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YIELDS OF OILSEED RAPE IN HABITAT CONDITIONS OF PODKARPACKIE PROVINCE

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A b s t r a c t: The objective of the study was the estimation of yields of winter oilseed rape, cultivar Visby F_1, in diversified habitat conditions of the Podkarpackie Province. The study showed that the average seed yield of winter oilseed rape amounted to 3.97 t ha^{-1}. The highest yields of oilseed rape were obtained in Przecław and Skołoszów. Yields obtained in Boguchwała were significantly lower, but only in relation to those obtained in Przecław. The lowest yields of oilseed rape were obtained in Nowy Lubliniec. Oilseed rape plants attained technical ripeness the earliest in Przecław and Nowy Lubliniec, as compared to those grown in Skołoszów and Boguchwała. In the years of the study oilseed rape plants did not suffer from frost bite, the poorest overwintering being noted in Przecław. Infestation with black spot of cruciferous plants was at similar levels in the particular localities. Fat content in the seeds did not depend significantly on the habitat conditions. The highest fat yield per hectare was obtained in Przecław, significantly lower in Skołoszów and Boguchwała, and the lowest in Nowy Lubliniec. Overwintering of oilseed rape plants was the poorest in the season of 2015/2016, but in spite of that the yield of seeds amounted to 4.07 t ha^{-1}. In the analysed years, oilseed rape plants attained their technical ripeness phase on similar dates. In 2015 fat content in seeds was the highest, nut fat yield per hectare was the lowest. In that year, the lowest level of infestation with black spot of coniferous plants was noted. On average, the highest seed yield and fat yield was obtained in 2017.

K e y w o r d s: *Brassica napus* L. ssp. *oleifera* Metzg., soil-climate conditions, crude fat, seed yield, fat yield

INTRODUCTION

Oilseed rape (*Brassica napus* L. ssp. *oleifera* Metzg.) is the most important oil bearing plant in Poland. In its cultivation, the winter form dominates over the spring form, mainly due to to higher yields. Statistical data (GUS, 2018) show that the average yields of oilseed rape in Poland amount to less than 3 t ha^{-1}. Whereas, the yielding potential of oilseed rape is considerably higher, but not always achieved in agricultural

practice (Bobrecka-Jamro *et al*. 2013). The level and quality of oilseed rape yields are affected by the cultivar (Weber *et al*. 2003, Bujak *et al*. 2008, Novickienė *et al*. 2010), cultivation technology (Kotecki *et al*. 2004, Wójtowicz 2004, Bartkowiak-Broda *et al*. 2005, Wielebski 2009a), and by the habitat conditions (Kaczmarek *et al*. 2003, Latusek and Bujak 2012). In the case of winter oilseed rape, the choice of cultivars is extensive, and the cultivation technology is well known and usually conducted at the intensive level (Jarecki *et al*. 2013, Hoppe and Wenda-Piesik 2018). Contemporary breeding of winter oilseed rape is aimed at the acquisition of cultivars with a high yielding potential and characterised by a high capacity for adaptation to diverse soil and climate conditions (Szała *et al*. 2015). Therefore, for cultivation one should select cultivars that are high yielding and tested in the given habitat conditions. The choice of cultivars is aided by published lists of cultivars recommended for a given province. Latusek and Bujak (2012) and Bujak *et al*. (2008) note that individual cultivars respond differently to the high level of cultivation technology, and in addition that is related to the interactions with particular localities and years of experiments. Studies conducted so far (Latusek and Bujak 2012, Kulig *et al*. 2012, Wójtowicz 2013, Skwaryło-Bednarz and Kotecki 2014) indicate that oilseed rape produces high yields, but in better soil--climate conditions. In less favourable conditions, oilseed rape yields are usually low. Weber *et al*. (2003) observed that genetic variation of cultivars becomes more apparent on better soils (class II or III), while on lighter soils the yields of the various cultivars are more uniform. Kaczmarek *et al*. (2003) and Ostovari *et al*. (2019) maintain that the diversified response of winter oilseed rape cultivars to changes in the soil-climate environment indicates the need for testing cultivars in many different environments to determine the kind of genotype-environment interaction.

