YIELD OF WINTER OILSEED RAPE CULTIVARS DEPENDING ON INTENSITY OF CULTIVATION PRACTICES

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Abstract. In the seasons 2008/2009-2010/2011 a strict field experiment was conducted aiming at the estimation of response of winter oilseed rape hybrid cultivars to different cultivation intensity. It was found that a higher level of cultivation technology in comparison with the lower affected a significant increase in the seed yield by 0.5 Mg·ha⁻¹, i.e. 11.9%. This resulted from a significant increase in the number of pods per plant and thousand seed weight. Plant density before harvest per 1 m² and the number of seeds per pod showed only an upward tendency. Higher level of cultivation technology did not modify significantly the content of protein and fat in seeds. However, fat yield per 1 ha was significantly diversified. The cultivar Exotic F₁ was characterized by significantly higher parameters of such features as: overwintering, the number of seeds per pod and TSW. The cultivar Visby F₁ in turn was characterized by a significantly higher number of pods per plant and a higher fat yield.

Key words: Brassica napus, hybrid cultivar, level of cultivation technology, yield components

INTRODUCTION

Among oil crops, oilseed rape should be regarded as a strategic species for the Polish agriculture. For this reason, research on its new cultivation technologies should be directed towards a higher utilization of biological progress, favourable effects of cultivation practices on the soil environment and improvement of economic effects of growing [Święcicki et al. 2011].

In Europe there is a growing increase in the number of oilseed rape hybrid cultivars registered, as well as in the area where these cultivars are grown. Hybrids introduced into cultivation are characterized not only by a higher productivity in comparison with the best open-pollinated cultivars but also by a better uniformity. Due to even maturing,
also less losses are observed during their harvesting, and the raw material obtained for oil industry is of a better quality. Thanks to their dynamic development in autumn, hybrid plants also use nutrients from soil more efficiently [Liersch et al. 2000]. In spite of the large yield potential of the currently grown cultivars, oilseed rape yields in Poland remain on a low level. Even under favourable conditions, farmers use about 60% of yield-forming abilities of oilseed rape. The main reason for this is insufficient plant nutrition while building the basis for the yield structure, when the final number of lateral shoots is established. This is a case which can take place also on farms that generally harvest large yields [Grzebisz et al. 2010].

According to Budzyński et al. [2005] oilseed rape growing should be carried out in the high-outlay system. Also the studies within the framework of post-register varietal experimentation are carried out on the so-called intensive level of cultivation technology. The yield level of winter oilseed rape observed in the post-register varietal experimentation most frequently stays within the range 3-6 ton of seeds per 1 ha. In the study by Dobek [2005] on the production technologies of winter oilseed rape, the one where simplifications in tillage were introduced turned out to be the most effective in respect of economy and energy.

It should be noted that the EU Directive which obligates the introduction of integrated plant protection principles from 2014 will enforce introduction of limitations in cultivation intensification. Therefore studies aiming at propagating the cultivars resistant to main pathogens and the use of good agricultural practices are of the utmost importance. Thus the genotypes which require less chemical protection should be identified [Seta and Mróczynski 2006, Seta et al. 2007, Święcicki et al. 2011]. Currently used cultivation methods should guarantee for only obtaining high yields but also provide the proper quality of harvested seeds. The quality of oilseed rape yield is determined mainly by the fat and protein content in seeds and the presence of harmful sulphur compounds called glucosinolates. Of the cultivation factors, mineral fertilization, particularly with nitrogen, has the highest effect on the quality of harvested seeds [Wielebski 2009b].

The aim of this study was to estimate the effect of diversified cultivation intensity on the height and quality of yield of winter oilseed rape hybrid cultivars.

