was big, 235 pcs·m⁻² on average, but their dry matter was on the level of 55 g·m⁻² on average. Rye varieties did not differ significantly due to the number of weeds, based on means from 2 years and locations, except of *Bojko*. Different reactions of rye varieties in relation to weeds in locations were observed. The most competitive varieties according to dry matter of weeds in dough stage were in Grabów: *Dańkowskie Złote*, *Daran* and *Walet*, and in Taraskowo: *Bosmo*, *Dańkowskie Diament* and *Rostockie*. There were no significant correlations between the level of infestation and morphological features of rye varieties: height and tillering. The observed level of weed infestation did not significantly affect grain yield of tested rye varieties.

Key words: weeds, competitiveness, rye varieties, organic cultivation, experimentation

PORÓWNANIE ZDOLNOŚCI KONKURENCYJNYCH W STOSUNKU DO CHWASTÓW 10 ODMIAN ŻYTA UPRAWIANEGO W SYSTEMIE EKOLOGICZNYM

Streszczenie

Porównano zachwaszczenie 10 odmian żyta ozimego uprawianego w systemie ekologicznym: *Bojko*, *Bosmo*, *Dańkowskie Amber*, *Dańkowskie Diament*, *Dańkowskie Złote*, *Daran*, *Kier*, *Rostockie*, *Stanko* i *Walet*. Badania przeprowadzono w latach 2012-2013 w 2 lokalizacjach: Grabowie n. Wisłą (województwo mazowieckie) i Taraskowie (województwo podlaskie). Oznaczono liczebność oraz powierzoną suchą masę chwastów w dwóch terminach: w fazie krzewienia oraz dojrzałości woskowej pszenicy oraz wykonano analizy wysokości, rozkrzewienia i plonowania badanych odmian żyta ozimego. W fazie dojrzałości woskowej liczebność chwastów w zasiewach żyta była znacząca, średnio 235 szt.·m⁻², ale ich sucha masa nie była duża, średnio 55 g·m⁻². Odmiany żyta ozimego, średnio z 2 lat badań i miejscowości, nie różniły się istotnie statystycznie pod względem liczby chwastów, z wyjątkiem odmiany *Bojko*. Stwierdzono różną reakcję odmian na zachwaszczenie w miejscowościach. Odmianami o największej konkurencyjności, mierzonej suchą masą chwastów w fazie dojrzałości woskowej były w Grabowie: *Dańkowskie Złote*, *Daran* i *Walet*, a w Taraskowie: *Bosmo*, *Dańkowskie Diament* i *Rostockie*. Nie stwierdzono wyraźnych zależności między poziomem zachwaszczenia a cechami morfologicznymi odmian żyta: wysokością i rozkrzewieniem. Obserwowany poziom zachwaszczenia nie wpływał istotnie na plony ziarna badanych odmian żyta ozimego.

Słowa kluczowe: chwasty, odmiany żyta, konkurencyjność, uprawa ekologiczna, badania

1. Introduction

According to the Central Statistical Office rye (*Secale cereale*) was the third most grown cereal in Poland in 2012, after wheat and barley. The area of rye was over 1 million hectares, representing about 10% of all crops [1]. This significant position of rye in the structure of sowings is due to its resistance to adverse climatic conditions and the possibility of cultivation on medium and light soils. In addition, rye shows allelopathic properties against certain weed species [2], and for this reason some rye varieties may be especially valuable for organic production. In organic farming system the use of chemicals is forbidden thus non-chemical weed control methods are important to achieve a high yield of good quality. For this purpose different agrotechnical practices are used, such as suitable crop rotation, selection of main crop varieties, selection of species and varieties of second crop, proper time of sowing and density of seeding, mulching, undersown crops [3]. Competitive ability of rye,

besides of allelopathic properties, are provided mainly by its relatively rapid growth in the initial phase. Initial growth of rye is often so strong that even in conventional system the use of herbicides could be dispensed [4]. Other features affecting the competitiveness of cereals are: number of tillers and the speed of row closure, leaf area and leaf angle, the height of plant [5, 6]. The differences in competitive abilities are evident not only between cereal species [7, 8], but also between varieties [9, 10]. The aim of the study was to compare the infestation and yielding of 10 varieties of rye grown in organic system.