The objective of the study was the comparison of yielding of a hybrid winter oilseed rape cultivar, Visby F_1, in relation to the diversified habitat conditions of the Podkarpackie Province.

MATERIAL AND METHOD

In the seasons of 2014/2015-2016/2017 a strict field experiment was set up, with winter oilseed rape cv. Visby F_1. The experiment was conducted at four localities in the Podkarpackie Province, at the variety testing experimental stations in Przecław (SDOO Przecław), Skołoszów (ZDOO Skołoszów), Nowy Lubliniec (ZDOO Nowy Lubliniec), and at the Podkarpacki Agricultural Advisory Centre in Boguchwała (PODR w Boguchwale). In Przecław, Skołoszów and Nowy Lubliniec the experiments were conducted within the framework of Post-registry Variety Testing.

The experiment was a single-factor one, conducted in four replicates. The hybrid cultivar Visby F_1 (Saaten Union Polska Sp. z o.o.) is suitable for cultivation in the Podkarpackie Province and produces a high and stable seed yield. The

humidity and temperature conditions are given according to the records from the Meteorological Station of the PODR in Boguchwała and from the Meteorological Stations of SDOO Przecław, ZDOO Skołoszów and ZDOO Nowy Lubliniec. Analysis of soil samples was performed at the accredited laboratory of the Regional Agricultural Chemical Station in Rzeszów, according to Polish standards. The soil conditions in which the experiment was conducted are presented in Table 1.

Table 1. Soil conditions (average for the years)

Parameter		PODR Boguchwała	SDOO Przecław	ZDOO Skołoszów	ZDOO Nowy Lubliniec
Agronomic category of soil		medium	medium	heavy	light
Soil suitability complex		good wheat	good wheat	very good wheat	good rye
Soil quality class		IIIa	IIIa	II	IVa
Soil pH in 1 M KCl		6.24	6.84	6.42	6.65
P_2O_5	mg 100 g^{-1} soil	18.3	18.7	19.6	19.0
K_2O		22.7	20.3	26.4	16.3
Mg		7.5	8.3	9.6	6.6

Oilseed rape cultivation was conducted in conformance with the methodology developed by the Research Centre for Cultivar Testing in Słupia Wielka. The surface area of an individual plot was 15 m^2. Row spacing was 25 cm, and sowing depth was 1.5-2 cm. The adopted sowing rate per unit of surface area was 50 seeds m^{-2}. The preceding crop was winter or spring cereals. Sowing was performed in the third decade of August. NPKMgS fertilisation was applied prior to sowing, at doses dependent on soil quality. In spring, before the start of vegetation, nitrogen fertilisation was applied (in ammonium form) 100 N kg ha^{-1} (20 BBCH), and in the phase of bud formation (in nitrate form) 70 N kg ha^{-1} (51 BBCH). In the course of vegetation, the plants were given supplemental fertilisation with a multi-component foliar-application fertiliser (PLONVIT RZEPAK: nitrogen, magnesium, sulphur and microelements). Weeds, diseases and pests were controlled throughout the vegetation season with the use of chemical plant protection agents applied in accordance to manufacturer's recommendations given on the label.

Plant overwintering (%) was calculated from the difference in the number of plants on the plot before winter and after the start of vegetation in spring. Infestation with black spot of cruciferous plants is given in the scale of 1-9°, where 9 denotes absence of the phenomenon. Estimation was conducted at the moment of the highest intensity of the disease on the leaves and pods. Technical ripeness is specified in the number of days from sowing to attaining the phase 87 BBCH.

Seed harvest was conducted in a single stage, in the phase of full ripeness, in the second or third decade of July. Seed yield from a plot was converted to the area of 1 ha, adopting seed moisture as 9% DM. Fat content in the seeds was determined with the Soxhlet method. The biological yield of crude fat per unit of surface area was calculated on the basis of the value of seed yield and of the seed content

of fat. The results obtained were processed statistically by means of the analysis of variance. Significance of differences between mean values was tested on the basis of Tukey's semi-intervals of confidence, at significance level of $\alpha = 0.05$. The calculations were made using the statistical software ANALWAR–5.3.FR.