**MATERIAL AND METHODS**

The strict experiment with winter oilseed rape was carried out in the seasons 2008/2009-2010/2011. It was located in the experimental fields of the Podkarpacki Agricultural Advisory Centre at Boguchwała (49°98’ N; 21°95’ E) near Rzeszów. It was a two-factorial experiment conducted in four replications. The experiment was established in brown soil, classified as the good wheat complex, soil quality class IIIa. It was characterized by a very high content of phosphorus and potassium, high or average of magnesium and an average content of microelements, except for boron. The first factor was the diversified cultivation intensity: A level (moderate intensity) and B level (high intensity) and the other factor was the hybrid cultivars Exotic F₁ and Visby F₁. The studied cultivars are characterized by a high an stable yield in the whole country. The cultivar Exotic F₁ was bred by the company Monsanto Technology LLC, whereas the cultivar Visby F₁ by Norddeutsche Pflanzenzucht Hans-Georg Lembke KG.
The planned density after germination was 60 szt.·m\(^{-2}\), the row spacing amounted to 20 cm, and the sowing density 2 cm. The previous crop was spring barley, and sowing was performed on the last 10 days of August each year. The area of plots was 15 m\(^2\) (for harvesting 12 m\(^2\)). Diversification of cultivation practices depending on the level of cultivation intensity was presented in Table 1.

<table>
<thead>
<tr>
<th>Cultivation practice</th>
<th>(A) moderately intensive</th>
<th>(B) highly intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen fertilization – Ammonium nitrate 34%</td>
<td>120 kg·ha(^{-1})</td>
<td>170 kg·ha(^{-1})</td>
</tr>
<tr>
<td>Insecticide – Decis 2.5 EC (deltamethrin)</td>
<td>0.2 dm(^3)·ha(^{-1})</td>
<td>0.2 dm(^3)·ha(^{-1})</td>
</tr>
<tr>
<td>Insecticide – Mospilan 20 SP (acetamiprid)</td>
<td>–</td>
<td>120 g·ha(^{-1})</td>
</tr>
<tr>
<td>Herbicide – Butisan Star 416 SC (metazachlor, chinomerek)</td>
<td>3 dm(^3)·ha(^{-1})</td>
<td>3 dm(^3)·ha(^{-1})</td>
</tr>
<tr>
<td>Herbicide – Lontrel 300 SL (clopyralid)</td>
<td>0.4 dm(^3)·ha(^{-1})</td>
<td>0.4 dm(^3)·ha(^{-1})</td>
</tr>
<tr>
<td>Fungicide – Horizon 250 EW (tebuconazole)</td>
<td>1.25 dm(^3)·ha(^{-1})</td>
<td>1.25 dm(^3)·ha(^{-1})</td>
</tr>
<tr>
<td>Fungicide – Caramba 60 SL (metconazole)</td>
<td>–</td>
<td>1 dm(^3)·ha(^{-1})</td>
</tr>
<tr>
<td>Foliar application – Basfoliar 36 Ex</td>
<td>–</td>
<td>10 dm(^3)·ha(^{-1})</td>
</tr>
<tr>
<td>Growth regulator – Spodnam DC (di-1-P-menten-555)</td>
<td>–</td>
<td>1.2 dm(^3)·ha(^{-1})</td>
</tr>
</tbody>
</table>

Fungicide Caramba 60 SL was applied at the green bud stage (BBCH 51), whereas Horizon 250 EW – at the stage of shedding the first flower petals (BBCH 65). Spodnam DC was applied without desiccation, since most pods had the greenish-yellowish colour. The preparation Decis 2.5 EC was used twice – at the beginning of budding (BBCH 52) and at full budding (BBCH 55), whereas Mospilan 20 SP – at the stage of end of budding (BBCH 59).

Mineral PK fertilization was performed under per-sow ploughing and it amounted to: 34.9 kg·ha\(^{-1}\) P and 99.6 kg·ha\(^{-1}\) K. Nitrogen fertilization was applied with division into one autumn and two spring rates.

During the oilseed rape growing, observations of the plant growth and development were conducted. These involved the following: emergences, budding, flowering and maturity (technical and full). Plant density per 1 m\(^2\) was calculated at the full emergences stage and before harvest.

At the technical maturity stage, 20 representative plants were collected from each plot and the following yield components were determined: the number of pods per plant, the number of seeds per pod and the thousand seed weight (at a humidity of 9%).

One-phase harvest of oilseed rape was performed on the dates: 10.07.2009, 12.07.2010 and 08.07.201. The seed weight obtained from the plots was converted into the yield per 1 ha, assuming a humidity of 15%. Seeds for chemical analyses were obtained during the harvest from each combination and there were determined as follows: crude fat – with the Soxhlet method and total protein (based on the nitrogen content) – with the Kjeldahl method. Based on the obtained seed yield and the fat content in them, the crude fat yield per an area unit was calculated.