2. Material and methods

The study was conducted in 2012-2013 in two organic farms: in Grabów on the Vistula River (Mazovia province) and Taraskowo (Podlasie province). 9 varieties of winter rye: *Bosmo*, *Dańkowskie Amber*, *Dańkowskie Diamond*, *Dańkowskie Złote*, *Daran*, *Kier*, *Rostockie*, *Stanko*, *Walet*

and one summer and winter sown variety - Bojko were cultivated in each farm. The field experiment was established in a randomized block design, with 4 replications for each variety. The sowing rate of rye cultivars were the same - 3 mln grains · ha⁻¹. Characteristics of the habitat conditions of each farm is shown in Table 1.

Table 1. The characteristics of habitat conditions
Tab. 1. Charakterystyka warunków siedliskowych

Items	Location of organic farm	
	Grabów Masovian voivodeship	Taraskowo Podlasie voivodeship
Complex of soil agricultural suitability	good wheat	very good rye
Soil type	Cambisol	leached Cambisol
Texture	silt loam	silt on sandy loam
Forecrop	clover+grassess	mixture of cereals and legumes

Source: Own work / Źródło: opracowanie własne

Pre-sowing treatments were performed in accordance with a good agricultural practice, and sowing at the optimum time for each locations. Harrowing treatments were done using a harrow tines in autumn, twice in Grabów and once in Taraskowo.

Weather conditions in the season 2011/2012 were unfavourable in the period preceding the germination of rye and during winter. In the late January and early February frost down to -20°C was occurred. Low temperatures and insufficient snow cover affected the density of crops. Higher losses in crops were observed in Grabów. Bojko variety was destroyed by frost in Grabów in 2012. Weather conditions in the season 2012/2013 were characterized by a favorable rainfall and temperature during the germination period, which encouraged the development of both the rye and weeds. Critical period for vegetation was July and beginning of August because of drought which influenced the nutrient uptake and caused lower yields and poorer grain quality parameters.

Analyses of weed infestation were performed at the tillering stage in spring and dough stage. Weed abundance and dry matter of weeds were assessed on sample plots of 0.5 m² in 4 replications for each variety. Moreover the number

of tillers and plant height of winter rye cultivars were established in 2012 in Grabów, on 30 plants of each variety, in 4 replications. Analysis of variance was done and the significance of differences were estimated using Fisher test at a significance level $\alpha = 0.05$. Because the weed abundance and dry matter of weeds were not normally distributed, they were transformed ($\log x+0.1$) prior to analysis of variance. Calculations were performed using Statgraphic Plus version 2.1.

3. Results

3.1. The assessment of competitive ability against weeds of rye varieties in tillering stage

In the tillering stage differences in number and dry matter of weeds in rye between locations and years of research were noted. In 2012 rye canopies, regardless of variety, were characterized by lower weed infestation in Grabów (20.2 pcs·m⁻², 0.8 g·m⁻² on average) than in Taraskowo (112.4 pcs·m⁻², 4.9 g·m⁻² on average) (Tab. 2, 3). It could be due to twice harrowing in Grabów, while in Taraskowo it was done only once. In 2012 weed infestation in rye was lower (20.2 pcs·m⁻², 0.8 g·m⁻²) than in the following year (133.6 pcs·m⁻², 29.7 g·m⁻²), which could be due to the weather conditions in the 2012/2013 season, when warm autumn and winter promoted the development and overwinter of weeds. Among the tested cultivars Kier, Walet, Dańkowskie Amber and Dańkowskie Złote were the most competitive in relation to weeds according to the average number of weeds. The most weeded varieties were Bojko, Dańkowskie Diament, Rostockie and Stanko (Tab. 2). In case of Kier, Dańkowskie Amber and Dańkowskie Diament a significant interaction, that is a different reaction to weeds in locations was observed.

The dry matter of weeds in the tillering stage was small, 15 g·m⁻² on average (Tab. 3). The smallest dry matter of weeds were found in the canopy of Walet, Dańkowskie Amber and Stanko whereas the largest in Bojko variety (Tab. 3). In this phase there was no significant correlations between the level of infestation and morphological features of rye varieties, such as height and tillering (Tab. 6). The highest varieties were Bosmo and Rostockie, and the most tillered - Dańkowskie Diament and Walet. The lowest and the least tillered was Kier variety, in which small number of weeds was observed, but large their mass.