RESULTS AND DISCUSSION

In Boguchwała, Przecław and Skołoszów, the highest precipitation total was noted in the season of 2016/2017, and the lowest in the season of 2014/2015 (Tables 2, 3, 4). In Nowy Lubliniec, the highest precipitation total was noted in the season of 2015/2016 and the lowest in the season of 2016/2017. Mean air temperatures were the highest in the season of 2015/2016, and the lowest in the season of 2016/2017. In 2015, oilseed rape sowing and emergence were hindered due to little rainfalls. In the autumn of each year, air temperatures decreased gradually, which had a beneficial effect on plant hardening before the winter. In the analysed vegetation seasons, the course of weather conditions during the winter period was favourable, the poorest overwintering being noted in Przecław. Seed harvest was generally conducted in favourable weather conditions. Only in July 2016 seed harvest was more difficult in Przecław, due to intensive rains.

Table 2. Weather conditions in the season of 2014/2015

Month	Precipitation totals (mm)				Mean air temperatures (°C)			
	PODR Boguchwała	SDOO Przecław	ZDOO Skołoszów	ZDOO Nowy Lubliniec	PODR Boguchwała	SDOO Przecław	ZDOO Skołoszów	ZDOO Nowy Lubliniec
VIII	65	102	72	102	18.8	17.6	18.6	18.3
IX	49	40	42	45	15.0	14.5	15.2	14.3
X	36	33	38	41	9.7	9.4	10.4	9.6
XI	9	9	18	22	5.4	5.4	5.4	4.7
XII	26	30	28	33	1.1	0.6	1.5	0.5
I	37	34	39	42	0.7	1.0	0.8	0.2
II	12	9	12	13	1.4	0.2	0.7	0.5
III	40	44	33	47	4.4	4.4	5.3	4.2
IV	31	25	24	49	8.8	8.3	8.7	7.6
V	92	110	64	96	13.1	12.4	13.1	12.4
VI	9	30	20	12	17.9	16.5	17.8	16.9
VII	65	100	114	86	20.5	19.7	20.4	19.6
Total	471	566	504	588	9.7	9.2	9.8	9.1

Wójtowicz (2005) reports that the environmental conditions have the strongest impact on the level of oilseed rape seed yields, since the environment affects the main yield components to a greater degree than nitrogen fertilisation and the

cultivar. Wójtowicz (2004) observed that the primary factor limiting the yielding of individual winter oilseed rape cultivars is rainfalls. In the aspect in question, Bocianowski *et al*. (2017) demonstrated a higher productivity of selected hybrid cultivars of oilseed rape, as well as their better adaptation to variable environmental conditions, especially drought. Chmura *et al*. (2016) demonstrated that the weather conditions also have an impact on the quality of oilseed rape seeds. Optimal for fat

Table 3. Weather conditions in the season of 2015/2016

Month	Precipitation totals (mm)				Mean air temperatures (°C)			
	PODR Boguchwała	SDOO Przecław	ZDOO Skołoszów	ZDOO Nowy Lubliniec	PODR Boguchwała	SDOO Przecław	ZDOO Skołoszów	ZDOO Nowy Lubliniec
VIII	22	8	14	13	22.3	21.0	21.2	21.3
IX	56	92	62	72	15.7	14.8	16.6	15.7
X	38	50	41	55	7.6	7.1	7.8	7.3
XI	110	64	58	74	5.3	4.9	5.8	4.8
XII	15	15	9	17	3.1	3.2	4.9	2.8
I	31	32	27	55	2.9	–2.6	–2.8	–3.9
II	65	78	59	51	4.1	4.0	5.0	3.8
III	39	39	38	35	4.5	4.7	4.7	4.1
IV	59	55	54	77	9.8	9.8	10.4	9.9
V	34	42	33	63	13.9	14.1	13.9	13.6
VI	39	24	31	56	18.7	18.6	18.4	18.4
VII	103	152	110	99	19.2	19.0	20.0	19.4
Total	611	651	536	667	10.1	9.9	10.5	9.8