The obtained results were analysed statistically using the analysis of variance (according to the split-plot model). Tukey’s multiple range test was used to test differences between the treatment means. The calculations were made using the statistic software ANAWAL-5FR.
The weather conditions were given according to the Podkarpacki Agricultural Advisory Centre at Boguchwał. The analysis of soil samples was made at the Regional Chemical and Agricultural Station in Rzeszów.

RESULTS AND DISCUSSION

Low temperatures in the winter 2010/2011 contributed to increased freezing of oilseed rape. Winter losses of plants at that time accounted for 21.7%, and the density after the winter – 44 plants·m⁻² (Table 2, 3).

Table 2. Monthly total precipitation and mean air temperatures in 2008-2011 acc. to records of the meteorological point at the Podkarpacki Agricultural Advisory Centre in Boguchwał

<table>
<thead>
<tr>
<th>Month</th>
<th>Precipitation, mm</th>
<th>Mean temperature, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>August</td>
<td>55.3</td>
<td>21.8</td>
</tr>
<tr>
<td>September</td>
<td>103.2</td>
<td>25.5</td>
</tr>
<tr>
<td>October</td>
<td>56.0</td>
<td>88.2</td>
</tr>
<tr>
<td>November</td>
<td>25.2</td>
<td>58.7</td>
</tr>
<tr>
<td>December</td>
<td>47.9</td>
<td>46.1</td>
</tr>
<tr>
<td>January</td>
<td>24.9</td>
<td>38.9</td>
</tr>
<tr>
<td>February</td>
<td>38.9</td>
<td>48.8</td>
</tr>
<tr>
<td>March</td>
<td>8.0</td>
<td>22.3</td>
</tr>
<tr>
<td>April</td>
<td>3.7</td>
<td>49.9</td>
</tr>
<tr>
<td>May</td>
<td>102.6</td>
<td>177.0</td>
</tr>
<tr>
<td>June</td>
<td>146.4</td>
<td>126.1</td>
</tr>
<tr>
<td>July</td>
<td>98.0</td>
<td>200.2</td>
</tr>
</tbody>
</table>

Table 3. Effect of studied factors on plant density: a, b, d [plants·m⁻²] and overwintering: c [%]

<table>
<thead>
<tr>
<th>Specification</th>
<th>Full emergences</th>
<th>Start of growth</th>
<th>Overwintering</th>
<th>Before harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
</tr>
<tr>
<td>(A) moderately intensive</td>
<td>55</td>
<td>45</td>
<td>81.8</td>
<td>42</td>
</tr>
<tr>
<td>(B) highly intensive</td>
<td>57</td>
<td>48</td>
<td>84.2</td>
<td>44</td>
</tr>
<tr>
<td>LSDₐ₁₀, I</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>Exotic F₁</td>
<td>54</td>
<td>47</td>
<td>87.0</td>
<td>45</td>
</tr>
<tr>
<td>Visby F₁</td>
<td>58</td>
<td>46</td>
<td>79.3</td>
<td>41</td>
</tr>
<tr>
<td>LSDₐ₁₀, II</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>LSDₐ₁₀, I × II</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>2008/2009</td>
<td>55</td>
<td>49</td>
<td>89.1</td>
<td>46</td>
</tr>
<tr>
<td>2009/2010</td>
<td>53</td>
<td>44</td>
<td>83.0</td>
<td>39</td>
</tr>
<tr>
<td>2010/2011</td>
<td>60</td>
<td>47</td>
<td>78.3</td>
<td>44</td>
</tr>
<tr>
<td>LSDₐ₁₀, years</td>
<td>5.56</td>
<td>4.45</td>
<td>8.36</td>
<td>5.95</td>
</tr>
</tbody>
</table>

ns – non-significant differences

Restarting of growth took place annually between 10th and 20th March. In 2010, evenly distributed precipitation and moderate temperatures during the spring-summer growth favoured the plant development. In contrast, a considerable rainfall deficit was recorded in April 2009 and the low total precipitation occurred in May 2011. Wójtowicz [2005] reports that the lack of rainfall in the course of flowering reduces the number of
pods per plant, and in the period of maturing it limits the 1000 seed weight. The consequence of this relationship is a reduction in yield. Kotecki et al. [2004] also stress that oilseed rape belongs to species heavily responding to changing climatic conditions, which is proved by the obtained differences in yields, both qualitative and quantitative, in individual years.