Table 2. Number of weeds (pcs·m⁻²) in rye varieties cultivated in different locations and years of research at tillering stage
Tab. 2. Liczba chwastów (szt./m²) w odmianach żyta ozimego w różnych miejscowościach i latach badań w fazie krzewienia

Varieties	Location and years						
	Grabów			Taraskowo	Mean		
	2012	2013	mean	2012	2012	2013	2012-2013
Bojko	destroyed by frost	141.5 abc	141.5*	192.5 c	192.5 b	141.5	167.0 b
Bosmo	31.0 b	144.5 abc	87.8	119.5 b	75.3 ab	144.5	109.9 ab
Dańkowskie Amber	23.0 ab	110.5 ab	66.8	76.0 a	49.5 ab	110.5	80.0 a
Dańkowskie Diament	14.0 a	163.0 c	88.5	117.0 ab	65.5 ab	163.0	114.3 a
Dańkowskie Złote	17.0 ab	121.5 abc	69.3	95.5 ab	56.3 ab	121.5	88.9 a
Daran	22.0 ab	135.0 abc	78.5	107.5 ab	64.8 ab	135.0	99.9 a
Kier	15.5 ab	99.5 a	57.5	122.0 bc	68.8 ab	99.5	84.1 a
Rostockie	22.0 ab	154.0 bc	88.0	100.0 ab	61.0 ab	154.0	107.5 a
Stanko	17.0 ab	146.5 abc	81.8	90.0 ab	53.5 ab	146.5	100.0 a
Walet	20.0 ab	119.5 abc	69.8	103.5 ab	61.8 ab	119.5	90.6 a
mean	20.2	133.6	76.4	112.4	61.8	133.6	97.2

* not statistically significant differences

Source: Own work / Źródło: opracowanie własne

Table 3. Dry matter of weeds ($\text{g}\cdot\text{m}^{-2}$) in rye varieties cultivated in different locations and years of research at tillering stage
 Tab. 3. Sucha masa chwastów (g/m^2) w odmianach żyta ozimego w różnych miejscowościach i latach badań w fazie krzewienia

Varieties	Location and years						
	Grabów			Taraskowo	Mean		
	2012	2013	mean	2012	2012	2013	2012-2013
Bojko	destroyed by frost	42.7*	42.7 b	19.8 d	19.8 b	42.7*	31.3 b
Bosmo	1.2*	26.8	14.0 a	2.6 abc	1.9 a	26.8	14.3 a
Dańkowskie Amber	0.9	25.2	13.1 a	1.9 a	1.4 a	25.2	13.3 a
Dańkowskie Diament	1.0	26.5	13.7 a	7.5 c	4.2 a	26.5	15.4 a
Dańkowskie Złote	0.6	30.4	15.5 a	1.8 ab	1.2 a	30.4	15.8 a
Daran	1.0	32.0	16.5 a	2.9 ab	2.0 a	32.0	17.0 a
Kier	0.4	31.4	15.9 a	4.8 bc	2.6 a	31.4	17.0 a
Rostockie	0.6	30.8	15.7 a	1.7 a	1.1 a	30.8	16.0 a
Stanko	0.7	27.6	14.1 a	3.5 abc	2.1 a	27.6	14.8 a
Walet	1.0	23.7	12.4 a	2.5 ab	1.7 a	23.7	12.7 a
mean	0.8	29.7	14.5	4.9	2.0	29.7	15.1

* not statistically significant differences

Source: Own work / Źródło: opracowanie własne

Table 4. Number of weeds ($\text{pcs}\cdot\text{m}^{-2}$) in rye varieties cultivated in different locations and years of research at dough stage
 Tab. 4. Liczba chwastów ($\text{szt.}/\text{m}^2$) w odmianach żyta ozimego w różnych miejscowościach i latach badań w fazie dojrzałości

Varieties	Location and years								
	Grabów			Taraskowo			Mean / średnio		
	2012	2013	Mean	2012	2013	mean	2012	2013	2012-2013
Bojko	de-destroyed by frost	130.0 a	130.0*	376.5*	381.0*	378.8*	376.5 b	255.5*	316.0 b
Bosmo	66.5 ab	187.0 ab	126.8	348.0	281.0	314.5	207.3 a	234.0	220.6 a
Dańkowskie Amber	73.0 ab	242.5 b	157.8	312.0	315.5	313.8	192.5 ab	279.0	235.8 a
Dańkowskie Diament	80.5 ab	188.0 ab	134.3	420.5	381.0	400.8	250.5 ab	284.5	267.5 a
Dańkowskie Złote	51.5 a	183.5 ab	117.5	243.5	358.5	301.0	147.5 a	271.0	209.3 a
Daran	73.0 ab	133.5 a	103.3	322.0	425.5	373.8	197.5 ab	279.5	238.5 a
Kier	95.5 b	143.0 a	119.3	369.0	402.5	385.8	232.3 ab	272.8	252.5 a
Rostockie	72.5 ab	127.5 a	100.0	297.0	292.0	294.5	184.8 ab	209.8	197.3 a
Stanko	90.5 b	192.0 ab	141.3	222.5	344.5	283.5	156.5 a	268.3	212.4 a
Walet	90.5 b	169.0 ab	129.8	293.5	251.5	272.5	192.0 ab	210.3	201.1 a
mean	77.1	169.6	123.3 A	320.5	343.3	331.9 B	213.7 A	256.5 B	235.1