Table 4. Weather conditions in the season of 2016/2017

Month	Precipitation totals (mm)				Mean air temperatures (°C)			
	PODR Boguchwała	SDOO Przecław	ZDOO Skołoszów	ZDOO Nowy Lubliniec	PODR Boguchwała	SDOO Przecław	ZDOO Skołoszów	ZDOO Nowy Lubliniec
VIII	59	68	57	38	17.9	17.6	18.7	18.3
IX	40	45	72	40	15.4	14.7	15.9	15.0
X	119	91	154	96	7.5	7.2	7.5	6.9
XI	36	98	67	49	3.5	3.6	3.2	2.3
XII	50	33	34	47	–0.7	0.6	0.2	–1.2
I	4	14	16	23	–6.0	–6.2	–5.1	–7.2
II	28	21	26	29	0.3	–0.3	–0.5	–1.1
III	37	38	30	31	6.2	5.9	6.4	5.7
IV	55	78	43	37	8.2	7.5	8.7	7.5
V	86	112	68	41	13.5	13.7	13.4	12.8
VI	41	42	49	45	18.4	18.7	18.1	17.9
VII	95	44	43	78	18.7	18.4	18.7	18.6
Total	650	684	659	554	8.6	8.5	8.8	8.0

accumulation in seeds are high rainfalls in the period of December-March, in April and May, with the accompanying higher air temperatures. In turn, lower rainfalls and lower temperature in those periods lead to higher protein content in seeds.

The average seed yield of winter oilseed rape in the experiment was 3.97 t ha^{-1} (Table 5). The highest oilseed rape yields were obtained in Przecław and Skołoszów. Seed yield in Boguchwała was significantly lower than that obtained in Przecław. Significantly the lowest was the seed yield obtained in Nowy Lubliniec. The mean seed yield difference between Przecław and Nowy Lubliniec was 1.92 t ha^{-1}. The weather conditions modified oilseed rape yields in the analysed years. In 2015 the yield was the lowest, while in 2017 the highest. The difference between those years was 1.14 t ha^{-1}. It should be mentioned that in Skołoszów high seed yields were obtained in 2016, and in the other localities in 2017.

Table 5. Oilseed rape seed yields (t ha^{-1})

Locality	2015	2016	2017	Mean
PODR Boguchwała	3.22	4.11	4.85	4.06
SDOO Przecław	3.58	5.12	5.32	4.67
ZDOO Skołoszów	3.68	4.88	4.58	4.38
ZDOO Nowy Lubliniec	2.90	2.16	3.20	2.75
$LSD_{0.05}$	0.28	0.56	0.62	0.48
Mean	3.35	4.07	4.49	3.97

Kaczmarek *et al*. (2003) and Skwaryło-Bednarz and Kotecki (2014), conducting studies on winter oilseed rape, found that the yields of the individual cultivars depended to a greater extent on the atmospheric conditions than on the potential productivity of soils. Also Kulig *et al*. (2012) report that the yielding of oilseed rape is strongly dependent on habitat conditions. Those authors obtained significantly higher yields of seeds of winter oilseed rape in better habitat conditions (Głubczyce), in relation to less favourable conditions (Pawłowice). Yields of oilseed rape seeds in the experiment conducted by the cited authors oscillated in the range of 5.37-5.92 t ha^{-1}. In another study, Kulig *et al*. (2010) demonstrated that the seed yield of population cultivars of oilseed rape is strongly dependent on habitat conditions, and additionally on the interaction of cultivars and years of study. Seed yields obtained by those authors ranged from 2.18 to 7.08 t·ha^{-1}. Wójtowicz and Czernik-Kołodziej (2003) report that the difference between the highest and the lowest yielding cultivar of winter oilseed rape can amount to over 20%. Gehringer *et al*. (2007) observed that in poorer soil conditions hybrid cultivars of oilseed rape, that uptake nutrients from the soil more effectively, will be more suitable for cultivation.

There was relatively little variation in the run of vegetation of winter oilseed rape plants in the localities under study. Technical ripeness of the plants was noted earlier in Przecław and Nowy Lubliniec, compared to Skołoszów and Boguchwała. In the years of the study, oilseed rape plants entered that development phase on a similar date. Overwintering of the plants was the poorest in Przecław, which has

been proven statistically. In spite of that, seed yields in that locality were satisfactory. This indicates a high regeneration-compensation capacity of oilseed rape plants. The worst year in terms of oilseed rape plants overwintering was 2016. Infestation with black spot of cruciferous plants was at a fairly stable level in the localities under study. A lower intensity of the diseases was noted in 2015, compared to 2016 and 2017. Fat content in seeds did not depend significantly on the habitat conditions. The highest fat content was determined in seed from the harvest of 2015. Fat yield per hectare was the highest in Przecław. Lower values were obtained in Skołoszów and Boguchwała, and the lowest in Nowy Lubliniec. Fat yield levels varied in the years of the study. The highest fat yields were produced by oilseed rape in 2017, and the lowest in 2015. The difference in fat yields between those years was 511.4 kg ha^{-1} (Table 6).