The duration of individual developmental stages was diversified in the years of the study. The full emergences were recorded after 11-15 days from the date of sowing the seeds. The beginning of budding occurred after 219-224 days, whereas the beginning of flowering after 232-238 days from sowing the seeds. The shortest period of growth was recorded in the season 2010/2011, whereas the longest in the season 2009/2010 (Table 4).

The level of cultivation technology diversified the spring-summer development of plants, prolonging the budding, flowering and maturing stages. Similar results were obtained by Wielebski [2009a], who recorded a delay in the beginning of oilseed rape flowering, using higher rates of nitrogen fertilization.

Table 4. Number of days to achieve particular developmental stages of plants

<table>
<thead>
<tr>
<th>Specification</th>
<th>Emergences (BBCH 10)</th>
<th>Budding beginning (BBCH 51)</th>
<th>Flowering beginning (BBCH 61)</th>
<th>Flowering end (BBCH 69)</th>
<th>Maturity beginning technical (BBCH 87)</th>
<th>Maturity full (BBCH 89)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) moderately intensive</td>
<td>13</td>
<td>219</td>
<td>232</td>
<td>261</td>
<td>311</td>
<td>320</td>
</tr>
<tr>
<td>(B) highly intensive</td>
<td>13</td>
<td>225</td>
<td>238</td>
<td>269</td>
<td>317</td>
<td>326</td>
</tr>
<tr>
<td>Exotic F1</td>
<td>14</td>
<td>224</td>
<td>236</td>
<td>266</td>
<td>315</td>
<td>324</td>
</tr>
<tr>
<td>Visby F1</td>
<td>12</td>
<td>220</td>
<td>234</td>
<td>264</td>
<td>313</td>
<td>322</td>
</tr>
<tr>
<td>2008/2009</td>
<td>11</td>
<td>224</td>
<td>235</td>
<td>265</td>
<td>312</td>
<td>322</td>
</tr>
<tr>
<td>2009/2010</td>
<td>15</td>
<td>221</td>
<td>238</td>
<td>267</td>
<td>318</td>
<td>327</td>
</tr>
<tr>
<td>2010/2011</td>
<td>13</td>
<td>221</td>
<td>232</td>
<td>263</td>
<td>312</td>
<td>320</td>
</tr>
</tbody>
</table>

Plant emergences were uniform, and the number of plants after emergences in 2008 and 2009 was slightly lower than that planned. Larger losses of plants after the winter and before harvesting were recorded for the cultivar Visby F1 than for the cultivar Exotic F1 (Table 3). The cultivation technology did not significantly modify the plant density.

Under conditions of good and even water supply during the spring growth, Jankowski and Budzynski [2007] observed that sparse sowings (60 seeds per 1 m²), ensuring the stand density in the course of maturing on a level of 46 plants per 1 m², were the best. In hybrid cultivars, they obtained the plant density the most favourable for the yield when sowing 60 and 120 seeds per 1 m². After increasing the seeding rate up to 180 seeds per 1 m², they observed a decrease in the seed yield by 230 kg per 1 ha (Kaszub F1z) and 325 kg per 1 ha (Kronos F1). Sowing 120-180 seeds per 1 m² in turn guaranteed the highest yield only in the open-pollinated cultivar Contact. Wielebski [2005] reports that apart from the plant density, the yield of compound hybrids is also determined by a large number of pods filled with well formed seeds.

A higher level of cultivation technology affected a significant increase in the number of pods per plant and TSW, whereas it had no effect on the number of seeds per pod. The cultivar Visby F1 had a significantly larger number of pods, whereas a smaller number of seeds per pod and TSW in comparison with the cultivar Exotic F1 (Table 5).
Table 5. Yield components of seeds per one rape plant (means for factors)