* not statistically significant differences

Source: Own work / Źródło: opracowanie własne

Table 5. Dry matter of weeds ($\text{g}\cdot\text{m}^{-2}$) in rye varieties cultivated in different locations and years of research at dough stage
 Tab. 5. Sucha masa chwastów (g/m^2) w odmianach żyta ozimego w różnych miejscowościach i latach badań w fazie dojrzałości

Varieties	Location and years								
	Grabów			Taraskowo			Mean		
	2012	2013	mean	2012	2013	mean	2012	2013	2012-2013
Bojko	destroyed by frost	51.8*	51.8 ab	121.5 b	64.0*	92.8 b	121.5 b	57.9*	89.7 b
Bosmo	23.9*	79.8	51.8 ab	59.4 ab	42.8	51.1 a	41.7 a	61.3	51.5 a
Dańkowskie Amber	25.4	78.8	52.1 ab	54.6 ab	60.9	57.8 ab	40.0 a	69.8	54.9 ab
Dańkowskie Diament	53.8	84.1	68.9 b	63.5 ab	39.1	51.3 a	58.7 a	61.6	60.2 ab
Dańkowskie Złote	19.4	41.5	30.4 a	48.6 a	60.7	54.7 ab	34.0 a	51.1	42.6 a
Daran	24.4	53.8	39.1 ab	75.2 ab	58.2	66.7 ab	49.8 a	56.0	52.9 ab
Kier	32.7	53.4	43.1 ab	72.8 ab	50.0	61.4 ab	52.8 a	51.7	52.3 ab
Rostockie	20.0	94.2	57.1 ab	65.2 ab	45.3	55.3 ab	42.6 a	69.8	56.2 ab
Stanko	26.6	65.5	46.1 ab	76.4 ab	52.2	64.3 ab	51.5 a	58.9	55.2 ab
Walet	27.6	56.0	41.8 ab	66.1 ab	81.3	73.7 ab	46.9 a	68.7	57.8 ab
mean	28.2	65.9	47.1 A	70.3	55.5	62.9 A	49.3 A	60.7 A	55.0

* not statistically significant differences

Source: Own work / Źródło: opracowanie własne

3.2. The assessment of competitive ability against weeds of rye varieties in dough stage

In the dough stage significant differences in the number of weeds in rye canopies between the locations and the years of research were noted. The average number of weeds, as in the tillering stage, was 63% lower in Grabów

(123 $\text{pcs}\cdot\text{m}^{-2}$ on average), where twice harrowing was done than in Taraskowo (332 $\text{pcs}\cdot\text{m}^{-2}$), where once harrowing treatment was performed (Tab. 4). Varieties of rye, average from two years of research and locations, did not differ significantly in terms of number of weeds, except of Bojko variety (Tab. 4).

Despite of the large number of weeds in rye canopies, dry matter of weeds was not big, 55 g·m⁻² on average (Tab. 5). There were no statistically significant differences in the dry matter of weeds in rye between locations and years of research. In Grabów dry matter of weeds was by 133% higher in 2013 than in 2012, which could be due to the low density of rye canopy after winter, and in Taraskowo about 21% lower in 2013 compared to previous year.

The most competitive varieties due to dry matter of weeds in dough stage were in Grabów: Dańkowskie Złote, Daran and Walet, whereas in Taraskowo: Bosmo, Dańkowskie Diament and Rostockie (Tab. 5). It was a different reaction of rye varieties to weed infestation in the locations of research. Walet variety was characterized by a small dry matter of weeds in Grabów (42 g·m⁻²) and high in Taraskowo (74 g·m⁻² on average) (Tab. 5). As in the tillering stage, there was no association between the studied morphological features: height and tillering and the level of weed infestation. Daran was the highest variety and Kier the lowest (tab. 6). Bosmo was characterized by the lowest tillering. The most weedy varieties in Grabów were Dańkowskie Diament and Rostockie in 2013, whereas in Taraskowo - Bojko and Walet (Tab. 5), although Rostockie variety was characterized by the longest stem and Walet by the biggest number of tillers (Tab. 6).