Table 6. Comparison of selected results in the localities and years of the study (mean)

Specification	Technical ripeness (days from date of sowing)	Overwintering (%)	Black spot of cruciferous plants (scale 1-9°)	Fat content in seeds (% DM)	Fat yield (kg ha^{-1})
PODR Boguchwała	314	89.0	7.8	47.4	1924.4
SDOO Przecław	310	75.7	7.9	48.5	2265.0
ZDOO Skołoszów	313	95.7	8.0	47.6	2084.9
ZDOO Nowy Lubliniec	310	98.3	7.9	48.0	1320.0
$LSD_{0.05}$	n.s.	11.33	n.s.	n.s.	172.38
2014/2015	313	93.3	8.6	48.8	1634.8
2015/2016	311	85.8	7.6	47.0	1912.9
2016/2017	312	90.0	7.5	47.8	2146.2

n.s. – not significant

In a study by Wielebski (2009a), the morphological features of plants before the harvest and the elements of the yield structure were dependent primarily on the habitat conditions and on the genetic traits of the cultivars, and only to a small degree on the level of cultivation technology. Wójtowicz (2005) reports that in the conditions of long-term water deficit, the yields of winter oilseed rape were significantly correlated with the number of plants on a unit of surface area and with the number of seeds in a pod. Whereas, with a uniform distribution of rainfalls in the period of spring-summer vegetation of plants, a significant correlation was found between the yield and the number of seeds in a pod.

A study by Wójtowicz and Czernik-Kołodziej (2003) shows that the yields of fat and protein of winter oilseed rape depend mainly on seed yield, and not on the content of those components in the seeds. In the aspect in question, Nogala-Kałucka *et al*. (2002) report that seeds of oilseed rape acquired from various cultivars and regions did not differ much in terms of their content of fat which was determined,

on average, at the level of 42% DM. In turn, the content of protein in seed samples from various regions, and also from selected cultivars, oscillated at the level of 19.3-21.7% DM. Wielebski (2009b) demonstrated that seeds of the analysed forms of oilseed rape grown in Łagiewniki, compared to seeds from Zielęcin, had a significantly higher content of fat (by 4.2 percentage points), and a lower content of protein (by 2 percentage points). Tańska and Rotkiewicz (2003) point out that the quality of oilseed rape seeds after harvest is determined by factors related with the post-harvest processing, and especially seed cleaning, drying and storage. They can cause such a deterioration in the technological quality of seeds that they can be considered as the critical points in the production or oilseed rape as an oil-bearing raw material.

CONCLUSIONS

1. The average seed yield of winter oilseed rape was 3.97 t ha^{-1}. The highest yields were obtained in Przecław and Skołoszów. In Boguchwała the yield was lower than in Przecław, and the lowest yield was obtained in Nowy Lubliniec. The effect of soil conditions on the yielding of winter oilseed rape was evident especially in years with favourable weather conditions.

2. Oil seed rape plants attained their technical ripeness earlier in Przecław and Nowy Lubliniec, relative to plants grown in Skołoszów and Boguchwała. The highest losses of plants after the winter were noted in Przecław. Infestation with black spot of cruciferous plants was at similar levels in all localities.

3. Fat content in seeds was not significantly modified by the habitat conditions. The highest fat content was obtained in Przecław, and the lowest in Nowy Lubliniec.

4. The poorest overwintering of plants was noted in the season of 2015/2016. In 2015 the yields of seeds and fat were the lowest, and in 2017 the highest. In 2015 the highest level of infestation with black spot of cruciferous plants was noted, and the highest fat content in seeds was determined. Plants of winter oilseed rape attained the phase of technical ripeness on similar dates in the years of the study.

Conflict of interest: The Authors does not declare conflict of interest.

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