<table>
<thead>
<tr>
<th>Cultivation level</th>
<th>Cultivation</th>
<th>Number of siliques per plant</th>
<th>Number of seeds per silique</th>
<th>Thousand seed weight, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) moderately intensive</td>
<td>Exotic F₁</td>
<td>111</td>
<td>25.0</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>Visby F₁</td>
<td>121</td>
<td>22.0</td>
<td>3.9</td>
</tr>
<tr>
<td>mean for A</td>
<td></td>
<td>116</td>
<td>23.5</td>
<td>4.2</td>
</tr>
<tr>
<td>(B) highly intensive</td>
<td>Exotic F₁</td>
<td>119</td>
<td>27.0</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>Visby F₁</td>
<td>127</td>
<td>24.0</td>
<td>4.4</td>
</tr>
<tr>
<td>mean for B</td>
<td></td>
<td>123</td>
<td>25.5</td>
<td>4.6</td>
</tr>
<tr>
<td>Mean for cultivar</td>
<td>Exotic F₁</td>
<td>115</td>
<td>26.0</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>Visby F₁</td>
<td>124</td>
<td>23.0</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>Long-term mean</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>119.5</td>
<td>24.5</td>
<td>4.4</td>
</tr>
<tr>
<td>LSD₀.₀₅ for:</td>
<td>cultivation level</td>
<td>6.2</td>
<td>r.n.</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>cultivar</td>
<td>8.6</td>
<td>2.9</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>cultivation level × cultivar</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

ns – non-significant differences

The study by Wójtowicz [2005] indicated that the environmental conditions had the largest impact on the height of winter oilseed rape seed yield. They had a larger effect on the number of pods per plant and per an area unit as well as on 1000 seed weight, than nitrogen fertilization and the cultivar. Also in the study by Wielebski [2009a], a different level of cultivation technology hardly affected morphological features of plants before harvesting (the plant height, the number of branches and degree of plant lodging) and yield components (the number of pods per plant, the number and weight of seeds per pod, and thousand seed weight). Kotecki et al. [2005] in turn found that the use of intensive cultivation technology of oilseed rape caused an increase in the number of pods per plant by 12%, the number of seeds per pod by 8% and the plant height in comparison with the standard, which resulted in an increase in the seed yield by 13%, the crude fat yield by 7% and the total protein by 22%. Kotecki et al. [2004] also report that morphological features depend not only on the genotype but they are also modified by the course of the weather. Wielebski [2009a], when comparing winter oilseed rape cultivars, observed that the number of pods per plant, the number of seeds per pod and 1000 seed weight are genotypic features. As compared with the open-pollinated cultivar (Bojan), the hybrid cultivars formed more pods on the plant, in which there were less seeds, but with a larger weight.

The results of the present study confirmed that after the application of a highly intensive technology a significant increase in the seed yield is obtained as compared with a moderately intensive technology. A mean difference in the period of this study amounted to 0.5 Mg·ha⁻¹, i.e. 11.9%. The studied cultivars yielded on the same statistical level. Only in the season 2010/2011 the cultivar Visby F₁ gave higher yields than the cultivar Exotic F₁ (Table 6). Wielebski [2009b] in the variant with an intensive level of cultivation technology obtained an increase in yield higher by 8% as compared with the standard combination, and differences between the years were 3-13%. The author also indicated the lack of significant cooperation of cultivars with the cultivation technology. In the study by Kotecki et al. [2004], all the studied factors had a significant effect on the seed yield, and an intensive level of cultivation technology contributed to an increase in the seed yield on average by 11%, as compared with the control.
Budzyński et al. [2005] found that the high-outlay technology was characterized by the highest productivity (on average 3.55 t·ha\(^{-1}\)). Reduction of outlays on technology resulted in a decrease in the seed yield by 13% (average-outlay technology) and 30% (low-outlay technology). In the study by Wójtowicz and Czernik-Kołodziej [2003], cultivars showed different degree of response to the level of cultivation technology intensity. In their experiment, increasing the cultivation intensity resulted in an increase in the seed yield by 8.1-13.9%, whereas the fat and protein yields were mainly dependent on seed yield.