The most abundant weed species in Grabów were: *Stellaria media*, *Viola arvensis*, *Apera spica-venti*, *Capsella bursa-pastoris*, *Veronica* sp., whereas in Taraskowo species

typical for light soils dominated, especially *Conyza canadensis*, *Viola arvensis*, *Scleranthus annuus*, *Rumex acetosella*, *Gypsophila muralis*, *Stellaria media*, *Equisetum arvense*, *Setaria glauca*. In Taraskowo density of small seedlings of *Conyza canadensis* in dough stage was 144 pcs·m⁻², which indicates the high potential for reproduction and confirms the high invasiveness of this species. In Grabów *Conyza canadensis* occurred in a small number: 0,8 pcs·m⁻² in 2012 and 4,5 pcs·m⁻² in 2013.

Analysis of yielding of 10 rye varieties points to the high variability of the results (Tab. 7). In the group of high yielding varieties in 2012 were: Bosmo, Kier and Dańkowskie Amber, whereas in 2013: Dańkowskie Diament, Bosmo and Walet. Summer and winter sown variety Bojko obtained low and unstable yields under organic system, mainly because of small frost resistance. The results from the study period of 2 years (2012 and 2013) indicate that regardless of the location the group of high yielding varieties contained Bosmo and Walet (Tab. 7). At the same time Bosmo variety was characterized by the low level of infestation in Taraskowo and Walet in Grabów. The observed level of infestation (mean 55 g·m⁻²) probably did not significantly affect grain yields of most studied cultivars of rye. In Rostockie canopy the largest dry matter of weeds - 94 g·m⁻² was noted in Grabów in 2013 and at the same time this variety has yielded at high level. In the case of Bojko variety big number and dry matter of weeds, in relation to small density of plants, could cause the yield reduction.

Tab. 6. The height and number of tillers of rye varieties in tillering and dough stage in 2012 in Grabów

Tab. 6. Wysokość oraz rozkrzewienie badanych odmian żyta ozimego w fazie krzewienia i dojrzałości woskowej w 2012 r. w Grabowie

Variety	Height (cm)		Number of tillers	
	tillering stage	dough stage	tillering stage	dough stage
Bojko	destroyed by frost	destroyed by frost	destroyed by frost	destroyed by frost
Bosmo	18.5	119.3	3.8	1.5
Dańkowskie Amber	17.7	112.9	3.9	1.7
Dańkowskie Diament	17.2	109.1	4.1	1.8
Dańkowskie Złote	17.7	115.5	3.7	1.7
Daran	17.3	126.0	3.7	1.8
Kier	16.1	107.4	3.4	1.8
Rostockie	18.4	124.2	3.7	1.7
Stanko	16.3	113.7	3.7	1.8
Walet	15.9	114.6	4.0	2.0
mean	17.2	115.8	3.8	1.8

Source: Own work / Źródło: opracowanie własne

Tab. 7. The grain yield of winter rye varieties in different locations and years of research (t·ha⁻¹)

Tab. 7. Plon ziarna żyta ozimego w różnych lokalizacjach i latach badań (t·ha⁻¹)

Varieties	Locations and yields					
	Grabów			Taraskowo		
	2012	2013	mean	2012	2013	mean
Bojko	destroyed by frost	2.62	2.15	2.62	2.90	2.76
Bosmo	4.16	3.30	3.73	4.01	3.01	3.51
Dańkowskie Amber	3.93	3.06	3.50	3.97	2.64	3.31
Dańkowskie Diament	3.48	3.47	3.48	3.54	3.02	3.28
Dańkowskie Złote	4.12	3.10	3.61	3.57	2.61	3.09
Daran	3.80	2.98	3.39	3.58	2.83	3.21
Kier	3.95	2.93	3.44	4.12	2.84	3.48
Rostockie	4.27	3.20	3.74	3.44	2.37	2.91
Stanko	4.08	2.92	3.50	3.59	2.97	3.28
Walet	3.80	3.21	3.51	3.99	2.98	3.49
mean	3.95	3.08	3.41	3.64	2.82	3.23

Source: Own work / Źródło: opracowanie własne

4. Discussion

A review of the literature shows that competitive ability of cereal varieties against weeds are depended mainly by different morphological and physiological characteristics, such as height, leaf area, tillering and plant resistance to shoots decay as a result of competition, the rate of growth, the use of nutrients and resistance to the stress of their deficiency [6, 9, 11]. In addition, some authors believe that the differences between varieties are also caused by their different allelopathic properties [12, 13]. According to Worthington and Reberg-Horton [14] the differences in the competitiveness due to weeds are the result of interaction of their allelopathic and suppressive ability.