Table 6. Seed yield, Mg·ha\(^{-1}\)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) moderately intensive</td>
<td>Exotic F(_1)</td>
<td>4.0</td>
<td>3.8</td>
<td>4.2</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>Visby F(_1)</td>
<td>4.3</td>
<td>4.1</td>
<td>4.8</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>mean for A</td>
<td>4.2</td>
<td>4.0</td>
<td>4.5</td>
<td>4.2</td>
</tr>
<tr>
<td>(B) highly intensive</td>
<td>Exotic F(_1)</td>
<td>4.5</td>
<td>4.3</td>
<td>5.0</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>Visby F(_1)</td>
<td>4.7</td>
<td>4.6</td>
<td>5.1</td>
<td>4.8</td>
</tr>
<tr>
<td></td>
<td>mean for B</td>
<td>4.6</td>
<td>4.5</td>
<td>5.1</td>
<td>4.7</td>
</tr>
<tr>
<td>Mean for cultivar</td>
<td>Exotic F(_1)</td>
<td>4.3</td>
<td>4.1</td>
<td>4.6</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>Visby F(_1)</td>
<td>4.5</td>
<td>4.4</td>
<td>5.0</td>
<td>4.6</td>
</tr>
<tr>
<td>Long-term mean</td>
<td></td>
<td>4.4</td>
<td>4.2</td>
<td>4.8</td>
<td>4.5</td>
</tr>
</tbody>
</table>

LSD\(_{0.05}\) for:

<table>
<thead>
<tr>
<th>source</th>
<th>LSD(_{0.05})</th>
</tr>
</thead>
<tbody>
<tr>
<td>cultivation level</td>
<td>0.35 0.46 0.55 0.42</td>
</tr>
<tr>
<td>cultivar</td>
<td>ns ns 0.35 ns</td>
</tr>
<tr>
<td>cultivation level × cultivar</td>
<td>ns ns ns ns</td>
</tr>
</tbody>
</table>

ns – non-significant differences

Kulig et al. [2010, 2012] report that in their study the yield of rape was strongly dependent on the environmental conditions. A significantly higher seed yield was obtained under more favourable conditions, when the seed yields of the hybrid (restored) cultivars stayed within the range 5.37-5.92 Mg·ha\(^{-1}\). A very strong impact of the weather conditions on oilseed rape seed yield is confirmed by Wielebski [2009a] and Liersch et al. [2000]. Weber et al. [2003] obtained large differences in yields of cultivars under conditions of intensive and standard variants of cultivation. The cultivar Buffalo, Lisek and Bristol were characterized by significantly higher yields in both cultivation systems.

High seed yields of oilseed rape (5.05-6.70 Mg·ha\(^{-1}\)) were also obtained in the study by Jankowski and Budzyński [2007]. They were relatively the highest in the years when the conditions for overwintering were favourable and on the contrary, the lowest, under difficult overwintering conditions.

The level of cultivation technology did not have a significant effect on the protein and fat content in seeds of both studied oilseed rape cultivars. However, the fat yield was significantly higher in the variant with the intensive technology than in the variant with a lower intensity. The fat yield from seeds of the cultivar Visby F\(_1\) was significantly higher than the fat yield obtained from the cultivar Exotic F\(_1\) (Table 7).

Wójtowicz and Jajor [2006] report that nitrogen fertilization has a significant effect on the content of fat and protein in seeds. In their experiment, under the influence of growing nitrogen rates, the fat content in seeds decreased and the protein content increased. In the study of those authors, the protein content ranged from 18.0 to 19.5%
and the fat content from 44.4 to 46.0%. In the study by Wielebski [2009b] in turn the mean content of fat ranged from 38.6 to 44.2%, and the content of protein from 19.2 to 23.4%. The author observed significant differences in fat and protein contents as affected by the level of cultivation technology in the years when there was a large rainfall deficit at the stages of flowering and seed formation. In contrast, he observed the lack of response to the cultivation intensity in the year when there was a large amount of rainfall in the period of oilseed rape flowering and seed formation.

Table 7. Protein and fat content in seeds and biological yield of fat

<table>
<thead>
<tr>
<th>Cultivation level</th>
<th>Cultivar</th>
<th>Total protein, %</th>
<th>Crude fat, %</th>
<th>Fat yield, Mg·ha⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>(A) moderately intensive</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exotic F₁</td>
<td>20.5</td>
<td>45.6</td>
<td>1.82</td>
<td></td>
</tr>
<tr>
<td>Visby F₁</td>
<td>18.5</td>
<td>46.4</td>
<td>2.04</td>
<td></td>
</tr>
<tr>
<td>mean for A</td>
<td>19.5</td>
<td>46.0</td>
<td>1.93</td>
<td></td>
</tr>
<tr>
<td><em>(B) highly intensive</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exotic F₁</td>
<td>19.5</td>
<td>44.0</td>
<td>2.02</td>
<td></td>
</tr>
<tr>
<td>Visby F₁</td>
<td>20.7</td>
<td>44.4</td>
<td>2.13</td>
<td></td>
</tr>
<tr>
<td>mean for B</td>
<td>20.1</td>
<td>44.2</td>
<td>2.08</td>
<td></td>
</tr>
<tr>
<td>Mean for cultivar</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exotic F₁</td>
<td>20.0</td>
<td>44.8</td>
<td>1.92</td>
<td></td>
</tr>
<tr>
<td>Visby F₁</td>
<td>19.6</td>
<td>45.4</td>
<td>2.09</td>
<td></td>
</tr>
<tr>
<td>Long-term mean</td>
<td>19.8</td>
<td>45.1</td>
<td>2.01</td>
<td></td>
</tr>
</tbody>
</table>

\[ \text{LSD}_{0.05} \text{ for:} \]
\[ \begin{array}{lll}
\text{cultivation level} & \text{ns} & \text{ns} & 0.14 \\
\text{cultivar} & \text{ns} & \text{ns} & 0.15 \\
\text{cultivation level} \times \text{cultivar} & \text{ns} & \text{ns} & \text{ns}
\end{array} \]

\text{ns – non-significant differences}

According to the results of the study by Kotecki \textit{et al.} [2004], an intensive level of cultivation technology contributed to an increase in the total protein content in seeds (by 1.4%) and a decrease in the crude fat level (by 2.5%). Wielebski [2009b] reports that the content of fat, protein and other components in seeds depends on the cultivar and environment to a larger degree than on the level of cultivation technology. In the variant with intensive cultivation, where he applied higher (by 60 kg·ha⁻¹ N) nitrogen fertilization in comparison with the standard cultivation, the seeds of the studied cultivars accumulated significantly more (on average by 0.5%) total protein and contained less (by 1.1%) fat. However, a decrease in fat content in the study by that author was lower than an increase in seed yield generated by an increased nitrogen fertilization. Thus an intensive technology resulted in a significant increase in both the protein and fat productivity per 1 ha.

**CONCLUSIONS**

1. Highly intensive level of cultivation technology in relation to the moderately intensive affected the significant increase in seed yield by 0.5 Mg·ha⁻¹, i.e. 11.9%. This resulted from a significant increase in the number of pods per plant and thousand seed weight. Plant density per 1 m² before harvest and the number of seeds per pod showed only an upward tendency.

2. Diversified level of cultivation technology did not have a significant effect on protein and fat content in the seeds. The fat yield per 1 ha was significantly higher on treatments with the more intensive cultivation technology.

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3. The cultivar Exotic F$_1$ in comparison with Visby F$_1$ was characterized by higher values of such features as: overwintering, the number of seeds per pod and TSW, but in contrast, a lower number of pods per plant and a lower fat yield.

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PLONOWANIE ODMIAN RZEPAKU OZIMEGO W ZAŁEŻNOŚCI OD INTENSYWNOŚCI AGROTECHNIKI

Streszczenie. W sezonach 2008/2009-2010/2011 przeprowadzono ścisłe doświadczenie polowe, którego celem było określenie reakcji odmian mieszańcowych rzepaku oziomego na zróżnicowaną intensywność uprawy. Stwierdzono, że wyższy poziom agrotechniki w stosunku do niższego wpływał na istotny wzrost plonu nasion o 0,5 Mg·ha⁻¹, tj. 11,9%. Było to wynikiem istotnego wzrostu liczby łuszczyn na roślinie i masy tysiąca nasion. Odsada roślin przed zbiorąm na 1 m² i liczba nasion w huszczynie wykazały tylko tendencję wzrostową. Wyższy poziom agrotechniki nie modyfikował istotnie zawartości białka i tłuszczu w nasionach. Plon tłuszczu z 1 ha był jednak istotnie zróżnicowany. Odmiana Exotic F₁ odznaczała się istotnie wyższymi parametrami takich cech, jak: przeziemowanie, liczba nasion w huszczynie i MTN. Z kolei odmiana Visby F₁ charakteryzowała się istotnie większą liczbą huszczyn na roślinie i wyższym plonem tłuszczu.

Słowa kluczowe: Brassica napus, komponenty plonu, odmiana mieszańcowa, poziom agrotechniki

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