Weed infestation of rye, average from two years of research, was characterized by a large number of weeds - 235 pcs·m⁻² on average (in the range from 51 to 401 pcs·m⁻² depending on the year, location and variety), but there were mostly small seedlings with dry matter of 55 g·m⁻² on average (in the range from 19 to 94 g·m⁻²). In Rezmerska - Piętka *et al.* studies [15] the long-term monocultures of rye, without using herbicides, were characterized by a large abundance of weeds, to 178 pcs·m⁻², with the dominance of *Centaurea cyanus*, *Lithospermum arvense*, *Viola arvensis*, *Matricaria inodora*, *Anthemis arvensis*, *Galium aparine*. Results of Blecharczyk *et al.* [16] research on rye grown in rotation, fertilized with manure and without the herbicide protection confirm a high competitiveness of Dańkowskie Złote variety which was expressed by a number of weeds only 44 pcs·m⁻² and the average fresh weight of weeds - 77 g·m⁻². In our study, the average dry matter of weeds for all tested varieties was 55.0 g·m⁻², and 42.6 g·m⁻² for Dańkowskie Złote, which means that this variety was distinguished by greater competitiveness in relation to the weeds than others. Sadowski and Rychcik [17] observed a higher level of weed infestation in rye canopies: in the tillering stage - 294 pcs·m⁻² for rye canopies with chemical weed control and 303 pcs·m⁻² with mechanical weed control and in dough stage - 167 pcs·m⁻² for herbicide treated rye canopies and 120 pcs·m⁻² for rye canopies with harrowing. These authors also found a lower weed biodiversity in chemically protected rye (13 weed species) in compare with rye grown in an organic system (16 species).

Despite of the lack of significant differences between varieties of winter rye, the results indicate a trend of some varieties: Dańkowskie Gold, Daran and Bosmo to stronger competition with weeds. The results are not conclusive, as in the case of certain varieties significant interaction was indicated, that is a different reaction of varieties to weeds in locations. In our study, there were no significant correlations between morphological features of rye varieties, such as the height and tillering and the level of infestation. Such relationships were found in studies of winter wheat cultivars grown under organic system [18]. Earlier observations indicated that the reason of the differences in competitive abilities of cereal varieties against weeds could be also plant density, leaf area, leaf angle and other features that were not included in this study [9, 18].

In assessment of the suitability of cereal varieties for cultivation in organic farming system the yielding potential should be also taken into account. The results obtained during the two years of research indicate that regardless of the location of the experiment in group of high yielding varieties were Bosmo and Walet which were also characterized

by a small weed infestation level. The dry matter of weeds on the level of 55 g·m⁻² on average in the case of most varieties of rye probably did not significantly affect grain yield. Other study shows that in the case of spring wheat only weed infestation more than 60 g·m⁻² can affect significantly grain yield [19]. This is confirmed by the results of Kapeluszný [20], which observed the significantly decline of spring wheat yield under weed infestation of 187 seedlings per 1 m² in the tillering stage and 96 pcs·m⁻² (62 g·m⁻²) before harvest. The competitiveness of rye varieties in relation to weeds and grain yield is affected by many factors so the research should be conducted for more than two years to obtain information about the suitability of varieties for cultivation in organic farming.

5. Conclusions

1. Weed abundance in rye canopies in dough stage was big, 235 pcs·m⁻² on average, but their dry matter was on the level of 55 g·m⁻² on average.
2. The varieties of rye did not differ significantly due to the number of weeds, based on means from 2 years and locations, except of summer and winter sown Bojko variety.
3. Different reactions of rye varieties in relation to weeds in locations were observed. The most competitive varieties according to dry matter of weeds in dough stage were in Grabów: Dańkowskie Złote, Daran and Walet, whereas in Taraskowo: Bosmo, Dańkowskie Diament and Rostockie.
4. There were no significant correlations between the level of infestation and morphological features of rye varieties: height and tillering.
5. The observed level of weed infestation did not significantly affect grain yield of tested rye varieties.

6. References

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